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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2019

1. (a) complete the following nuclear reaction equations

(i) $^{27}_{13}Al + {}^{4}_{2}He \longrightarrow \ldots\ldots\ldots\ldots + {}^{1}_{0}n.$ (1 mark)

(ii) $^{113}_{48}Cd + \ldots\ldots\ldots\ldots \longrightarrow {}^{114}_{48}Cd + Y.$ (1 mark)

(iii) $^{233}_{91}Pa \longrightarrow \ldots\ldots\ldots\ldots + {}^{0}_{-1}e.$ (1 mark)

(iv) $^{7}_{3}Li + \ldots\ldots\ldots\ldots \longrightarrow {}^{4}_{2}He + {}^{4}_{2}He.$ (1 mark)

2. State what would be observed and with equation(s) for the reaction(s) that would take place to a solution of iron(II) sulphate when;

(a) Aqueous sodium hydroxide was added drop-wise until in excess and the mixture was allowed to stand. (3½ marks)

(b) A few drops of concentrated sulphuric acid was added followed by concentrated nitric acid and the mixture was boiled (3 marks)

3. A hydrocarbon Z, with molecular formula C_xH_y, reacts with oxygen according to the following equation:

$$C_xH_y + \left(x + \tfrac{y}{4}\right)O_2 \longrightarrow xCO_2 + \tfrac{y}{2}H_2O.$$

When 20cm^3 of Z was exploded in 200cm^3 of an excess amount of oxygen, it burnt completely with a sooty flame. The volume of the residual gas after cooling to room temperature was 160 cm^3. When aqueous potassium hydroxide was added, the volume of the gas that finally remained was 20cm^3.

(a) Calculate the molecular formula of Z. (2 marks)

(b) When Z was treated with bromine in the presence of iron (III) bromide, the bromine was decolorized. Identify Z. (1 mark)

(c) Write equation(s) to show how Z can be synthesized from ethyne. (1½ marks)

4. The data in the Table 1 was obtained for the reaction between an alkylhalide, *R* and sodium hydroxide solution.

Table 1

Experiment	[R] (mol dm^{-3})	[$\bar{O}$H] (mol dm^{-3})	Rate (mol dm^{-3} s^{-1})
1	0.100	0.50	2.0×10^{-3}
2	0.100	0.25	2.0×10^{-3}
3	0.050	0.25	1.0×10^{-3}
4	0.025	0.25	5.0×10^{-4}

(a) Determine the order of the reaction with respect to:

(i) Alky halide, *R*. (1 mark)

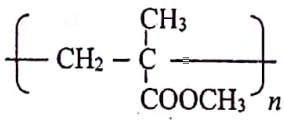
(ii) Sodium hydroxide. (1 mark)

(b) Write the rate equation for the reaction. (1 mark)

(c) (i) State the class of alkylhalide. (1 mark)

(ii) Give a reason for your answer in (c) (i) (1 mark)

5. (a) Perspex is a synthetic polymer with a structure;



(i) Name the type of reaction that leads to the formation of Perspex. (½ mark)

(ii) Write the structure of the monomer of Perspex. (1 mark)

(b) When 1.25×10^{-3} moles of Perspex were heated strongly with silicon (IV) oxide as a catalyst, 4.85g of the monomer was produced. Calculate the;

(i) Value of *n* (2 marks)

(ii) Molar mass of Perspex (1 mark)

(c) State one use of Perspex. (½ mark)

6. (a) When manganese (II) nitrate was heated, a black solid *R*, was formed.
Write equation for the reaction that took place. (1½ marks)

(b) *R* was heated with excess potassium hydroxide:

(i) State what was observed (1 mark)

(ii) Write equation for the reaction that took place. (1½ marks)

(c) To the mixture in (b), chlorine gas was bubbled. Write equation for the reaction that took place. (1½ marks)

7. The standard electrode potentials for some redox systems are shown below.

$FeO_4^{2-}(aq) + 8H^+(aq) + 3e^- \longrightarrow Fe^{3+}(aq) + 4H_2O(l)$ $E^o = +2.20V$

$O_2(g) + 4H^+(aq) + 4e^- \longrightarrow 2H_2O(l)$ $E^o = +1.23V$

(a) Write:

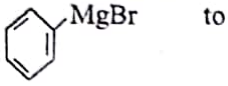
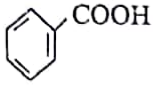
(i) The cell notation for the cell formed when the half cells are combined. (1 mark)

(ii) The overall equation for the reaction. (1½ marks)

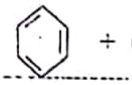
(b) (i) Calculate the e.m.f. of the cell in (a) (1 mark)

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(ii) State whether the cell reaction in (a) (ii) is feasible or not. Give a reason for your answer. (1 mark)

8. Write equation(s) to show how the following conversions can be effected:
   (a) CH_3CH_2CHO to $CH_3CH_2NH_2$ (3½ marks)
   (b)  to  (2½ marks)

9. (a) Write equation for the reaction between fluorine and;
   (i) Water (1½ marks)
   (ii) Hot concentrated sodium hydroxide. (1½ marks)
   (b) Although fluorine is an element in group (VII) of the Periodic Table, it behaves differently from the other members of the group.
   State three reasons why fluorine behaves differently from the other members. (1½ marks)

10. Complete the following equations and in each case outline a mechanism for the reaction.
   (a) $(CH_3)_3C-Br \xrightarrow[CH_3CH_2OH/heat]{CH_3CH_2\bar{O}Na^+} \ldots\ldots\ldots\ldots$ (3 marks)
   (b)  $+ CH_3COCl \xrightarrow{AlCl_3} \ldots\ldots$ (3 marks)
   (c) $HC\equiv CH \xrightarrow[(2)CH_3CH_2Br]{(1)\ Na/NH_3(l)} \ldots\ldots\ldots\ldots$ (3 marks)

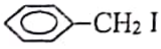
11. Table 2 shows acid dissociation constants, Ka, for some acids at 25°C.

Table 2

Acid	Ka (mol dm^{-3})
H−COOH	1.70×10^{-4}
CH_3COOH	1.70×10^{-5}
CH_3CH_2COOH	1.35×10^{-5}

   (i) State the trend in acid strength of the acids in Table 2. (1 mark)
   (ii) Explain your answer in (a) (i) (3 marks)
   (b) Calculate the pH of a 0.5M CH_3CH_2COOH solution (1½ marks)
   (c) (i) 45.0cm^3 of a solution in (b) was mixed with 35.0cm^3 of a 0.5M potassium hydroxide solution.
   Calculate the change in pH of the solution. (2½ marks)
   (ii) Predict the effect of adding **two** drops of dilute hydrochloric acid to the solution in (c) (i). (1 mark)

12. (a) The atomic number of aluminium is 13.
   Write the;
   (i) electronic configuration of aluminium (1 mark)
   (ii) formula of the chloride of aluminium (1 mark)
   (b) Write equation for the reaction between aluminium chloride and:
   (i) water (1½ marks)
   (ii) excess ammonia solution (1½ marks)
   (iii) excess sodium hydroxide solution (3 marks)
   (c) Name **one** reagent that can be used to distinguish between aluminium and lead(II) ions in solution. (1 mark)

13. Name one reagent that can be used to distinguish between the following pairs of compounds. In each case, state what would be observed if each member of the pair is separately treated with the reagent you have named.
   (a) $CH_3COOCH_2CH_3$ and CH_3CH_2COOH (3marks)
   (b) $HO-\overset{\overset{O}{\|}}{C}-H$ and $HO-\overset{\overset{O}{\|}}{C}-\overset{\overset{O}{\|}}{C}-OH$ (3marks)
   (c)  and H_3C  (3marks)

14. (a) Define the term molar conductivity. (1 mark)
   (b) (i) Sketch a graph to show the variation of molar conductivity of sodium chloride with dilution. (2 marks)
   (ii) Explain the shape of the graph in (b) (i) (2½ marks)
   (c) The electrolytic conductivity of a saturated solution of silver chloride at 25°C is $1.5 \times 10^{-4}\Omega^{-1}m^{-1}$.
   The molar conductivities at infinite dilution of silver and chloride ions are 62×10^{-3} and $7.7 \times 10^{-3}\Omega^{-1}m^{-2}mol^{-1}$ respectively.
   Determine the solubility of silver chloride at 25°C (3½ marks)

15. Cobalt (II) nitrate dissolves in water to form a pink solution and decomposes on heating to form a green solid
   (a) Write equation to show the effect of heat on cobalt (II) nitrate. (1½ marks)

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(b) State what would be observed and write equation for the reaction that would take place when the following substances are added to the solution of cobalt (II) nitrate in water.

(i) Concentrated hydrochloric acid (2 marks)

(ii) Aqueous ammonium thiocyanate solution (2 marks)

(iii) Aqueous sodium hydroxide. (3½ marks)

16. (a) (i) Draw the structure and name the shape of the following oxyanions (4 marks)

Oxyanion	Structure	shape
SO_3^{2-}		
SO_4^{2-}		

(ii) Explain the structure of the SO_3^{2-} ion (1½ marks)

(b) (i) Name the reagent(s) that can be used to distinguish between the oxyanions in (a) (i). (1 mark)

(ii) State what would be observed; if a solution of each of the oxyanion is treated separately with the reagent(s) you have named in (b) (i). (1 mark)

(iii) Write the equation(s) for any reaction(s) that would take place when a solution of each of the oxyanions is treated separately with the reagent(s) you have named in (b) (i). (1½ marks)

17. (a) State **three** conditions that enable isolation of a solute from a mixture by solvent extraction. (1½ marks)

(b) When one litre of an aqueous solution containing 25.0g of solute X was shaken with 500cm^3 of ethoxyethane, 9.7g of X was extracted in the ethoxyethane layer.
Calculate the partition coefficient of X between ethoxyethane and water (2 marks)

(c) The solution in (b) was shaken with two successive 250cm^3 portions of ethoxyethane. Calculate the total mass extracted. (4 marks)

(d) Comment on the result in (c) (1 mark)

(e) State **one** application of solvent extraction. (½ mark)

END

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2019

1. (a) (i) $^{27}_{13}Al + {}^{4}_{2}He \longrightarrow {}^{30}_{15}P + {}^{1}_{0}n$

(ii) $^{113}_{48}Cd + {}^{1}_{0}n \longrightarrow {}^{114}_{48}Cd + \gamma$

(iii) $^{233}_{91}Pa \longrightarrow {}^{233}_{92}U + {}^{0}_{-1}e$

(iv) $^{7}_{3}Li + {}^{1}_{1}H \longrightarrow {}^{4}_{2}He + {}^{4}_{2}He$

2. (a) **Green precipitate, insoluble** in excess sodium hydroxide solution and **turns brown** on standing

$Fe^{2+}(aq) + 2\overline{O}H(aq) \longrightarrow Fe(OH)_2(s)$

$4Fe(OH)_2(s) + ½O_2(g) + 2H_2O(l) \longrightarrow 4Fe(OH)_3(s)$; or

$2Fe(OH)_2(s) + ½O_2(g) \longrightarrow Fe_2O_3 \cdot 2H_2O(s)$

(b) **Green solution** of Iron (II) sulphate **turns brown (or yellow)** and **brown fumes** are evolved

$3Fe^{2+}(aq) + NO_3^-(aq) + 4H^+(aq) \longrightarrow 3Fe^{3+}(aq) + 2H_2O(l) + NO(g)$

or, $Fe^{2+}(aq) + NO_3^-(aq) + 2H^+(aq) \longrightarrow Fe^{3+}(aq) + NO(g) + H_2O(l)$

or, $6Fe^{2+}(aq) + 8H^+(aq) + 2NO_3^-(aq) + O_2(g) \longrightarrow 6Fe^{3+}(aq) + 4H_2O(l) + 2NO_2(g)$

or, $Fe^{2+}(aq) + H^+(aq) + HNO_3(aq) \longrightarrow Fe^{3+}(aq) + H_2O(l) + NO_2(g)$

3. (a) $C_xH_y + \left(x + \frac{y}{4}\right)O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O.$

$1cm^3 \quad \left(x + \frac{y}{4}\right)cm^3 \quad xcm^3$

$20cm^3 \quad 20\left(x + \frac{y}{4}\right)cm^3 \quad 20xcm^3$

Volume of CO_2 formed $= 20x = 140$

Thus; $20x = 140$

$$x = \frac{140}{20} = 7$$

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Volume of O_2 used $= 20\left(x + \frac{y}{4}\right) = (200 - 20)$

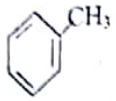
Hence; $20\left(x + \frac{y}{4}\right) = 180$

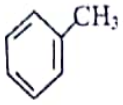
$20\left(7 + \frac{y}{4}\right) = 180$

$140 + 5y = 18$

$y = \frac{180-140}{5} = 8$

Therefore; molecular formula of Z is $\mathbf{C_7H_8}$

(b)  or $C_6H_5CH_3$ or methyl benzene.

(c) $3HC{\equiv}CH \xrightarrow[60-70°C \text{ (or heat)}]{\text{Organo nickel}}$  $\xrightarrow[FeBr_3]{CH_3Br,}$ 

Note;- In step 1; (Cu or Fe, 400−600°C) can be used instead of (organo nickel, 60−70°C)
Also; in step 2: ($FeCl_3$ or $AlCl_3$ or $AlBr_3$) could be used instead of $FeBr_3$

4. (a) (i) **Determining order of reaction by inspection method;**
In experiments 2 and 3, keeping the **concentration of the hydroxide ions constant** and **halfing the concentration of R**, The **rate of reaction is also halfed**, hence the reaction is **first order** with respect to the alkyl halide R;

or; Determining order of reaction by calculation method;
Considering experiments 2 and 3

$$2.0 \times 10^{-3} = k(0.1)^x(0.25)^y$$
$$1.0 \times 10^{-3} = k(0.05)^x(0.25)^y$$

Hence; $\left(\frac{2.0\times10^{-3}}{1.0\times10^{-3}}\right) = \left(\frac{0.1}{0.05}\right)^x$

$$2 = 2^x$$

$\therefore x = 1$; Hence order of reaction with respect to the alkyl halide; R is **first order**

(ii) **Determining order by inspection method;**
In experiments, 1 and 2, keeping the **concentration of R constant** and **halfing the concentration of sodium hydroxide**, gives **no effect on the rate of reaction**, hence the reaction is **zero order** with respect to sodium hydroxide.

or, Determining order by calculation method;
Using experiments 1 and 2

$$2.0 \times 10^{-3} = k(0.1)^x(0.5)^y$$
$$2.0 \times 10^{-3} = k(0.1)^x(0.25)^y$$

Hence; $\left(\frac{0.5}{0.25}\right)^y = \left(\frac{2.0\times10^{-3}}{2.0\times10^{-3}}\right)$

$2^y = 1$; **Therefore, y = 0**

Hence; The order of reaction with respect to sodium hydroxide is **zero order**

(b) Rate $= k[R]^1[\bar{O}H]^0$ **or** Rate $k[R]^1$

(c) (i) Tertiary alkyl halide
(ii) The rate of reaction **only depends on the concentration of alkyl halide** and is **independent of the concentration of the hydroxide ion.**

5. (a) (i) Addition polymerization
(ii) $H_2C = \underset{\displaystyle CH_3}{\overset{\displaystyle |}{C}}\ COOCH_3$

(b) (i) 1.25×10^{-3} moles of polymer produce 4.85g of monomers

$\therefore$ 1mole of polymer produce $\left(\frac{4.85}{1.25\times10^{-3}}\right)$ **= 3880g of monomers**

Molecular mass of monomer $= (12 \times 5) + (8 \times 1) + (2 \times 16) = 100$

Therefore; $n = \frac{3880}{100}$ **= 39**

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(ii) Molar mass of Perspex = (molecular mass of monomer) × valueof n
= (100 × 39) = **3900g**

(c) **Uses of Perspex**

-making aeroplane windows
-making safety wind screnes
-making optical lenses
-making corrugated roof lights

6. (a) $Mn(NO_3)_2(s) \longrightarrow MnO_2(s) + 2NO_2(g)$

(b) (i) The **black solid dissolved** to give a **green liquid** or solution

(ii) $2MnO_2(s) + 4KOH(s)$ or $(l) + O_2(g) \longrightarrow 2K_2MnO_4(l) + 2H_2O(g)$

or, $2MnO_2(s) + 4\bar{O}H(s)$ or $(l) + O_2(g) \longrightarrow 2MnO_4^{2-}(l) + 2H_2O(g)$

(c) $MnO_4^{2-}(l) + \frac{1}{2}Cl_2(g) \longrightarrow MnO_4^{-}(l) + Cl^{-}(l)$

7. (a) (i) $Pt(s) \mid H_2O(l), H^+(aq) \mid O_2(g) \parallel FeO_4^{2-}(aq), H^+(aq), Fe^{3+}(aq) \mid Pt(s)$

or, $Pt(s) \mid H_2O(l), H^+(aq) \mid O_2(g) \parallel FeO_4^{2-}(aq), H^+(aq), Fe^{3+}(aq), H_2O(l) \mid Pt(s)$

(ii) $4FeO_4^{2-}(aq) + 2OH^-(aq) \longrightarrow 4Fe^{3+}(aq) + 3O_2(g) + 10H_2O(l)$

(b) (i) $Emf_{cell} = E^{\theta}_{Right} - E^{\theta}_{Left}$
$= +2.20 - (+1.23) = \mathbf{+0.97V}$

(ii) Cell reaction is **feasible** because the Emf of cell is **positive**

8. (a) $CH_3CH_2CHO \xrightarrow[\text{heat}]{Cr_2O_7^{2-}/H^+} CH_3CH_2COOH \xrightarrow[\text{heat}]{(NH_4)_2CO_3(s)} CH_3CH_2CONH_2$

$CH_3CH_2CONH_2 \xrightarrow[\text{warm}]{Br_2/\text{conc.NaOH}} CH_3CH_2NH_2$

Alternatively;

$CH_3CH_2CHO \xrightarrow[\text{heat}]{MnO_4^-/\text{conc.}H_2SO_4} CH_3CH_2COOH \xrightarrow[\text{or } PCl_5 \text{ or } PCl_3]{SOCl_2} CH_3CH_2COCl$

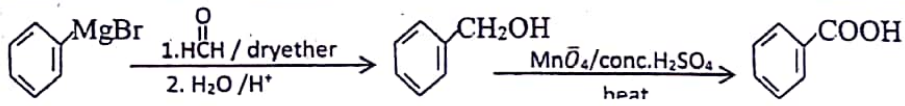
$CH_3CH_2COCl \xrightarrow{\text{conc.}NH_3} CH_3CH_2CONH_2 \xrightarrow[\text{warm}]{Br_2/\text{conc.NaOH}} CH_3CH_2NH_2$

Alternatively;

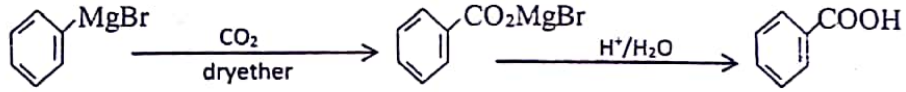
$CH_3CH_2CHO \xrightarrow[\text{heat}]{CrO_3/H^+} CH_3CH_2COOH \xrightarrow[\text{or CaO(s)/NaOH(s)}]{\text{Soda lime}} CH_3CH_3$

$CH_3CH_3 \xrightarrow[\text{dibenzyl peroxide}]{SO_2Cl_2,\ 40-80^\circ C} CH_3CH_2Cl \xrightarrow[\text{Alcoholic } NH_3]{\text{Excess}} CH_3CH_2CONH_2 \xrightarrow[\text{conc.NaOH, warm}]{Br_2} CH_3CH_2NH_2$

(b)



or



9. (a) (i) $2F_2(g) + 2H_2O(l) \longrightarrow 4HF(aq) + O_2(g)$

(ii) $2F_2(g) + 4NaOH(aq) \longrightarrow O_2(g) + 4NaF(aq) + 2H_2O(l)$

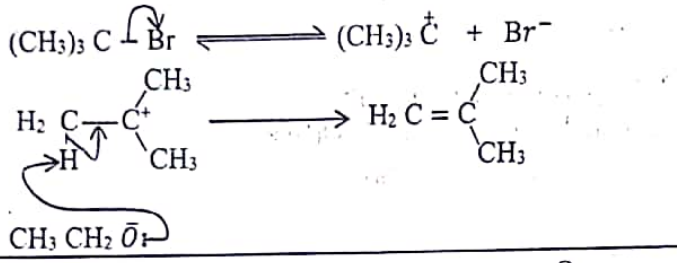
or, $2F_2(g) + 4\bar{O}H(aq) \longrightarrow O_2(g) + 4F^-(aq) + 2H_2O(l)$

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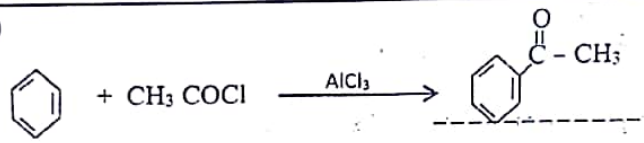
(b) -Fluorine atom has the **highest electronegativity value**
-Fluorine atom has the **smallest atomic radius**
-Fluorine molecule has the **lowest bond dissociation energy**
-Fluorine atom has the **largest** positive electrode potential
-Fluorine atom **lacks vacant d-orbitals**

10. (a) $(CH_3)_3C-Br \xrightarrow[CH_3CH_2OH/heat]{CH_3CH_2\bar{O}Na^+} H_2C=C(CH_3)CH_3$

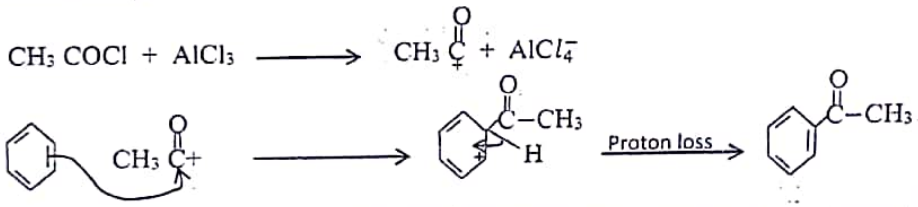
Mechanism;



(b)



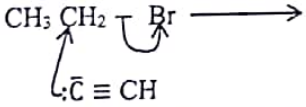
Mechanism;



(c) $HC\equiv CH \xrightarrow[2.CH_3CH_2Br]{1.Na/NH_3(l)} CH_3CH_2C\equiv CH$

Mechanism;

$HC\equiv CH + Na \longrightarrow HC\equiv C^-Na^+ + \frac{1}{2}H_2$



11. (a) (i) Acidic strength **increases from propanoic acid to ethanoic acid to methanoic acid**
(ii) The strength of an acid depends on the **ease of release** of a **proton** (hydrogen ion)
The **strength of the oxygen-hydrogen bond increases** with **increase in the number of carbon atoms in the alkyl group attached on the carbonyl group.**
This is because alkyl groups have a **positive inductive effect** which **decreases the polarity of the oxygen-hydrogen bond**
Methanoic acid has a **hydrogen atom** instead of an alkyl group attached to the carbonyl group and hydrogen has **no inductive effect** hence the oxygen-hydrogen bond in methanoic acid is the **weakest** and the acid **easily releases** a proton.

(b) Equation of ionization
$CH_3CH_2COOH(aq) \rightleftharpoons H^+(aq) + CH_3CH_2CO\bar{O}(aq)$

$$Ka = \frac{[H^+][CH_3CH_2CO\bar{O}]}{[CH_3CH_2COOH]}$$

But; $[H^+] = [CH_3CH_2CO\bar{O}]$ and $[CH_3CH_2COOH] = 0.5M$

Hence; $Ka = \frac{[H^+]^2}{[CH_3CH_2COOH]}$

$$[H^+] = \sqrt{1.35\times10^{-5}\times0.5}$$
$$= 2.598\times10^{-3} moldm^{-3}$$

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$pH = -\log_{10}[H^+]$

$= -\log(2.598 \times 10^{-3}) \quad = \quad 2.58$

(c) (i) Moles of KOH in $35.0cm^3 = \left(\frac{35.0}{1000} \times 0.5\right) = 0.0175$moles

Equation of reaction between KOH and $CH_3\ CH_2\ COOH$

$KOH(aq) + CH_3\ CH_2\ COOH(aq) \longrightarrow CH_3CH_2\ COOK(aq) + H_2O(l)$

Moles of salt; $(CH_3CH_2\ COOK)$ formed = 0.0175moles

(since mole ratio of KOH; $CH_3CH_2\ COOK = 1:1$)

Volume of resultant solution = $45cm^3 + 35cm^3 = 80cm^3$

Hence; $80cm^3$ resultant solution contain $0.0175moles$ of salt.

Therefore; $1000cm^3$ of resultant solution contain $\left(\frac{1000\times0.0175}{80}\right)$ moles of salt

Thus; concentration of salt in resultant solution = $0.21875moldm^{-3}$

Moles of propanoic acid in $45.0cm^3 = \left(\frac{45.0}{1000} \times 0.5\right) = 0.0225$moles

Moles of propanoic acid which reacted with KOH = 0.0175moles

(since mole ratio of KOH; $CH_3CH_2COOH = 1:1$)

Hence: moles of excess propanoic acid = (0.0225-0.0175) = $\mathbf{0.005}\boldsymbol{moles}$

Thus; $80cm^3$ of resultant solution contain 0.005 moles of propanoic acid

$1000cm^3$ of resultant solution contain $\left(\frac{1000\times0.005}{80}\right)$mole of propanoic acid

$= 0.0625moldm^{-3}$

Therefore; concentration of propanoic acid in resultant solution = 0.0625M

Since the resultant solution consists of propanoic acid which is a weak acid and its salts; potassium propanoate from a strong base, the solution is an **acidic buffer**;

Thus; from;

$$Ka = \frac{[salt][H^+]}{[acid]}$$

$$[H^+] = \frac{Ka[acid]}{[salt]} = \frac{1.35\times10^{-5}\times0.0625}{0.21875}$$

$$\simeq 3.857 \times 10^{-6} moldm^{-3}$$

But; $pH = -\log_{10}[H^+]$

$= -\log_{10}(3.857 \times 10^{-6}) = \mathbf{5.41}$

Therefore; pH change = $5.41 - 2.58 = \mathbf{2.83}$

(ii) No change in pH

Note; The solution in (c) (i) is a buffer and so resists change in pH when a small amount of acid is added

12. (a) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

(ii) $AlCl_3$

(b) (i) $AlCl_3(s) + 3H_2O(l) \longrightarrow Al(OH)_3(s) + 3HCl(aq)$

or $Al^{3+}(aq) + 3H_2O(l) \longrightarrow Al(OH)_3(s) + 3H^+(aq)$

(ii) $Al^{3+}(aq) + 3\bar{O}H(aq) \longrightarrow Al(OH)_3(s)$

or; $AlCl_3(s) + 3NH_3(aq) + 3H_2O(l) \longrightarrow Al(OH)_3(s) + 3NH_4Cl(aq)$

(iii) $Al^{3+}(aq) + 3\bar{O}H(aq) \longrightarrow Al(OH)_3(s)$

$Al(OH)_3 + \bar{O}H(aq) \longrightarrow Al(OH)_4^-(aq)$

(c) Potassium iodide **solution**

or; Ammonia solution followed by litmus solution

or; Dilute hydrochloric acid **or**; Dilute sulphuric acid

13. (a) Reagent – sodium carbonate solution or sodium hydrogen carbonate solution

Observation; $CH_3\ COOCH_2\ CH_3$ -gives no observable change

$CH_3\ CH_2\ COOH$ -gives bubbles of a colourless gas

or;

Reagent – sodium metal or calcium metal or potassium metal or magnesium metal

Observation; $CH_3\ COOCH_2\ CH_3$ -gives no observable change

$CH_3\ CH_2\ COOH$ -gives bubbles or (Effervescence) of a colorless gas

(b) Reagent – Ammoniacal silver nitrate **solution**

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Observation;

HO – C(=O) – H –gives a silver mirror

HO – C(=O) – C(=O) – OH -gives no observable change.

or;

Reagent - Fehling's solution

Observation;

HO – C(=O) – H –gives a reddish brown precipitate

HO – C(=O) – C(=O) – OH -gives no observable change.

(c) Reagent – **Hot** sodium hydroxide **solution** followed by dilute nitric acid and silver nitrate solution

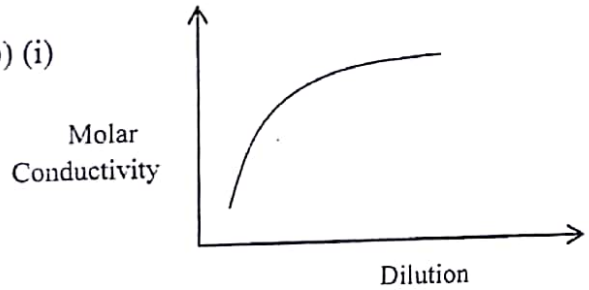
Observation;

 CH_2I - gives a **yellow precipitate**

H_3C-  -I -gives **no observable change.**

14. (a) The conductance of an aqueous solution containing **one mole** of an electrolyte placed between two electrodes of **unit distance** apart and each of **unit** cross-sectional area **or** Elctrolytic conductivity divided by concentration

(b) (i)



(ii) Molar conductivity **increases with increase in dilution** and **reaches a constant value at infinite dilution.**

This is because increase in dilution makes the **ions to be far apart** and **ionic interference is reduced** and hence the **mobility of the ions increases** hence **increase in molar conductivity.**

At infinite dilution, **ionic interference has been eliminated** and any **further dilution results into no change in molar conductivity.**

(c) Molar conductivity of silver chloride at infinite dilution ; $\Lambda_o(AgCl)$ = molar conductivity at infinite dilution of silver ions ; $\Lambda_o(Ag^+)$ + molar conductivity at infinite dilution of chloride ions; $\Lambda_o(Cl^-)$

$= 6.2 \times 10^{-3} + 7.7 \times 10^{-3}$

$= 1.39 \times 10^{-2}\Omega^{-1}m^2mol^{-1}$

From; $\Lambda_o = \frac{k}{c}$ (where c = solubility or concentration)

Then; $c = \frac{k}{\Lambda_o} = \frac{1.50\times10^{-4}}{1000}$

$= 1.079 \times 10^{-2} molm^{-3}$

Thus; solubility; $c = \frac{1.079\times10^{-2}}{1000} = 1.079 \times 10^{-5} moldm^{-3}$

Alternatively;

Solubility; $c = \frac{10^{-3}k}{\Lambda_o} = \frac{10^{-3}\times1.54\times10^{-4}}{1.39\times10^{-2}} = 1.079 \times 10^{-5} moldm^{-3}$

15. (a) $Co(NO_3)_2(s) \longrightarrow 2CoO(s) + 4NO_2(g) + O_2(g)$

(b) (i) Solution turns **from pink** to **blue**

$Co^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons CoCl_4^{2-}(aq)$

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or $Co(H_2O)_6^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons CoCl_4^{2-}(aq) + 6H_2O(l)$

(ii) **Pink** solution of cobalt (II) nitrate turns **blue**

$Co^{2+}(aq) + SCN^-(aq) \longrightarrow Co(SCN)^+(aq)$

or $Co^{2+}(aq) + 2SCN^-(aq) \longrightarrow Co(SCN)_2(aq)$

(iii) **Blue precipitate** turns **brown** or **pink** on standing

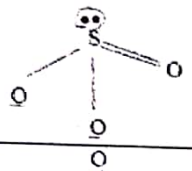
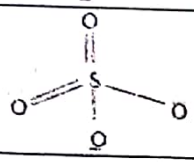
$Co(H_2O)_6^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Co(OH)_2(s) + 6H_2O(l)$

or $Co^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Co(OH)_2(s)$

Then; $4Co(OH)_2(s) + O_2(g) \longrightarrow 2Co_2O_3 \cdot 2H_2O(s)$

16.

(a) (i)

Oxyanions	Structure	Shape
SO_3^{2-}		Trigonal pyramidal
SO_4^{2-}		Tetra hedral

(ii) The sulphite ion possesses a **lone pair of electrons on the sulphur atom** and **three bonding pairs of electrons**. The bonding pairs of electrons repel each other but the repulsion between the lone pair of electrons and bond pair of electrons is **greater** than that between the bond pairs of electrons. This **reduces the bond angle** forming a trigonal pyramidal shape.

(b) (i) Dilute nitric acid followed by barium nitrate **solution**
or; Dilute hydrochloric acid followed by barium chloride solution.

(ii) SO_3^{2-} -gives no observable change
SO_4^{2-} -gives a white precipitate

(iii) $Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s)$

Alternatively;
Reagent (s) -Acidified potassium manganate (VII) **solution**
Observation; SO_3^{2-} -Would turn the **purple** solution of the manganate (VII) **colourless**
SO_4^{2-} -Would give **no observable change**

Equation;

$2MnO_4^-(aq) + 5SO_3^{2-}(aq) + 6H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 3H_2O(l) + 5SO_4^{2-}(aq)$

Alternatively;
Reagent – Acidified potassium dichromate (VI) **solution**
Observation; SO_3^{2-} - Would turn the **orange** solution of the dichromate (VI) to **green**
SO_4^{2-} - Would give **no observable change**

Equation;

$3SO_3^{2-}(aq) + Cr_2O_7^{2-}(aq) + 8H^+(aq) \longrightarrow 2Cr^{3+}(aq) + 4H_2O(l) + 3SO_4^{2-}(aq)$

17. (a) -The two solvents should **not react** with each other
-The solvents must be **immiscible** with each other
-The solute should be **more soluble** in the extracting solvent
-Solute should **not dissociate** or **associate** in any of the solvents

(b) Mass of solute x remaining in water $= (25.0 - 9.7)g = 15.3g$

Concentration of x in water $= \frac{15.3}{1000}$

Concentration of x in ethoxyethane $= \frac{9.5}{500}$

Hence; partition coefficient; $K_D = \frac{concentration\ of\ x\ in\ ether}{concentration\ of\ x\ in\ water}$

$= \frac{9.5}{500} \times \frac{1000}{15.3} = \mathbf{1.27}$

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(c) Let; the mass of x extracted by the 1st 250cm^3 portion of ethoxyethane = y grams

Hence; mass of x remaining in water = $(25.0 - y)$g

Concentration of x in ethoxyethane = $\frac{y}{250}$

Concentration of x in water = $\frac{25.0-y}{1000}$

$K_D = \frac{concentration\ of\ x\ in\ ethoxy\ ethane}{concentration\ of\ x\ in\ water}$

$$1.27 = \frac{y}{250} \times \frac{1000}{(25.0-y)}$$

Therefore; $y = 6.0$g

Hence; mass of x remaining in water = $(25.0 - 6.0) = \mathbf{19.0g}$

Let; mass of x extracted by the 2nd 250cm^3 portion of ethoxyethane = w grams

Hence; mass of x remaining in water = $(19.0 - w)$g

Concentration of x in ethoxyethane = $\frac{w}{250}$

Concentration of x in water = $\frac{19.0-w}{1000}$

Hence; $1.27 = \frac{w}{250} \times \frac{1000}{(19.0-w)}$

Therefore; $w = 4.58$g

Thus; Total mass extracted = $(6.0 + 4.58)$ $= \mathbf{10.58g}$

(d) Mass extracted by two successive portions of 250cm^3 of ethoxyethane is greater than the mass extracted by using 500cm^3 portion once.

(e) -Purification of zinc ores
-Separation of azeotropic mixtures
-Extraction of oil from simsim
-Separation of inorganic solids eg Iron (III) chloride from manganese (II) Chloride.

QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2019

1. (a) The atomic numbers of scandium and manganese are 21 and 25 respectively. Write the electronic Configuration of
   (i) scandium (1 mark)
   (ii) manganese (1 mark)
   (iii) scandium(III) ion (1 mark)
   (iv) manganese(VII) ions (1 mark)

   (b) Explain why scandium only forms compounds in which its oxidation state is +3, while manganese forms compounds in which its oxidation states are +2 and +7 (3 marks)

   (c) Potassium hydroxide was fused with manganese(IV) oxide in the presence of oxygen to form a green solid X. X was dissolved in water to form a green solution. On bubbling carbon dioxide gas through the green solution, a purple solution Y and a brown solid were formed.
   (i) Name solid X and write equations for the reaction leading to the formation of solid X.(2 ½ marks)
   (ii) Write equation leading to the formation of solution Y (1 ½ marks)

   (d) When sulphur dioxide was bubbled through acidified solution Y, the color of solution turned from purple to colourless, Explain. (3 marks)

   (e) State what would be observed and write equation for the reaction that would take place if to the resultant solution in (d) was added:
   (i) Dilute sodium hydroxide solution (3 marks)
   (ii) Acidified barium nitrate solution (2 ½ marks)

2. (a) (i) State what is meant by the term **partition coefficient** (2 marks)
   (ii) State four conditions under which partition law is valid (2 marks)

   (b) (i) Describe an experiment to determine the partition coefficient of iodine between ether and water.(6 marks)
   (ii) Give four reasons why ethoxyethane (ether) is most commonly used in solvent extraction of organic compounds from their aqueous solutions (2 marks)

   (c) The partition coefficient of a substance Z between methyl benzene and water is 12. Calculate the mass of Z that would be extracted from 200cm^3 of an aqueous solution containing 8.0g of Z by:

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(i) Shaking with $50cm^3$ of methylbenzene (2 marks)

(ii) Shaking successively with two separate $25cm^3$ – portions of methylbenzene (4 marks)

(iii) Comment on your answers in (i) and (ii) (1 mark)

(d) State two applications of partition law other than solvent extraction (1 mark)

3. (a) The boiling points of 2-chlorobutane and 2-iodobutane are 68°C and 119°C respectively. When treated with aqueous sodium hydroxide followed by acidified silver nitrate solution, 2-chlorobutane forms a white precipitate after 15 minutes, whereas 2-iodobutane almost immediately. Explain:

(i) Why the boiling point of 2-chlorobutane is lower than that of 2-iodobutane (2 marks)

(ii) The formation of the white precipitate in 2-chlorobutane takes a longer time than in 2-iodobutane. (3 marks)

(b) Write

(i) the equation for the reaction of 1-chlorobutane with aqueous sodium hydroxide. (1 mark)

(ii) the mechanism for the reaction in (b)(i) above. (1 mark)

(c) The reaction in (b)(i) is exothermic. Sketch a labeled potential energy versus reaction coordinate diagram for the reaction (2 ½ marks)

(d) (i) Write equation of reaction for the conversion of benzene to chlorobenzene (1 mark)

(ii) Outline a mechanism for the reaction in (d)(i) (3 marks)

(e) Write equations to show how 2-bromobutane can be converted to butanone (2 ½ marks)

(f) (i) Name one reagent that can be used to confirm the formation of butanone (1 mark)

(ii) State what would be observed if butanone was present (1 mark)

(iii) Write equation for the reaction of butanone and the reagent you have name in (f)(i) (1 mark)

(g) A solution containing iodine and sodium hydroxide was added to butanone. State what was observed.(1 mk)

4. (a) (i) Define the term **standard enthalpy change** of a reaction (1 mark)

(ii) Briefly describe how enthalpy of neutralization of nitric acid by sodium hydroxide can be determined (5 marks)

(iii) Explain why the enthalpy of neutralization of sodium hydroxide by nitric acid is $57.1KJmol^{-1}$ whereas the the enthalpy of neutralization of sodium hydroxide by hydrocyanic acid is $12.0KJ\ mol^{-1}$ (2 marks)

(b) The heat change that takes place when one mole of a gaseous ion is completely dissolved in enough solvent is called hydration energy. State the factors that affect hydration energy and explain their effects (4 marks)

(c) The standard enthalpies of hydration and lattice energies of lithium chloride and potassium chloride are given in Table 1 below.

Salt	Lattice energy($KJ\ mol^{-1}$)	Hydration energy ($KJ\ mol^{-1}$)
Potassium chloride	–682	–883
Lithium chloride	–718	–695

(i) Calculate the enthalpy of solution of lithium chloride and potassium chloride (2 ½ marks)

(ii) State which of the two salts would be more soluble in water at a given temperature and give a reason for your answer. (1 mark)

(d) Using the thermochemical data below, determine the lattice energy of sodium chloride. (4 ½ marks)

Heat of atomization of sodium = $108\ KJmol^{-1}$

Dissociation energy of chlorine = $242,2\ KJmol^{-1}$

Ionization energy of sodium = $500\ KJmol^{-1}$

Electron affinity of chlorine = $-364\ KJmol^{-1}$

Enthalpy of formation of sodium chloride = $-411.4\ KJmol^{-1}$

5. (a) Carbon, silicon, tin and lead are some of the elements in group(IV) of the Periodic Table. Discuss the reactivity of the elements with;

(i) Water (4 marks)

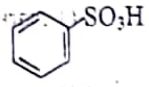
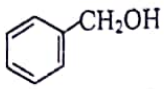
(ii) Sodium hydroxide solution (6 marks)

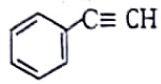
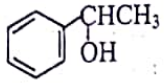
(iii) Concentrated sulphuric acid (7 ½ marks)

(b) State what would be observed and write equation of the reaction that would take place if excess concentrated hydrochloric acid was mixed with lead(IV) oxide and heated (2 ½ marks)

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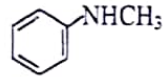
6. Write equations to show how the following compounds can synthesized.

(a)  from  (4 ½ marks)

(b)  from  (3 ½ marks)

(c) $CH_3-\underset{OH}{\underset{|}{CH}}-CH_3$ from CH_3CH_2COOH (3 ½ marks)

(d) $CH_3-\underset{NH_2}{\underset{|}{CH}}-CH_3$ from $CH_3-\underset{H}{\underset{|}{\overset{OH}{\overset{|}{C}}}}-CH_3$ (3 marks)

(e)  from $HC \equiv CH$ (5 ½ marks)

7. (a) Define the term **Eutectic mixture** (1 mark)

(b) Briefly describe how a phase diagram of a mixture biphenyl and napthalene can be determined in the laboratory (3 marks)

(c) Table 2 below shows the melting points of various mixtures of naphthalene - biphenyl

Mole fraction of naphthalene	0.125	0.275	0.450	0.625	0.800
Melting point(°C)	58.0	47.0	40.0	53.0	58.0

(i) Draw a fully labeled diagram of the naphthalene – biphenyl system.
(The melting points of Napthalene and biphenyl are 80°C and 71°C) (5 marks)

(ii) Determine the eutectic temperature and composition of the eutectic mixture. (3 marks)

(d) Describe the changes that would take place if a liquid mixture of the above system containing 80% biphenyl was cooled from 85°C to 30°C (6 marks)

(e) Explain what would be observed when increasing quantities of biphenyl are added to naphthalene (2 marks)

8. Explain each of the following observations and where applicable illustrate your answer with equation(s)

(a) Hydrogen sulphide is a gas at room temperature whereas water is a liquid under similar conditions (4½ marks)

(b) When a cold mixture of sodium nitrite and concentrated hydrochloric acid solution is added separately to ethyl amine and phenylamine, bubbles of a colourless gas are produced with ethylamine but phenyl amine only forms colourless solution (6½ marks)

(c) When hydrazine (NH_2NH_2) is added to an acidified solution of potassium manganite(VII), the potassium manganite(VII) solution turns from purple to colourless and a colorless gas is evolved. (4 marks)

(d) When a limited amount of chlorine is added into sodium thiosulphate solution, a yellow precipitate is formed. (5 marks)

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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2 (P525/2), 2019

Question. One.

(a) (i) Sc $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^1$ or $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^1\ 4s^2$

(ii) Mn $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$ or $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$

(iii) Sc^{3+} $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

(iv) Mn^{7+} $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

(b) Scandium **loses two electrons of the 4s-orbital** and **one electron from the 3d-orbitals** to form scandium (III) ion which has the outer most 3p sub-energy level that is **full of electrons** and hence **stable**
Manganese **loses two electrons of the 4s-orbital** to form manganese (II) ion which has **half filled 3d-orbitals** that are **stable.**
Manganese can also **lose the two 4s-orbital electrons** and **five electrons of the 3d-orbitals** to form $3p^6$ sub-energy level which is **full** of electrons and therefore stable forming manganese (VII) ion

(c) (i) Potassium manganate (VI)

$4KOH(s) + 2MnO_2(s) + O_2(g) \longrightarrow 2K_2MnO_4(s) + 2H_2O(l)$

or $4\bar{O}H(aq) + 2MnO_2(s) + O_2(g) \longrightarrow 2MnO_4^{2-}(aq) + 2H_2O(l)$

(ii) $3MnO_4^{2-}(aq) + 2CO_2(g) \longrightarrow 2MnO_4^{-}(aq) + MnO_2(s) + 2CO_3^{2-}(aq)$

Or $3MnO_4^{2-}(aq) + 4H^+(a) \longrightarrow MnO_2(s) + 2MnO_4^{-}(aq) + 2H_2O(l)$

(d) Sulphur dioxide **reduced** manganate (VII) ions to **manganese (II) ions**

$2MnO_4^{-}(aq) + 5SO_2(g) + 2H_2O(l) \longrightarrow 2Mn^{2+}(aq) + 5SO_4^{2-}(aq) + 4H^+(aq)$

or $2MnO_4^{-}(aq) + 5SO_3^{2-}(aq) + 6H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 5SO_4^{2-}(aq) + 3H_2O(l)$

(e) (i) **White precipitate** turns **brown** on standing

$Mn^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Mn(OH)_2(s)$

$4Mn(OH)_2(s) + O_2(g) \longrightarrow 2Mn_2O_3(s) + 4H_2O(l)$

or, $4Mn(OH)_2(s) + O_2(g) \longrightarrow 2Mn_2O_3 \cdot 2H_2O(s)$

or, $2Mn(OH)_2(s) + O_2(g) \longrightarrow 2MnO_2(s) + 2H_2O(l)$

(ii) White precipitate

$Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s)$

Question. Two.

(a) (i) This is the **constant ratio** of the concentrations of a solute between two **immiscible liquid solvents** in the **same container** at a **constant temperature**

(ii) The temperature of the entire system should be constant
The solute should be in the same molecular state in both solvents
The solute should not react with the solvents
The solute should not saturate one of the solvents

(b) (i) A **known mass** of iodine is dissolved in a **known volume** of ether in a separating funnel
A **known volume** of water is added to the separating funnel and the mixture **shaken** for **some time** and **left to settle** at a **fixed temperature**
After settling, a known volume of the ether layer is **pipetted** and titrated against a **standard** solution of **sodium thiosulphate** in presence of **starch indicator.**
The iodine in the ether layer reacts with sodium thiosulphate according to the equation

$I_2(aq) + 2S_2O_3^{2-}(aq) \longrightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

Using the equation; the concentration of iodine in the ether layer is calculated.
The concentration of iodine in the aqueous layer (water) is also calculated by subtracting the concentration of iodine in the ether from the original concentration of iodine taken at the start
The partition coefficient of iodine between ether and water is then obtained from the expression;

Partition coefficient; $K_D = \frac{concentration\ of\ iodine\ in\ ether}{concentration\ of\ iodine\ in\ water}$

Alternatively;
Iodine (any quantity) is introduced into a mixture of ether and water in a **separating funnel.**
The mixture is **shaken** for some time and allowed to **settle** at a **constant temperature**

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At equilibrium, a **known volume** of the ether layer is **pipetted** and titrated against a **standard** solution of **sodium thiosulphate** in presence of **starch indicator.**
The iodine in ether reacts with the sodium thiosulpahte according to the equation

$$I_2(aq) + 2S_2O_3^{2-}(aq) \longrightarrow I^-(aq) + S_4O_6^{2-}(aq)$$

Using the equation, the **concentration of iodine in ether layer is calculated**
The same **procedure is repeated** for the aqueous layer.
The partition coefficient is then obtained from the expression

$$K_D = \frac{concentration\ of\ iodine\ in\ ether}{concentration\ of\ iodine\ in\ water}$$

(iii)
- It is immiscible with water
- It is a good organic solvent
- It is very volatile and hence can be distilled off or recovered after use.
- It is generally **inert** (un reactive) hence cannot react with most of the organic compounds

(c) (i) Let; mass of z extracted by $50cm^3$ of methyl benzene $= xg$
Hence; mass of z remaining in water $= (8 - x)g$
Concentration of z in methyl benzene $= \frac{x}{50}$
Concentration of z in water $= \frac{8-x}{200}$

Thus; $K_D = \frac{concentration\ of\ z\ in\ methyl\ benzene}{concentration\ of\ z\ in\ water}$

$$12 = \frac{x}{50} \times \frac{200}{(8-x)}$$
$$x = 96$$
$$\therefore x = \frac{96}{16} = 6g$$

(ii) Let; mass of z extracted by the first $25cm^3$ portion of methyl benzene be yg
Hence; mass of z remaining in water $= (8 - y)$
Thus; $12 = \frac{y}{25} \times \frac{200}{(8-y)}$
$$20y = 96$$
$$y = 4.8g$$
Mass of z remaining in water after 1st extraction $= 8 - 4.8 = 3.2g$
Let; mass of z extracted by the 2nd $25cm^3$ portion of methyl benzene be wg
Hence; mass of z remaining in water $= (3.2 - w)g$
Thus; $12 = \frac{w}{25} \times \frac{200}{(3.2-w)}$
$$\frac{8w}{(3.2-w)} = 12$$
$$20w = 38.4$$
$$w = 1.92g$$
Therefore; Total mass of z extracted $= 4.8 + 1.92 = 6.72g$

(iii) Smaller successive portions of the same solvent **extract more solute** than one large volume used at once

(d) - Determination of formula of complex ions
- In chromatography.

Question. Three.

(a) (i) Iodine in 2 – iodobutane has a **bigger atomic radius** than chlorine in 2 – chlorobutane. 2-iodobutane therefore has a **higher molecular mass** than 2-chloro butane. Thus, 2-iodo butane molecules are held by **stronger vander waal's forces** than 2-iodo butane and hence **more heat energy** is required to overcome the stronger vander waal's forces in 2-iodo butane than 2-chloro butane.

(ii) Iodine has a **bigger atomic radius** than chlorine and so the carbon-iodine bond in 2-iodo butane is **longer** and hence **weaker** than the carbon-chlorine bond in 2 – chlorobutane . Thus, the iodine atom is **more easily substituted** by the hydroxide ion than the chlorine atom, hence more time is taken by chloride ions to form **insoluble silver chloride** than that taken by the released iodide ions to form silver iodide

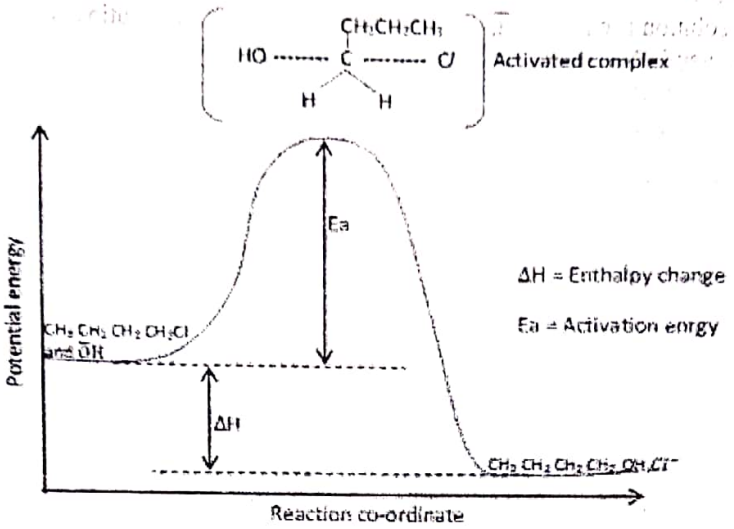
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(b)

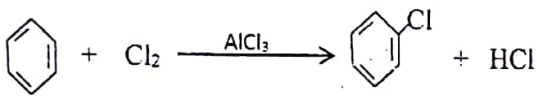
(i) $CH_3CH_2CH_2CH_2Cl \xrightarrow[\text{heat}]{\bar{O}H(aq)} CH_3CH_2CH_2CH_2OH + Cl^-$

(ii) $CH_3CH_2CH_2CH_2Cl + :\bar{O}H \longrightarrow CH_3CH_2CH_2CH_2OH + Cl^-$

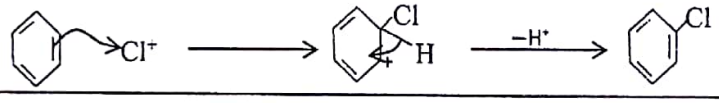
(c)



(d) (i)



(ii) $Cl_2 + AlCl_3 \longrightarrow Cl^+ + AlCl_4^-$



(e)

$CH_3\underset{\displaystyle Br}{\underset{|}{C}}HCH_2CH_3 \xrightarrow[\text{heat}]{\bar{O}H(aq)} CH_3\underset{\displaystyle OH}{\underset{|}{C}}HCH_2CH_3 \xrightarrow[\text{Conc. } H_2SO_4,\ \text{heat}]{MnO_4^-} CH_3\overset{\displaystyle O}{\overset{\|}{C}}CH_2CH_3$

or

$CH_3\underset{\displaystyle Br}{\underset{|}{C}}HCH_2CH_3 \xrightarrow[\text{heat}]{KOH/CH_3CH_2OH} CH_3CH=CHCH_3$

$CH_3CH=CHCH_3 \xrightarrow[2.H_2O/warm]{1.\text{conc. } H_2SO_4} CH_3\underset{\displaystyle OH}{\underset{|}{C}}HCH_2CH_3$

$CH_3\underset{\displaystyle OH}{\underset{|}{C}}HCH_2CH_3 \xrightarrow[\text{heat}]{Cr_2O_7^{2-}/H^+} CH_3\overset{\displaystyle O}{\overset{\|}{C}}CH_2CH_3$

(f) (i) 2, 4-dinitrophenylhydrazine

(ii) Yellow precipitate

(iii) $CH_3CH_2\overset{\displaystyle O}{\overset{\|}{C}}CH_3 + 2,4\text{-}(O_2N)_2C_6H_3NHNH_2 \xrightarrow{H^+} CH_3CH_2C(CH_3)=N-NH-2,4\text{-}(O_2N)_2C_6H_3 + H_2O$

(g) Yellow precipitate

Question. Four.

(a) (i) The enthalpy change (heat change) when a reaction takes place in molar quantities as shown in the equation under standard conditions of 1atm pressure and 298kelvin temperature

(ii) A **known volume, V_1cm^3** of nitric acid of known concentration **M_1** is placed in a plastic container or an insulated calorimeter and its **initial temperature** recorded as **$T_1°C$.**

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A **known volume**, V_2 **cm**^{3} of sodium hydroxide solution of known concentration, M_2 is placed in another container and its initial temperature is recorded as T_2°C
The amount of the alkali must be equal to or more than that of the acid
The alkali is added to the acid and the mixture **stirred** and the **highest** (final) steady temperature, T_3°C is recorded

Assumptions;
Density of solution is equal to **1gcm**$^{-3}$, specific heat capacity of solution is **4.2Jg**$^{-1}$ °C^{-1} heat capacity of container is **negligible**

Treatment of results

Average initial temperature $= \frac{T_1+T_2}{2} = T_0$°C

Temperature change, $\Delta T = (T_3 - T_0)$°C

Mass of solution $= (V_1 + V_2)$g

Heat change $= \left((V_1 + V_2) \times 4.2 \times \Delta T\right) Joules$

Number of moles of nitric acid which reacted $= \left(\frac{V_1}{1000} \times M_1\right)$

Thus; $\left(\frac{M_1V_1}{1000}\right)$ moles of nitric acid liberate $\left((V_1 + V_2) \times 4.2 \times \Delta T\right)$J

Hence; 1mole of nitric acid liberates $\left[\frac{(V_1+V_2)\times4.2\times\Delta T\times1000}{M_1V_1}\right]$J

Therefore, heat of neutralization of nitric acid $= -\left[\frac{(V_1+V_2)\times4.2\times\Delta T}{M_1V_1}\right]$KJ/mol

(ii) Nitric acid is a **strong acid** and sodium hydroxide is a **strong base** and so the only reaction involved is between hydrogen ions and hydroxide ions to form one mole of water in which an enthalpy change that occurs is -57.1KJmol^{-1}

$$H^+(aq) + \bar{O}H(aq) \longrightarrow H_2O(l);\ \Delta H = -57.1 KJmol^{-1}$$

Hydrocyanic acid however, is a **weak acid** and therefore the reaction involves **further ionization** of the weak acid which is **endothermic** ie

$$HCN(aq) \rightleftharpoons H^+(aq) + \bar{C}N(aq),\ \Delta H = +QKJmol^{-1}$$

Hence the overall enthalpy change equal to $57.1+Q = -12 KJmol^{-1}$

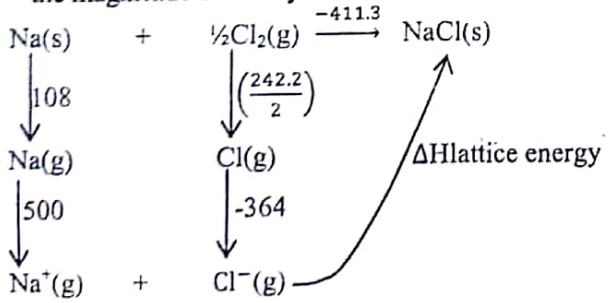
(b) - Ionic radius
When the ionic radius is **small**, the force of attraction of ions for water molecules is **strong** and the hydration energy is therefore **high**
- Ionic charge
When the ionic charge is **high**, ther force of attraction of the ions for water molecules is **strong** and therefore the hydration energy is **high**.

(c) (i) For; LiCl; ΔHsolution = ΔHlattice energy + ΔHhydration energy
$= +718 + (-695) = +23 KJmol^{-1}$

For; KCl; ΔHsolution = ΔHlattice energy + ΔHhydration energy
$= +862 + (-883) = -21 KJmol^{-1}$

(ii) Potassium chloride is **more soluble** in water because its **enthalpy of solution is exothermic** or because the magnitude of the hydration is more than the lattice energy.

(d)



From Hess's law;
$-411.3 = 108 + 500 + (½ \times 242.2) + -364 + \Delta H$lattice energy
ΔHlattice energy $= -776.4 KJ$

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Question. Five.

(a) (i) **Heated** carbon reacts with **steam** to form **carbon monoxide** and **hydrogen**

$C(s) + H_2O(g) \longrightarrow CO(g) + H_2(g)$

Heated silicon reacts with **steam** to form **silicon (IV) oxide** and **hydrogen**

$Si(s) + 2H_2O(g) \longrightarrow SiO_2(s) + H_2(g)$

Heated tin reacts with **steam** to form **tin(iv)oxide** and **hydrogen gas**

$Sn(s) + 2H_2O(g) \longrightarrow SnO_2(s) + 2H_2(g)$

Lead reacts with **soft water** in the presence of **oxygen** (or air) to form **lead (II) hydroxide**

$2Pb(s) + 2H_2O(l) + O_2(g) \longrightarrow 2Pb(OH)_2(s)$

(ii) Carbon **doesnot** react with sodium hydroxide solution

Silicon reacts with **hot concentrated** sodium hydroxide solution to form **sodium silicate** and **hydrogen.**

$Si(s) + 2NaOH(aq) + H_2O(l) \longrightarrow Na_2SiO_3(aq) + 2H_2(g)$

or $Si(s) + 2\bar{O}H(aq) + H_2O(l) \longrightarrow SiO_3^{2-}(aq) + 2H_2(g)$

Tin reacts with **hot concentrated** sodium hydroxide solution to form **sodium stannate (IV)** and **hydrogen**

$Sn(s) + 2NaOH(aq) + 2H_2O(l) \longrightarrow Na_2Sn(OH)_4(aq) + H_2(g)$

or $Sn(s) + 2\bar{O}H(aq) + 2H_2O(l) \longrightarrow Sn(OH)_4^{2-}(aq) + H_2(g)$

or $Sn(s) + 2\bar{O}H(aq) + 4H_2O(l) \longrightarrow Sn(OH)_6^{2-}(aq) + 2H_2(g)$

or $Sn(s) + 2\bar{O}H(aq) + H_2O(l) \longrightarrow SnO_3^{-}(aq) + 2H_2(g)$

lead reacts with **hot concentrated** sodium hydroxide solution to form **sodium plumbate (II)** and **hydrogen**

$Pb(s) + 2NaOH(aq) + 4H_2O(l) \longrightarrow Na_2Pb(OH)_6(aq) + 2H_2(g)$

or $Pb(s) + 2\bar{O}H(aq) + 4H_2O(l) \longrightarrow Pb(OH)_6^{2-}(aq) + 2H_2(g)$

or $Pb(s) + 2\bar{O}H(aq) + 2H_2O(l) \longrightarrow Pb(OH)_4^{2-}(aq) + H_2(g)$

or $Pb(s) + 2\bar{O}H(aq) \longrightarrow PbO_2^{2-} + H_2(g)$

(iii) Carbon reacts with **hot concentrated** sulphuric acid to form **carbon dioxide, sulphur dioxide** and **water.**

$C(s) + 2H_2SO_4(aq) \longrightarrow CO_2(g) + 2SO_2(g) + 2H_2O(l)$

Tin reacts with **hot concentrated** sulphuric acid to form **Tin (IV) sulphate, sulphur dioxide** and **water**

$Sn(s) + 4H_2SO_4(aq) \longrightarrow Sn(SO_4)_2(aq) + 2SO_2(g) + 4H_2O(l)$

Lead reacts with **hot concentrated** sulphuric acid to form **lead (II) sulphate, sulphur dioxide** and **water**

$Pb(s) + 2H_2SO_4(aq) \longrightarrow PbSO_4(s) + SO_2(g) + 2H_2O(l)$

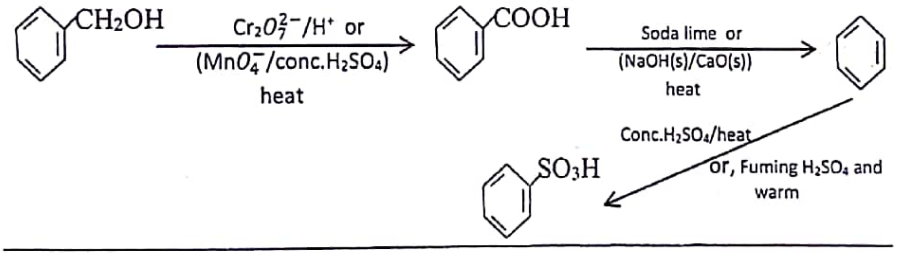
(b) **Brown solid dissolved** with **effervescence of a greenish yellow gas** to form a **colourless solution**

$PbO_2(s) + 6HCl(aq) \longrightarrow PbCl_4^{2-}(aq) + 2H_2O(l) + Cl_2(g) + 2H^+(aq)$

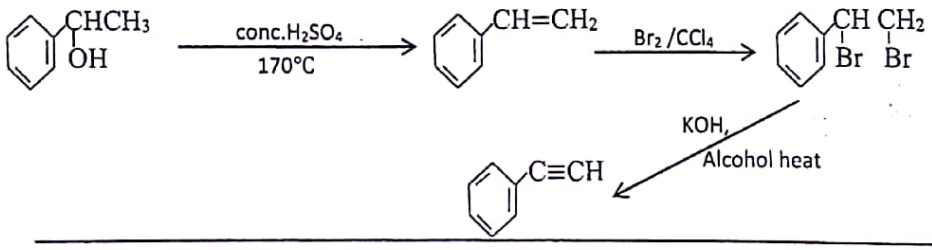
or $PbO_2(s) + 6HCl(aq) \longrightarrow H_2PbCl_4(aq) + 2H_2O(l) + Cl_2(g)$

Question. Six.

(a)



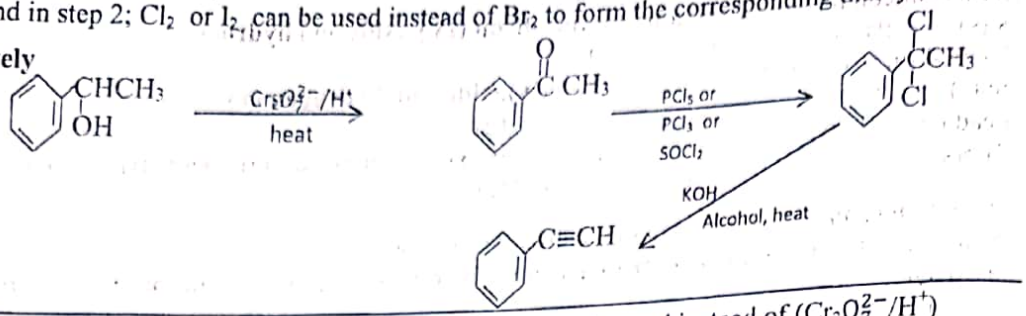
(b)



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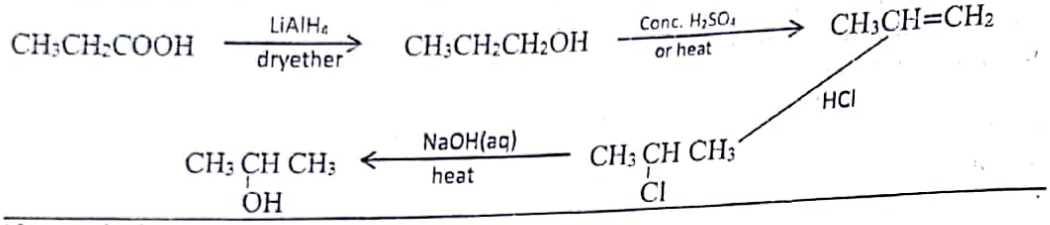
Note; In step 1; (conc. H_3PO_4/heat) or (Al_2O_3/heat) or (Al_2O_3/300 – 350°C) can be used instead of (conc. H_2SO_4, 170°C)
And in step 2; Cl_2 or I_2 can be used instead of Br_2 to form the corresponding dialkyl halide.

Alternatively

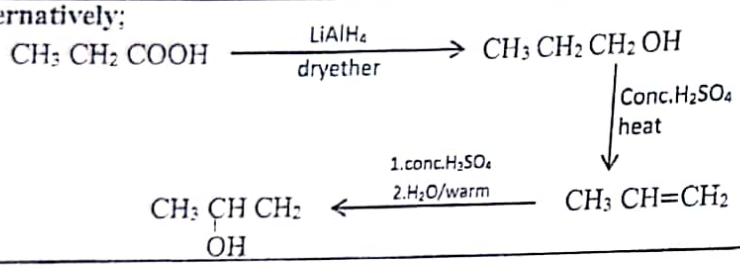


Note: in step 1: (CrO_3/H^+) or MnO_2 or (Cu /Ag) can be used instead of ($Cr_2O_7^{2-}/H^+$)

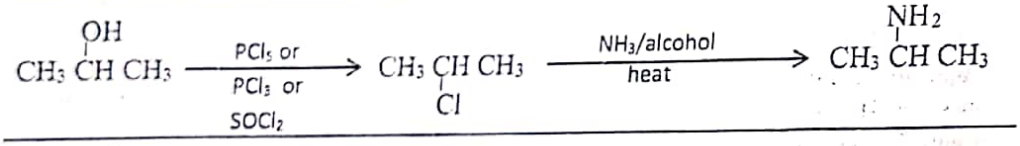
(c)



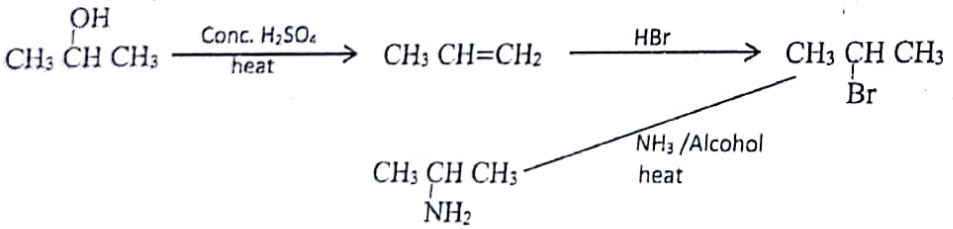
Alternatively;



(d)

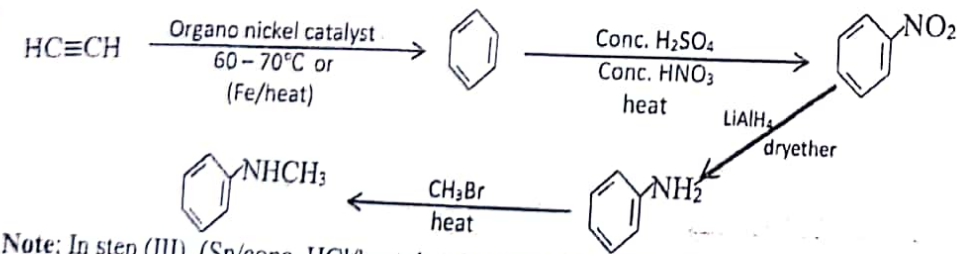


Alternatively;



Note; In step 2; of the last alternative answer; HCl or HI can be used instead of HBr to form the corresponding alkyl halide

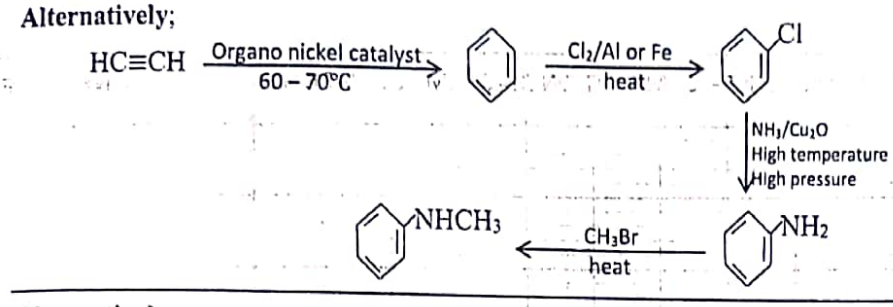
(e)



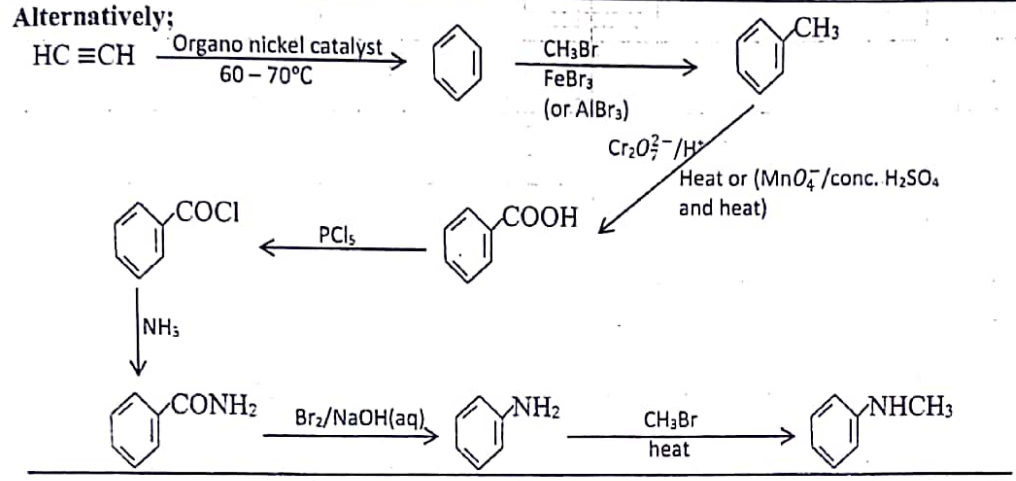
Note; In step (III) (Sn/conc. HCl/heat then NaOH(aq)) or (Fe/dilute HCl and then Na_2CO_3) can be used instead of ($LiAlH_4$/dry ether)

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Alternatively;



Alternatively;



Question. Seven.

(a) A solid mixture which melts at constant temperature to form a liquid of the same composition.
or A liquid mixture which freezes or solidifies at constant temperature without change in composition.

(b) -Mixture of various compositions of solid naphthalene and biphenyl are **prepared**.
-Each mixture is **heated separately** until it melts.
-Each mixture is **allowed to cool** while **stirring** and the **constant temperature** at which it freezes recorded.
-The **melting points** of pure naphthalene and pure biphenyl are **determined in the same way**
-A graph of melting points **against composition is plotted** and the phase diagram drawn.

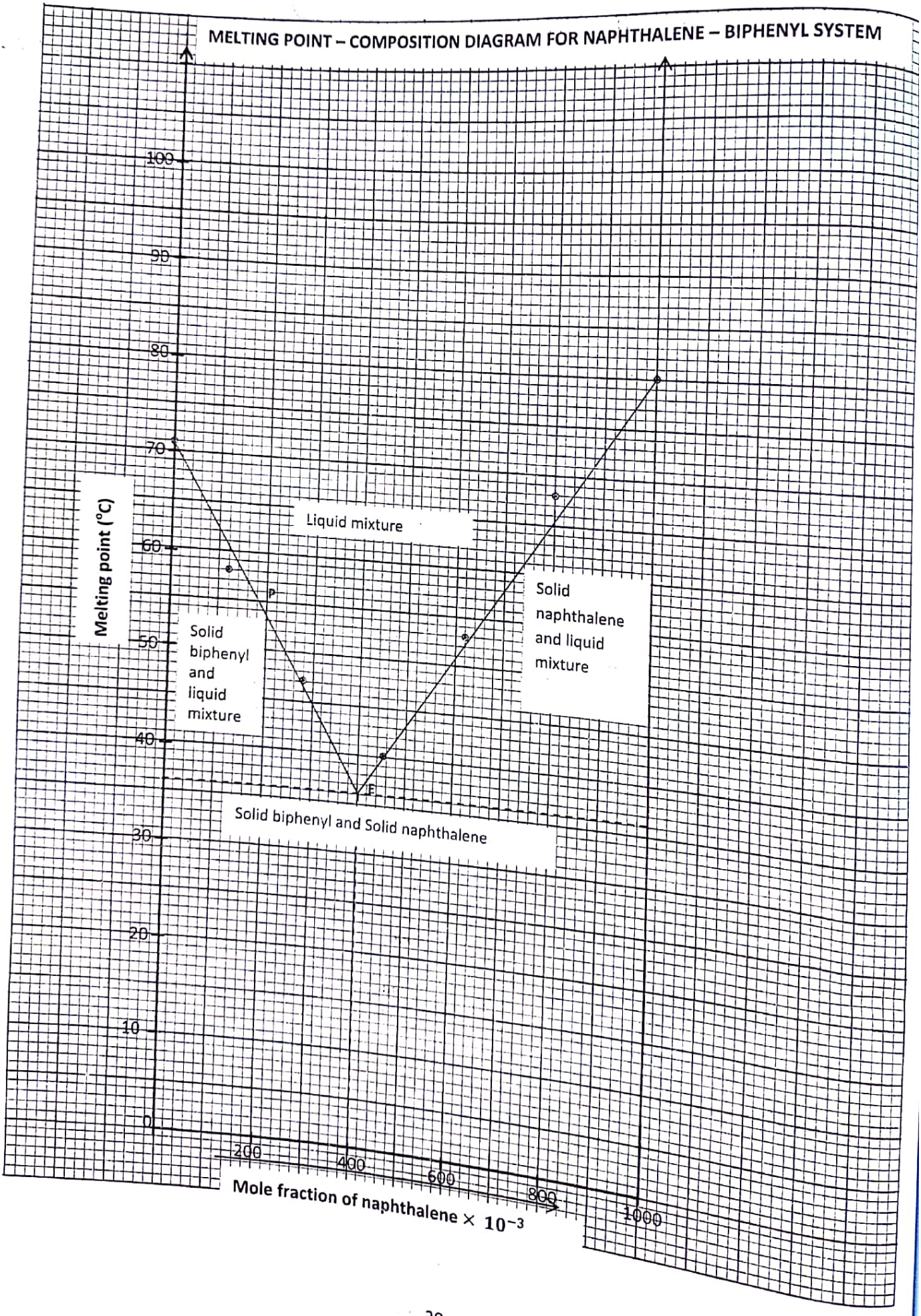
(c) (i) See graph on the next page

(ii) Eutectic temperature = 36°C
Eutectric composition = 0.4

(d) From 85°C, the mixture **cools** to **53°C** (point P) **without change in phase and composition**
At point P, biphenyl **begins to solidify** as the composition or mole fraction of naphthalene **increases** in the liquid mixture.
The melting point or freezing point of biphenyl **decreases** up to the **eutectric point (E)** as further cooling is done.
At the eutectic point, the **temperature** and **composition remain constant** until the whole **system solidifies** and then the solid mixture cools with **no change in phase** and composition up to 30°C.

(e) The melting point of naphthalene reduces up to the eutectic point
At the eutectic point, the melting point is constant and further addition of biphenyl **increases** the melting point towards that of pure biphenyl.

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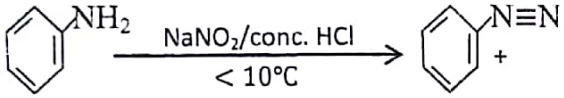
Question. Eight.

(a) The oxygen atom in water has a **small atomic radius** and **high electro negativity** compared to the sulphur atom in hydrogen sulphide. The oxygen-hydrogen bond in water is **strongly polar** whereas the sulphur-hydrogen bond in hydrogen sulphide is not.
Water molecules, therefore, are held together by **hydrogen bonds** whereas hydrogen sulphide molecules are held by **vander waal's forces** which are **weaker** than hydrogen bonds and require **less heat energy** to be broken, hence water has a higher boiling point than hydrogen sulphide.

(b) Ethylamine reacts with a **cold** solution of sodium nitrite and concentrated hydrochloric acid (nitrous acid) to form ethanol and **nitrogen**

$$CH_3CH_2NH_2 \xrightarrow[< 10°C]{NaNO_2/conc.\ HCl} CH_3CH_2OH + N_2$$

Phenyl amine reacts with a **cold** solution of sodium nitrite and concentrated hydrochloric acid (nitrous acid) at temperature below 10°C to form a benzene diazonium salt which is **very soluble**



(c) Hydrazine **reduces** acidified manganate (VII) ions to **manganese (II) ions** and the hydrazine its self oxidized to **nitrogen**

$$\left[\begin{array}{l} NH_2NH_2(g) \longrightarrow N_2(g) + 4H^+ + 4e \\ MnO_4^-(aq) + 8H^+(aq) + 5e \longrightarrow Mn^{2+}(aq) + 4H_2O(l) \end{array}\right]$$

or $4MnO_4^-(aq) + 5NH_2NH_2(g) + 12H^+(aq) \longrightarrow 4Mn^{2+}(aq) + 16H_2(g) + 5N_2(g)$

(d) Chlorine **oxidizes** excess sodium thio sulphate solution to **sulphate ions** with formation of **sulphur**

$$\left[\begin{array}{l} Cl_2(g) + 2e \longrightarrow 2Cl^-(aq) \\ S_2O_3^{2-}(aq) + H_2O(l) \longrightarrow SO_4^{2-}(aq) + S(s) + 2H^+(aq) + 2e \end{array}\right]$$

or $Cl_2(g) + S_2O_3^{2-}(aq) + H_2O(l) \longrightarrow SO_4^{2-}(aq) + S(s) + 2H^+(aq) + 2Cl^-(aq)$

Alternatively:

Chlorine reacts with water to form **hydrochloric acid and hydrochlorous acid** (an acidic solution)

$$Cl_2(g) + H_2O(l) \rightleftharpoons HCl(aq) + HOCl(aq)$$

Sodium thio sulphate dispropotionates in the **acidic** solution to form **sulphur**

$$S_2O_3^{2-}(aq) + 2H^+(aq) \longrightarrow SO_2(g) + H_2O(l) + S(s)$$

QUESTIONS TO 'A'LEVEL CHEMISTRY; PAPER 1(P525/1), 2018

1. Various concentrations of **X** and **Y** were reacted at a constant temperature. The table below shows the initial concentrations of **X** and **Y** and their initial rates for the reaction.

Experiment	[X] (mol dm^{-3})	[Y] (mol dm^{-3})	Initial rate (mol s^{-3})
1	0.2	0.2	3.5×10^{-4}
2	0.4	0.4	1.4×10^{-3}
3	0.8	0.4	5.6×10^{-3}

(a) State the order of reaction with respect to **X** and **Y**.
(i) **X** (½ mark) (ii) **Y** (½ mark)
(b) Give reasons for your answers in (a) (02 marks)
(c) Determine the overall order of the reaction. (½ mark)
(d) Calculate the value for the rate constant for the reaction. (1½ marks)

2. (a) A solid **Q** contains 9.37% by mass of magnesium, 10.39% nitrogen and 42.18% water.
(i) Calculate the empirical formula of **Q.** (02 marks)
Determine the molecular formula of **Q**. (*RFM of Q = 256*) (1 mark)
(b) Solution of Q reacts with iron (II) sulphate in the presence of concentrated sulphuric acid to form a brown ring. Identify Q. (½ marks)
(c) Write equation for the reaction that would take place is Q was heated (1½ marks)

3. Name a reagent that can be used to distinguish between the following pairs of compounds.

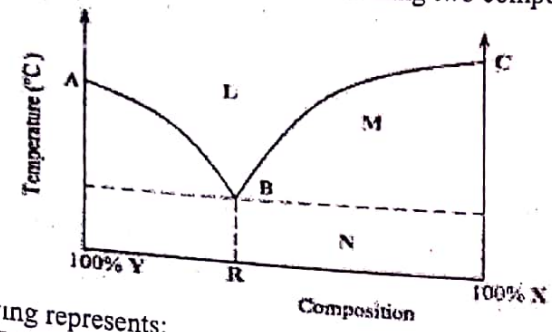
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In each case, state what would be observed if each member of the pair was treated with the reagent you have named.

(a) $CH_3 - \underset{CH_3}{CH}\ C \equiv C\ CH_3$ and $CH_3\ CH_2\ \underset{CH_3}{CH}\ C \equiv CH$

(b)  and $CH_3\ CHO$

4. The temperature –composition diagram for a system containing two components **X** and **Y** is shown below.



(a) State what the following represents:
(i) Regions: **L, M** and **N** (1½ marks)
(ii) Points: **A, B** and **C** (1½ marks)
(iii) Curves: **AB** and **BC** (1 mark)
(b) State what would happen when a mixture of composition **R** is heated. (½ mark)

5. Write equation for the reaction between aqueous sodium hydroxide and
(a) chromium (III) oxide (1½ marks) (b) beryllium oxide (1½ marks) (c)tin (II) oxide(1½ marks)

6. Complete the following equations and in each case, write a mechanism for the reaction.

(a) $(CH_3)_2\ C = CH\ CH_3 \xrightarrow{HBr}$

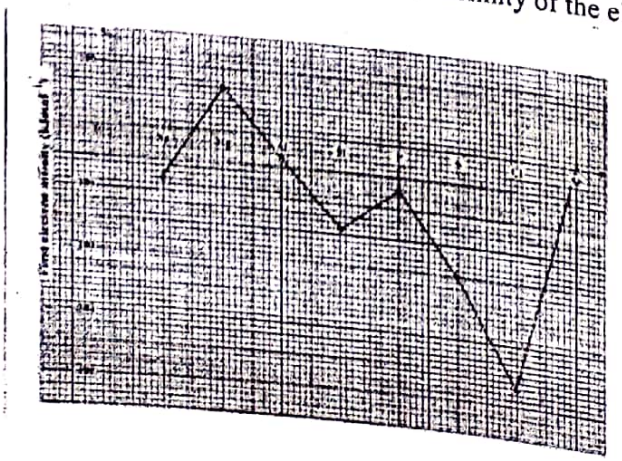
(b)  $+\ CH_3\ CH_2 - \overset{O}{\overset{\|}{C}} - Cl \xrightarrow[50°C]{AlCl_3}$ (2½ marks)

7. When a current of 0.65 A was passed through copper (II) sulphate solution using platinum electrodes for 35 minutes, 0.0143g of hydrogen and 0.113g of oxygen were evolved. (2½ marks)
(a) Write equation for the reaction that took place at the
(i) anode. (1 mark) (ii) cathode. (1 mark)
(b) Determine the quantity of electricity required to evolve 1 mole of gas at each electrode. At the
(i) anode. (2 marks) (ii) At the cathode. (1 mark)

8. State what would be observed and write equation for the reaction that would take place when:
(a) Excess concentrated hydrochloric acid was added to lead (II) oxide.
(b) Potassium iodide was added to copper (II) sulphate solution.

9. Write equation in each case to show how the following conversions can be effected:
(a)  from benzene. (2½ marks)
(b) $CH_3\ CONH_2$ from chloroethane (2½ marks)

10. The figure below shows the variation of the first electron affinity of the elements in Period 3 of the Periodic Table. (2½ marks)



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Explain each of the following observations:

(i) There is a general increase in the first electron affinity from sodium to argon (1½ marks)

(ii) The first electron affinity of magnesium is higher than that of aluminium. (4 marks)

(iii) The first electron affinity of phosphorous is less than that of sulphur. (3½ marks)

11. (a) Silver chloride dissolves in water according to the following equation

$AgCl(s) \rightleftharpoons Ag^{+}(aq) + Cl^{-}(aq)$

Write the expression for the solubility product, Ksp of silver chloride. (1 mark)

(b) The electrolytic conductivity of a saturated solution of silver chloride in water at 25the electrolytic conductivity of a saturated solution of silver chloride in water at 25°C is $3.41 \times 10^{-6}\Omega^{-1}cm^{-1}$ and that of pure water is $1.6 \times 10^{-6}\Omega^{-1}cm^{-1}$. Calculate the solubility product of a saturated solution of silver chloride at 25°C.

(The molar conductivities at infinite at infinite dilution of silver nitrate, potassium nitrate and potassium chloride are 133.4, 145.0 and 149.9 $\Omega^{-1}cm^{-1}$ respectively at 25 (4½ marks)

(c) Ammonia solution was added to a solution containing silver chloride.

(i) State how the solubility of silver chloride was affected (1 mark)

(ii) Explain your answer in (c) (i) above. (2½ marks)

12. Compound **T** C_3H_6O reacts with 2, 4-dinitrophenylhydrazine to form a yellow precipitate.

(a) Write the names and the structural formulae of all possible isomers of **T**. (3 marks)

(b) **T** reacts with ammoniacal silver nitrate solution to form silver. Identify **T** (1 mark)

(c) Write equation and indicate a mechanism for the reaction between **T** and 2, 4-dinitrophenylhydrazine under acidic condition. (5 marks)

13. Manganese is a d-block element in the Periodic Table.

(a) Define the term **d-block element**. (1 mark)

(b) (i) Write the electronic configuration of manganese. (½ mark)

(ii) State the common oxidation states exhibited by manganese in its compounds. (1½ marks)

(iii) Write the formulae of oxides of manganese in each of the oxidation states you have stated in (b)(ii) (1½ marks)

(c) A black oxide, Y of manganese was fused with a mixture of potassium hydroxide and potassium nitrate to give a compound which when treated with water gave a green solution.
The green solution turned purple when acidified with sulphuric acid Identify:

(i) Y (1 mark)

(ii) the ion that gives the green solution its colour (1 mark)

(iii) the ion that gives the purple solution its colour (1 mark)

(d) Write ionic equation for the reaction leading to the formation of the purple solution. (1½ marks)

14. (a) (i) Sketch a graph to show the pH change when hydrochloric acid is titrated with ammonia solution. (1½ marks)

(ii) Explain the shape of your sketch graph in (a) (i) (3½ marks)

(b) Calculate the pH of a resultant solution formed when $10cm^3$ of a 0.1M sodium hydroxide solution is added to $25cm^3$ of a 0.1M ethanoic acid at 25°C.
(*Dissociation constant of ethanoic acid at* 25°C $= 1.8 \times 10^{-5} moldm^{-3}$) (4 marks)

15. (a) Beryllium, magnesium, calcium and barium are some of the elements that belong to Group II of the Periodic Table.
State how the elements react with sulphuric acid and give the conditions for the reactions. (3 marks)

(b) (i) State how the solubilities of the sulphates of Group II elements vary down the group. (1 mark)

(ii) Explain your answer in (b) (i) (2 marks)

(c) Write equation for the reaction of:

(i) beryllium with sodium hydroxide solution (1½ marks)

(ii) calcium carbide with water. (1½ marks)

16. In the manufacture of ammonia, nitrogen is catalytically hydrogenated to give ammonia according to the following equation.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g); \quad \Delta H = 92.5kJ$

(a) (i) Name the catalyst used in the reaction (½ mark)

(ii) Write the expression for the equilibrium constant, Kp for the reaction. (1 mark)

(b) State what would happen to the position of the equilibrium if:

(i) pressure was increased (1 mark)

(ii) temperature was increased (1 mark)

(c) When 3 moles of hydrogen and 1 mole of nitrogen were mixed and allowed to attain equilibrium at 100 atms and 400°C, the equilibrium mixture contained 25% of ammonia by volume.
Calculate the:

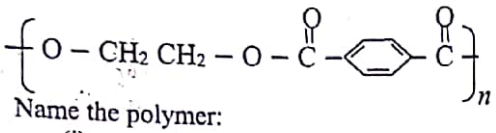
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(i) number of moles of nitrogen and hydrogen at equilibrium. (3 marks)
(ii) value of the equilibrium constant, Kp at 400°C. (2½ marks)

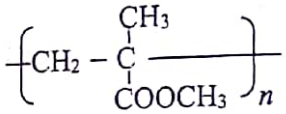
17. (a) Differentiate between **addition** and **condensation** polymers. (2 marks)

(b) The structural formulae of two polymers **R** and **T** are shown below.

R



T



Name the polymer:

(i) **R** (1 mark)

(ii) **T** (1 mark)

(c) Write the structural formula(e) of monomers(s) of the polymers R and T respectively. (3 marks)

(d) Give one use of:

(i) **R** (1 mark)

(ii) **T** (1 mark)

END

SOLUTIONS TO 'A'LEVEL CHEMISTRY; PAPER 1(P525/1), 2018

1. (a) (i) Second order

(ii) Zero order

(b) **Doubling** the concentration of X while keeping the concentration of Y **constant,** the **rate of reaction increases by four times**. This indicates that the reaction is second order with respect to X.
Doubling both the concentration of X and Y, the rate of reaction **increases by four times,** an indication that the reaction is **zero order** with respect to Y.

Alternatively

The reason could be given by calculation as follows

Order of reaction with respect to X

Considering experiments 2 and 3

$$\left(\frac{0.8}{0.4}\right)^{X} = \left(\frac{5.6\times10^{-3}}{1.4\times10^{-3}}\right)$$

$$2^{X} = 4$$

$$2^{X} = 2^{2}$$

$$Hence\ X = 2(2^{nd}\ \text{order})$$

Order of reaction with respect to Y

Considering experiments 1 and 2

$$\left(\frac{0.4}{0.2}\right)^{Y} \times \left(\frac{0.4}{0.2}\right)^{X} = \left(\frac{1.4\times10^{-3}}{3.5\times10^{-4}}\right)$$

$$\left(\frac{0.4}{0.2}\right)^{Y} \times \left(\frac{0.4}{0.2}\right)^{2} = \left(\frac{1.4\times10^{-3}}{3.5\times10^{-4}}\right)$$

$$2^{Y} \times 4 = 4$$

$$2^{Y} = 1$$

$$\therefore Y = 0\ \text{(zero order)}$$

(c) Overall order of reaction $= 2 + 0 = 2$

(d) Since; $Rate = K[X]^2[Y]^0$

Thus; $Rate\ constant; K = \frac{Rate\ of\ reaction}{[X]^2}$

$$= \frac{3.5\times10^{-4}}{(0.2)^2}\ \text{(Considering experiment 1)}$$

$$= 8.75 \times 10^{-3}$$

2.

Composition of Q;

	Mg	N	O	H_2O
Moles;	$\frac{9.37}{24}$	$\frac{10.39}{14}$	$\frac{38.06}{16}$	$\frac{42.18}{18}$
	0.39	0.781	2.38	2.34
Mole ratio;	$\frac{0.39}{0.39}$	$\frac{0.781}{0.39}$	$\frac{2.38}{0.39}$	$\frac{2.34}{0.39}$
	1 :	2 :	6 :	6

24

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Emperical formula of Q is $MgN_2O_6(H_2O)_6$

(ii) $(MgN_2O_6(H_2O)_6)n = 256$

$24n + (2 \times 14)n + (6 \times 16)n + (6 \times 18)n = 256$

$\therefore n = 1$

Thus; molecular formula of Q is $MgN_2O_6(H_2O)_6$ or $MgN_2O_6 \cdot 6H_2O$

(b) $Mg(NO_3)_2 \cdot 6H_2O$ or magnesium nitrate hexahydrate.

(c) $2Mg(NO_3)_2 \cdot 6H_2O(s) \longrightarrow 2MgO(s) + 4NO_2(g) + O_2(g) + 12H_2O(l)$

3. (a) Reagent - Ammoniacal silver nitrate solution

Observation; $CH_3 - \underset{\underset{CH_3}{|}}{CH}\ C \equiv C\ CH_3$ No observable change

$CH_3\ CH_2\ \underset{\underset{CH_3}{|}}{CH}\ C \equiv CH$ forms a **white precipitate**

Alternatively;

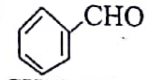
Reagent – Ammoniacal copper (I) chloride solution

Observation; $CH_3 - \underset{\underset{CH_3}{|}}{CH}\ C \equiv C\ CH_3$ No observation change

$CH_3\ CH_2\ \underset{\underset{CH_3}{|}}{CH}\ C \equiv CH$ forms a **red precipitate**

(b) Reagent – **Aqueous** iodine and sodium hydroxide **solution**

Observation



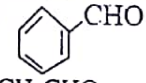
CH_3CHO - no observable change

- gives a pale yellow precipitate

Alternatively;

Reagent – Fehlings solution

Observation



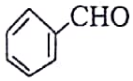
- no observable change

CH_3CHO - forms a reddish brown precipitate

Alternatively;

Reagent – Ammoniacal silver nitrate solution

Observation



- no observable change

CH_3CHO - gives a silver mirror

Note; Fehlings solution is a solution of copper (II) sulphate, sodium hydroxide and potassium tastrate.

4. (a) (i) L liquid mixture

M Solid X and liquid mixture

N Solid X and solid Y

(ii) A melting point of pure Y or freezing point of pure Y

B Eutectic point

C melting point of pure X or freezing point of pure X

(iii) AB variation of freezing point (or melting point) of Y as X is added.

BC variation of freezing point (or melting point) of X as Y is added

(b) The solid mixture **melts** at B to form a liquid mixture of the **same composition**

5. (a) $Cr_2O_3(s) + 6\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Cr(OH)_6^{3-}(aq)$

or $Cr_2O_3(s) + 2\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Cr(OH)_4^{-}(aq)$

or $Cr_2O_3(s) + 2\bar{O}H(aq) \longrightarrow 2CrO_2^{-}(aq) + H_2O(l)$

or $Cr_2O_3(s) + 6NaOH(aq) + 3H_2O(l) \longrightarrow 2Na_3Cr(OH)_6(aq)$

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or $Cr_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \longrightarrow 2NaCr(OH)_4(aq)$

or $Cr_2O_3(s) + 2NaOH(aq) \longrightarrow 2NaCrO_2(aq) + H_2O(l)$

(b) $BeO(s) + 2NaOH(aq) + H_2O(l) \longrightarrow Na_2Be(OH)_4(aq)$

or $BeO(s) + 2\bar{O}H(aq) + H_2O(l) \longrightarrow Be(OH)_4^{2-}(aq)$

or $BeO(s) + 2\bar{O}H(aq) \longrightarrow BeO_2^{2-}(aq) + H_2O(l)$

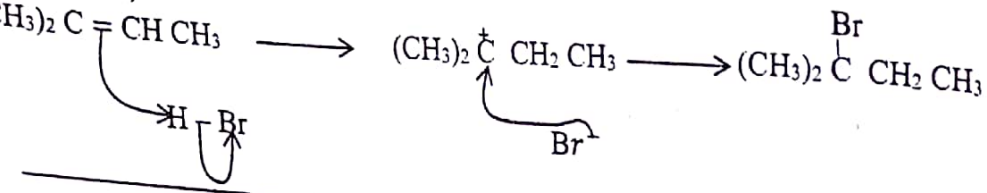
or $BeO(s) + 2NaOH(aq) \longrightarrow Na_2BeO_2(aq) + H_2O(l)$

(c) $SnO(s) + 2NaOH(aq) + H_2O(l) \longrightarrow Na_2Sn(OH)_4(aq)$

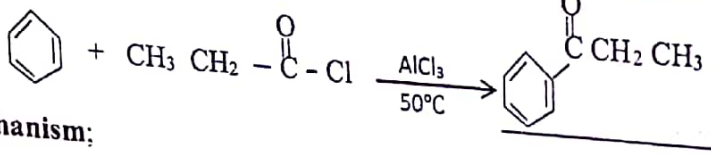
or $SnO(s) + 2\bar{O}H(aq) + H_2O(l) \longrightarrow Sn(OH)_4^{2-}(aq)$

6. (a) $(CH_3)_2C = CHCH_3 \xrightarrow{HBr} (CH_3)_2\underset{Br}{C}CH_2CH_3$

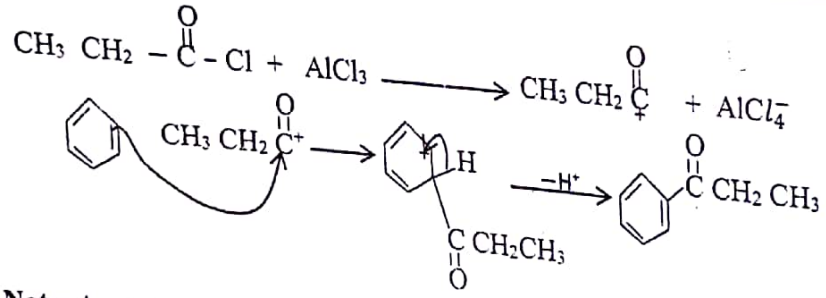
Mechanism;



(b)



Mechanism;



Note; A candidate would also begin the above mechanism as;

7. (a) (i) $4\bar{O}H(aq) \longrightarrow 2H_2O(l) + O_2(g) + 4e$

$CH_3CH_2\overset{O}{\overset{\|}{C}}-Cl + AlCl_3 \longrightarrow CH_3CH_2\overset{O}{\overset{\|}{C}}_{\delta+}\cdots\cdots AlCl_4^{\delta-}$

(ii) $Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$

(b) (i) Quantity of electricity $= current(amperes) \times Time(seconds)$

$= 0.65 \times 35 \times 60 = 1365\ coloumbs$

Rmm of $O_2 = 2 \times 16 = 32$

Number of moles of oxygen in $0.113g = \frac{0.113}{32} = 3.53 \times 10^{-3} moles$

Thus; $3.53 \times 10^{-3} moles\ of\ O_2 is\ evolved\ by\ 1365\ coloumbs$

$\therefore 1 mole\ of\ O_2 is\ evolved\ by\ \frac{1365}{3.53\times10^{-3}} = \mathbf{386685 coloumbs}$

(ii) Reaction leading to formation of gas at cathode;

$2H^+(aq) + 2e \longrightarrow H_2(g)$

Moles of hydrogen evolved $= \frac{0.0143}{2} = 7.15 \times 10^{-3} moles$

$7.15 \times 10^{-3} moles\ of\ H_2\ are\ evolved\ by\ 1365 coloumbs$

$\therefore 1 mole\ of\ H_2\ is\ evolved\ by\ \frac{1365}{7.15\times10^{-3}} = \mathbf{1090909\ coloumbs}$

8. (a) **The yellow solid dissolves** forming a **colourless solution**

$PbO(s) + 4HCl(aq) \longrightarrow H_2PbCl_4(aq) + H_2O(l)$

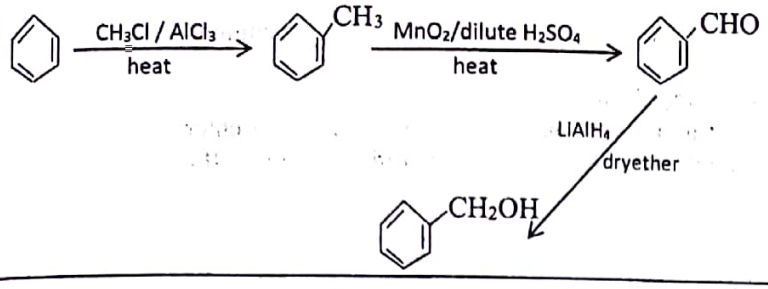
or, $PbO(s) + 2H^+(aq) + 4Cl^-(aq) \longrightarrow PbCl_4^{2-}(aq) + H_2O(l)$

(b) **Blue solution** turns **brown** and a **white precipitate** forms.

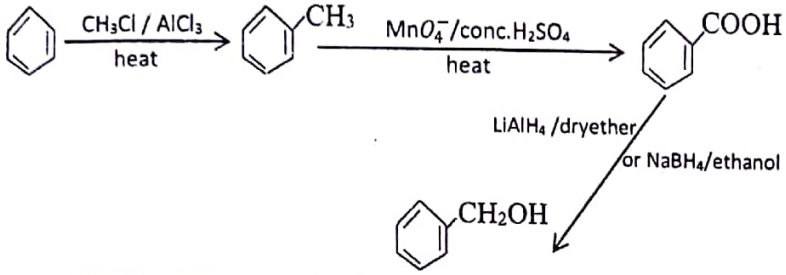
$2Cu^{2+}(aq) + 4I^-(aq) \longrightarrow Cu_2I_2(s) + I_2(aq)$

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9. (a)



Alternatively;



(b) $CH_3CH_2Cl \xrightarrow[heat]{NaOH(aq)} CH_3CH_2OH \xrightarrow[heat]{Cr_2O_7^{2-}/H^+} CH_3COOH \xrightarrow[heat]{(NH_4)_2CO_3} CH_3CONH_2$

10. (a) (i) From Sodium to argon, **atomic radius decreases, nuclear charge increases** and hence **effective nuclear charge increases** and as a result the **attraction** for the incoming electron **increases** and thus **electron affinity increases**.

(ii) Mg – $1s^2\ 2s^2\ 2p^6\ 3s^2$ and Al – $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

In magnesium, the electron is added to the **3s–subshell** which is **completely filled** with electrons and thus **energetically stable**.

The incoming electron, therefore, experiences greater repulsion from the outer two electrons than nuclear attraction. In aluminium the 3p-sub energy level has one electron and hence **incompletely filled** with electrons and thus **energetically unstable**, therefore the added electron experiences more attraction from the nucleus than repulsion.

(iii) P; $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$ S; $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

In phosphorus, the electron is added to a **half filled 3p-subshell** which is **energetically stable**. The incoming electron therefore experiences greater repulsion than attraction from the nucleus hence a lower electron affinity.

In sulphur, the electron is added to the **3p subenergy level with four electrons** and hence is **energetically unstable**.

Therefore the incoming electron experiences **more nuclear attraction than repulsion** hence higher electron affinity.

11. (a) $Ksp = [Ag^+][Cl^-]$

(b) From, Kohrausch's law;

$$\Lambda_o(AgCl) = \Lambda_o(AgNO_3) + \Lambda_o(KCl) - \Lambda_o(KNO_3)$$
$$= 133.4 + 149.9 - 145.0$$
$$= 138.3\Omega^{-1}cm^2mol^{-1}$$

Electrolytic conductivity of AgCl; $K(AgCl) = Ksolution - Kwater$

$$= 3.41 \times 10^{-6} - 1.6 \times 10^{-6} = \mathbf{1.81 \times 10^{-6}\Omega^{-1}cm^{-1}}$$

$$[AgCl] \text{ or } C = \frac{1000K}{\Lambda_o} = \frac{1.81\times10^{-6}\times1000}{138.3}$$
$$= 1.31 \times 10^{-5} moldm^{-3}$$
$$Ksp = (1.31 \times 10^{-5})^2 = \mathbf{1.72 \times 10^{-10} mol^2dm^{-6}}$$

(c) (i) Solubility increases

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(ii) Ammonia reacts with silver ions to form a **siuble complex ion** of diammine silver (I) ion. i.e

$Ag^+(aq) + 2NH_3(aq) \longrightarrow Ag(NH_3)_2^+(aq)$

This **lowers the concentration of silver ions** in solution. More silver chloride **dissolves** in order to restore the **equilibrium position and to maintain the value of equilibrium constant.**

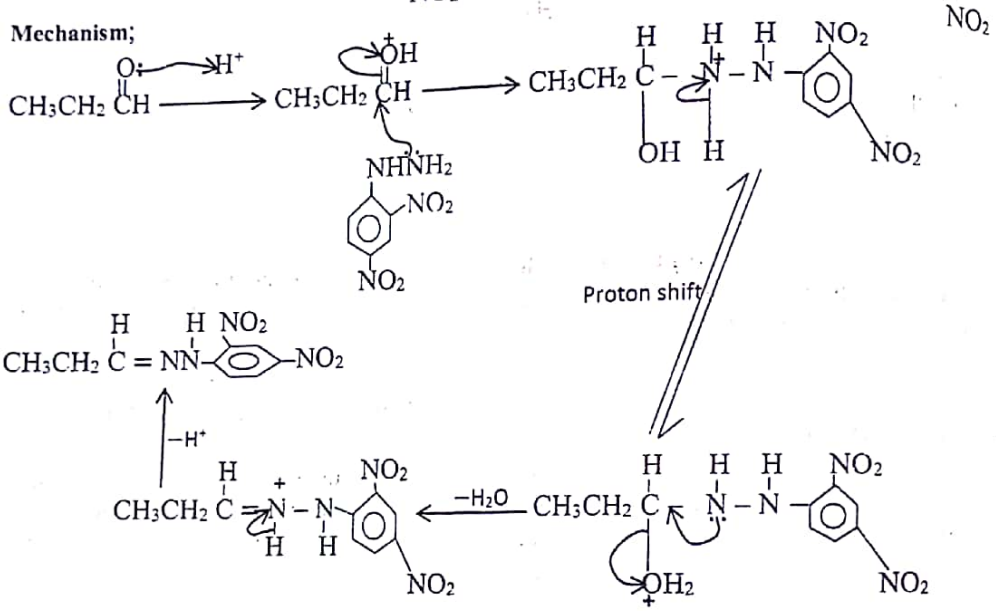
12. (a) $CH_3C(=O)CH_3$ Propanone

CH_3CH_2CHO Propanal

(b) $CH_3CH_2C(=O)H$ or Propanal

(c) $CH_3CH_2C(=O)H + O_2N(C_6H_3)NHNH_2(NO_2) \xrightarrow{H^+} CH_3CH_2C(H)=NNH(C_6H_3)(NO_2)_2$

Mechanism;



13. (a) An element in which the outer most electrons are found in the d-subenergy level

(b) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$ or $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$

(ii) +2, +4 and +7

(iii) MnO, MnO_2 and Mn_2O_7

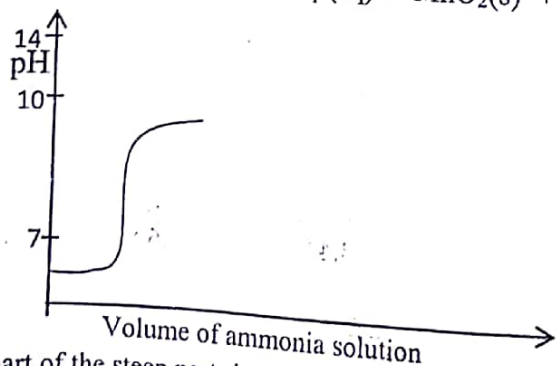
(c) (i) Manganese (IV) oxide or manganese dioxide or MnO_2

(ii) $MnO_4^{2-}(aq)$ or manganate (VI) ion

(iii) Manganate (VII) ion or Permanganate ion or $MnO_4^-(aq)$

(d) $3MnO_4^{2-}(aq) + 4H^+(aq) \longrightarrow 2MnO_4^-(aq) + MnO_2(s) + 2H_2O(l)$

14. (a) (i)



Note - Largest part of the steep part should be below 7

- The highest point should be below 10.

(ii) -Initially the pH is **low** because of the **high concentration of hydrogen ions** from complete

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ionization of hydrochloric acid which is a **strong acid**

- The **pH then gradually rises** as ammonia solution is added because the **hydrogen Ions are being neutralized** by the ammonia solution added.
- This is then followed by a **sharp rise** in pH with **little ammonia** solution added signifying that the end point has been reached
- The **pH of solution at end point is less than 7** because the ammonium chloride salt formed is **hydrolysed by water forming hydrogen ions.**
- After the end point, there is a gradual rise in pH due to **excess ammonia solution** added which together with the ammonium chloride salt also form a **buffer solution** that resists pH change.

(c) $Number\ of\ moles\ of\ NaOH\ added = \frac{10}{1000} \times 0.1 = 1.0 \times 10^{-3} moles$

$Number\ of\ moles\ of\ CH_3COOH = \frac{25}{1000} \times 0.1 = 2.5 \times 10^{-3} moles$

Ethanoic acid reacts with sodium hydroxide according to the equation;

$CH_3COOH(aq) + NaOH(aq) \longrightarrow CH_3COONa(aq) + H_2O(l)$

$Number\ of\ moles\ of\ CH_3COOH\ that\ reacted = 1.0 \times 10^{-3}$

(since mole ratio of CH_3COOH : NaOH = 1:1)

$Number\ of\ moles\ of\ salt\ formed = 1.0 \times 10^{-3} moles$ (since; NaOH: CH_3COONa = 1:1)

$Number\ of\ moles\ of\ excess\ acid = 2.5 \times 10^{-3} - 1.0 \times 10^{-3} = \mathbf{1.5 \times 10^{-3} moles}$

$volume\ of\ ressultant\ solution = 10 + 25cm^3 = 35cm^3$

$concentration\ of\ CH_3COOH$ in resultant solution;

$$= \left(\frac{1000 \times 1.5 \times 10^{-3}}{35}\right) = \mathbf{0.04286 moldm^{-3}}$$

$concentration\ of\ CH_3COONa\ salt$ in resultant solution;

$$= \left(\frac{1000 \times 1.0 \times 10^{-3}}{35}\right) = \mathbf{0.0286 moldm^{-3}}$$

$$Hence;\ pH = Pka + \log\frac{[salt]}{[acid]}$$

$$pH = -\log 1.85 \times 10^{-5} + \log\left(\frac{0.0286}{0.04286}\right) = 4.57$$

Alternatively;

From; $Ka = \frac{[CH_3CO\bar{O}][H^+]}{[CH_3COOH]}$

$$assumptions;\ [CH_3CO\bar{O}] = [salt] \quad and \quad [CH_3COOH] = 0.04286M$$

$$Hence;\ [H^+] = \frac{ka[acid]}{[salt]}$$

$$= \frac{1.85 \times 10^{-5} \times 0.04286}{0.0286}$$

$$= 2.7724 \times 10^{-5} moldm^{-3}$$

But; $pH = -\log_{10}[H^+]$

$= -\log 2.7724 \times 10^{-5} = \mathbf{4.57}$

15. (a) - Beryllium reacts with **warm dilute** sulphuric acid to form **beryllium sulphate solution** and **hydrogen gas**
- Magnesium reacts with **cold dilute** sulphuric acid forming **magnesium shulphate solution** and **hydrogen gas.**
- Calcium and Barium **react slowly** with **cold dilute** sulphuric acid and the reaction stops due to **formation of insoluble sulphates**
- Beryllium reacts with **hot concentrated** sulphuric acid to form **beryllium sulphate, water** and **sulphur dioxide**
- Magnesium reacts with **hot concentrated** sulphuric acid to form **magnesium sulphate solution, water** and **sulphur dioxide**
- Calcium and Barium react with **hot concentrated** sulphuric acid to form **insoluble sulphates** which stop the reaction.

(d) (i) The solubility decreases down the group ie from Beryllium sulphate to barium sulphate

(ii) From Beryllium sulphate to barium sulphate, both **lattice energy** and **hydration energy** decrease

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due to increase in cationic radius. However, **hydration energy decreases more rapidly than lattice energy** leading to decrease in solubility.

(c) (i) $Be(s) + 2NaOH(aq) + 2H_2O(l) \longrightarrow Na_2Be(OH)_4(aq) + H_2(g)$

or, $Be(s) + 2\bar{O}H(aq) + 2H_2O(l) \longrightarrow Be(OH)_4^{2-}(aq) + H_2(g)$

or, $Be(s) + 2NaOH(aq) \longrightarrow Na_2BeO_2(aq) + H_2(g)$

or, $Be(s) + 2\bar{O}H(aq) \longrightarrow BeO_2^{2-}(aq) + H_2(g)$

(ii) $CaC_2(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(aq) + C_2H_2(g)$

16. (a) (i) Iron

(ii) $Kp = \dfrac{(P_{NH_3})^2}{(P_{N_2})(P_{H_2})^3}$

(b) (i) Equilibrium position would shift **from left to right**

(ii) Equilibrium position would shift **from left to right**

(c) (i) Let $x = number\ of\ moles\ of\ nitrogen\ that\ reacted\ at\ equilibrium$

	$N_2(g)$	+	$3H_2(g)$	⟶	$2NH_3(g)$
Initially;	1mole		3moles		0
Moles at Equilibrium;	$(1-x)$mole		$(3-3x)$mole		$2x$moles

Total number of moles at Equilibrium $= (1-x) + (3-3x) + 2x$

$= 4 - 2x$

$$\%\ of\ NH_3 = \left(\frac{2x}{4-2x}\right) \times 100 = 25$$

$$Hence; x = 0.4moles$$

$$Thus; moles\ of\ nitrogen\ at\ equilibrium = 1 - x$$

$$= (1 - 0.4) = 0.6moles$$

$$moles\ of\ hydrogen\ at\ equilibrium = 3(1 - 0.4) = 1.8moles$$

(ii) Total number of moles at equilibrium $= 4 - 2x$

$= 4 - 2(0.4) = \mathbf{3.2}\boldsymbol{moles}$

Partial pressure of; N_2, $P_{N_2} = \left(\frac{0.6}{3.2} \times 100\right) = 18.75atm$

Partial pressure of H_2; $P_{H_2} = \left(\frac{1.8}{3.2} \times 100\right) = 56.25atm$

Partial pressure of; NH_3; $P_{NH_3} = \left(\frac{0.8}{3.2} \times 100\right) = 25atm$

Thus; $Kp = \frac{(25)^2}{(18.75)(56.25)^3} = \mathbf{1.87 \times 10^{-4}}\boldsymbol{atm^{-2}}$

17. Addition polymer is one formed when very many molecules which are **unsaturated** combine **without loss of small molecules**, while condensation polymers are formed when two different **bi functional** monomers combine with **loss of small molecules** e.g water

(b) (i) Terylene or Dacron

(ii) Perspex or Polymethyl-2-methylpropenoate

(c) R; $HOCH_2CH_2OH$ and HO_2C–C$_6$H$_4$–CO_2H

T; $H_2C = \underset{\underset{CH_3}{|}}{C} - \overset{\overset{O}{\|}}{C} - O\,CH_3$ and H_3COOC–C$_6$H$_4$–$COOCH_3$ (for Dacron)

(d) (i) Making clothes (Fabrics)

(ii) Making lenses, rulers, corrugated roof lights, and aero plane windows

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QUESTION TO 'A' LEVEL CHEMISTRY; PAPER 2 (P525/2), 2018

1. (a) A compound Q contains 64.9% carbon, 13.5% hydrogen and the rest being oxygen. 1.85g of Q in the vapour form occupied 969.8 cm^3 at 200°C
   (i) Calculate the empirical formula of Q. (3 marks)
   (ii) Determine the molecular formula of Q (3 marks)
   (b) Q reacts with sodium with effervescence nut has no effect on sodium carbonate. Write the names and the structures of all possible isomers of Q. (4 marks)
   (c) When treated with anhydrous zinc chloride in the presence of concentrated hydrochloric acid, Q formed two layers after about 8minutes. Identify Q. (1 mark)
   (d) Q reacted with acidified chromium trioxide to give a compound A. Write equation for the reaction
   (i) leading to the formation of A (1 mark)
   (ii) between A and acidified 2,4 –dinitrophenylhydrazine and outline a mechanism for the reaction. (4½ marks)
   (e) Write equation to show how Q can be prepared from an alkene and outline a mechanism for the reaction. (3 ½ marks)

2. (a) Explain the principle on which steam distillation is based (3 ½ marks)
   (b) State
   (i) the conditions necessary for steam distillation (3 marks)
   (ii) one advantage of steam distillation over fractional distillation (1 mark)
   (c) The following data was obtained for the steam distillation of bromobenzene at 760 mmHg pressure

Temperature (°C)	90	92	94	96	98	100
Vapour pressure of water (mmHg)	526	567	611	658	707	760
Vapour pressure of bromobenzene (mmHg)	96	106	114	123	132	141

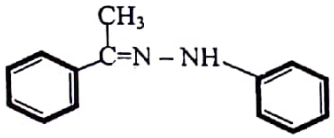
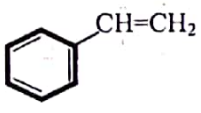
   (i) On the same axes, plot graphs of vapour pressure of the mixture and of each component against temperature (5 marks)
   (ii) Determine the boing point of the mixture (1 mark)
   (iii) Calculate the percentage by mass of bromobenzene in the distillate. (3 ½ marks)
   (d) State how a sample of dry bromobenzene can be obtained from the distillate. (2 marks)
   (e) State one other application of steam distillation (1 mark)

3. (a) Explain what is meant by the term
   (i) Solubility product (3 marks)
   (ii) Common ion effect (3 marks)
   (b) (i) Describe briefly how the solubility product of magnesium hydroxide in water can be obtained.(5 marks)
   (ii) State how solubility product can be used to predict precipitation or dissolution. (3 marks)
   (c) The solubility product of calcium sulphate at 25°C is $2.4 \times 10^{-5}\ mol^2 dm^{-6}$.
   Calculate the solubility of calcium sulphate in $mol\ \ dm^{-3}$ in
   (i) water (2 marks)
   (ii) 0.5 M sulphuric acid. (2 marks)
   (d) State one condition under which solubility product is valid. (1 mark)

4. The table below shows the melting point of some oxides of elements in Group (IV) of the Periodic Table.

Compound	CO_2	SiO_2	GeO_2	SnO_2	PbO_2
Melting point (°C)	-56.5	1700	1116	1827	752

   (a) Explain the trend in the melting points of the oxides
   (b) Compare the reactivity of the oxides with dilute acids and with dilute alkalis.
   (*Illustrate you answer with equations*) (6 ½ marks)
   (c) State what would be observed and write equation for the reaction that would take place if lead(IV) oxide was warmed with concentrated hydrochloric acid. (3 ½ marks)
   (d) When sulphur dioxide gas was passed over heated lead(IV) oxide, a white solid was formed. Explain. (3½ mks)

5. Using equations show how the following conversions can be made. Indicate conditions and the reagents for the reactions.
   (a) Benzene from chlorobenzene. (4 marks)
   (b) But-2-yne from butan-2-ol (4 ½ marks)
   (c) CH_3COCH_3 from $CH_3CH_2CH_2OH$ (5 ½ marks)
   (d)  from  (4½ marks)
   (e) $CH_3CH_2CH_2CH_3$ from CH_3CH_2OH (2 marks)

6. In the industrial preparation of sulphuric acid by contact process, sulphur dioxide reacts with oxygen according to

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the following equation; $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) + Heat$

(a) Explain what would happen to the concentration of sulphur trioxide if (1½ marks)
(i) more sulphur dioxide was added. (1½ marks)
(ii) the volume of the reaction vessel was increased (1½ marks)
(iii) the reaction vessel was cooled

(b) At 700°C and total pressure of 1.0 atm, the partial pressure at equilibrium for sulphur dioxide and oxygen are 0.27 and 0.41 atm respectively. (3 marks)
Calculate the equilibrium constant, *Kp* for the reaction.

(c) (i) Write equations to show how sulphuric acid can be obtained from sulphur trioxide. (3 marks)
(ii) Concentrated sulphuric acid contains 98% by mass of the acid. Calculate the volume of the concentrated sulphuric acid that will be required to make 0.2M solution of sulphuric acid. (3 marks)
(H = 1; S = 32; O = 16; Density of concentrated sulphuric acid = 1.84 gcm^{-3})

(d) Explain what would be observed when concentrated sulphuric acid reacts with
(i) hydrobromic (3 marks)
(ii) hydroiodic acid (3½ marks)

7. (a) (i) State the term that refers to formation of soap and write equation for the reaction that leads to formation of soap. (2½ marks)
(ii) Name a locally available raw material from which soap can be prepared. (½ mark)

(b) (i) Describe how a sample of solid soap can be prepared in the laboratory starting from the raw material you have named (a)(ii) (5 marks)
(ii) Outline how a sample of a soapless detergent can be prepared.
(Your answer should include equations)
(iii) Explain the cleaning action of soap. (3 ½ marks)

(c) Explain (4 ½ marks)
(i) one disadvantage of using soap for washing as opposed to the use of a soapless detergent. (2 marks)
(ii) one disadvantage of using soapless detergent. (2 marks)

8. (a) One of the ores from which copper can be extracted is copper pyrites. Write the formula of copper pyrite. (1 marks)

(b) During the extraction of copper from copper pyrite, the ore is concentrated, roasted, smelted and reduced to impure copper, which is then refined to obtain pure copper.
(i) Describe how the copper is concentrated. (3 marks)
(ii) Write equation for the reaction which takes place during roasting and reduction of the copper ore (3mks
(iii) State why the ore is smelted (1 mark)
(iv) Explain what takes place during the refinery process. *(Diagram is not required)* (3 marks)

(c) Explain the reaction of aqueous copper(II) sulphate with a solution of
(i) potassium iodide (2 ½ marks)
(ii) ammonia (4 marks)
(iii) sodium carbonate (2 ½ marks)

END

SOLUTIONS TO A - LEVEL CHEMISTRY; P525/2, 2018

Question. One.

(a) (i) Percentage of oxygen in $Q = 100 - (64.9 + 13.5) = 21.6\%$

	C	H	O
Composition of Q;			
Number of moles;	$\frac{64.9}{12}$	$\frac{13.5}{1}$	$\frac{21.6}{16}$
	5.408	13.5	1.35
Mole ratio;	$\frac{5.408}{1.35}$	$\frac{13.5}{1.35}$	$\frac{1.35}{1.35}$
	4 :	10 :	1

Emperical formula of Q is $C_4H_{10}O$

(ii) Using; $Pv = \frac{m}{mr}RT$

Molecular mass, $mr = \frac{mRT}{Pv}$

$= \frac{1.85 \times 8.314 \times (200+273)}{101325 \times 969.8 \times 10^{-6}} = 74g$

Alternatively; using $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

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Volume of Q at stp; $V_2 = \frac{P_1V_1T_2}{T_1P_2}$

$= \frac{101325 \times 969.8 \times 273}{(200+273) \times 101325} = 559.7366cm^3$

Hence; $559.7366cm^3$ of Q weigh 1.85g

$\therefore 22400cm^3$ *of Q weigh* $\frac{22400 \times 1.85}{559.7366}$

molecular mass of $Q = 74g$

Thus; $(C_4H_{10}O)n = 74$

$(4 \times 12)n + (10 \times 1)n + (1 \times 16)n = 74$

$\boldsymbol{n = 1}$

Hence; molecular formula of Q is $C_4H_{10}O$

(b) Butan-1-ol; $CH_3\,CH_2\,CH_2\,CH_2\,OH$

Butan-2-ol; $CH_3\,\underset{\underset{OH}{|}}{CH}\,CH_2\,CH_3$

2-methylpropan-1-ol; $CH_3\,\underset{\underset{CH_3}{|}}{CH}\,CH_2\,OH$

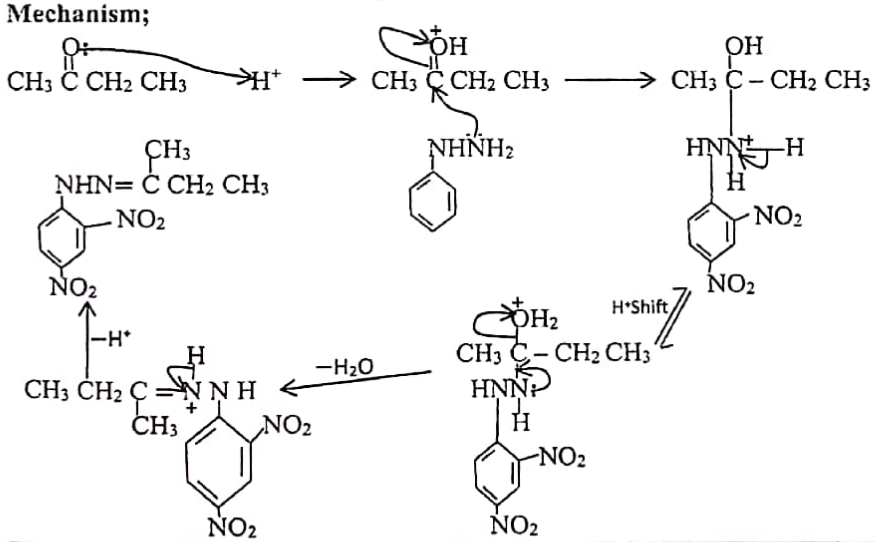
2-methylpropan -2-ol; $CH_3\,\underset{\underset{CH_3}{|}}{\overset{\overset{OH}{|}}{C}} - CH_3$

(c) $CH_3\,\underset{\underset{OH}{|}}{CH}\,CH_2\,CH_3$ or Butan -2 –ol

(d) (i) $CH_3\,\underset{\underset{OH}{|}}{CH}\,CH_2\,CH_3 \xrightarrow[\text{heat}]{CrO_3/H^+} CH_3\,\overset{\overset{O}{\|}}{C}\,CH_2\,CH_3$

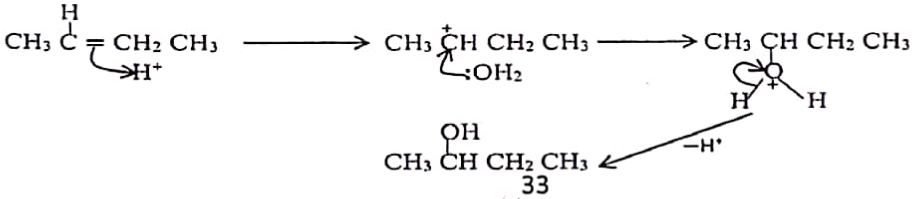
(ii) $CH_3\,\overset{\overset{O}{\|}}{C}\,CH_2\,CH_3 + C_6H_3(NHNH_2)(NO_2)_2 \xrightarrow{H^+} CH_3\,C(CH_3)=N-NH-C_6H_3(NO_2)_2 + H_2O$

Mechanism;



$CH_3\,\underset{\underset{H}{|}}{\overset{\overset{CH_3}{|}}{C}} = CH_2\,CH_3 \xrightarrow[2.H_2O/warm]{1.Conc.\ H_2SO_4} CH_3\,\underset{\underset{OH}{|}}{CH}\,CH_2\,CH_3$

(e) **Mechanism;**



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Question. Two.

(a) When a mixture of two **immiscible liquids** is **agitated** or **heated**, each component of the mixture **exerts its own vapour pressure independent of the other** and the vapour pressure above the mixture is the **sum of the vapour pressures** of the two components.
When the **temperature increases**, the **vapour pressure of the mixture also increases** and the mixture boils when the sum of the vapour pressures is equal to the atmospheric pressure at a **temperature lower** than the boiling point of the individual components.

(b) (i) - The substance to be steam distilled must have a higher molecular mass.
- The substance to be steam distilled must be immiscible with water
- The substance to be steam distilled must exert a higher vapour pressure around the boiling point of water.

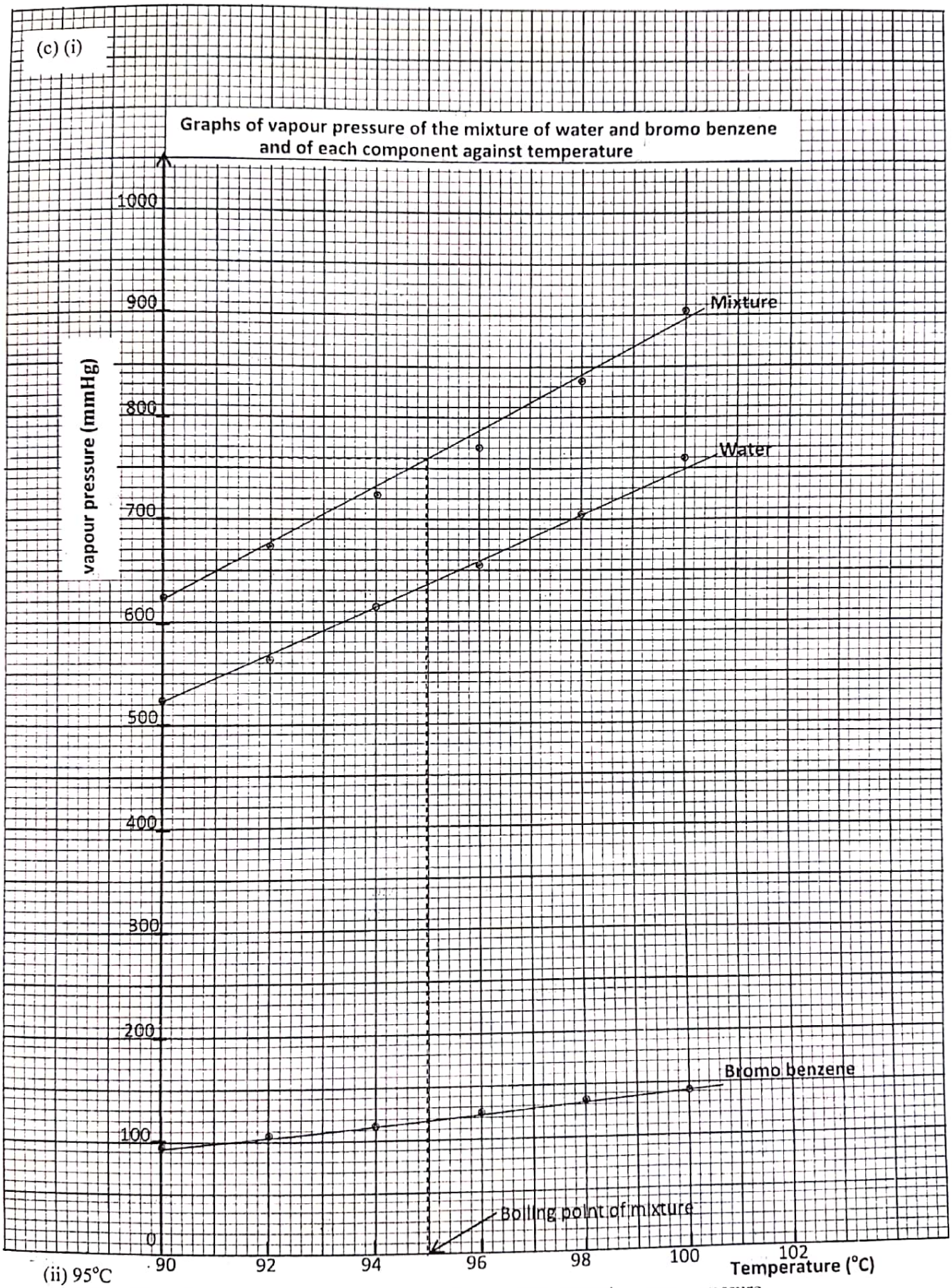
(ii) - Avoids decomposition of organic compounds that decompose at their boiling points
- Steam distillation occurs at lower temperature and therefore the process saves energy

(c)

Temperature (°C)	90	92	94	96	98	100
Vapour pressure of water (mmHg)	526	567	611	658	707	760
Vapour pressure of bromobenzene (mmHg)	96	106	114	123	132	141
Vapour pressure of mixture (mmHg)	**622**	**673**	**725**	**781**	**839**	**901**

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(c) (i)



(ii) 95°C

Note; The boiling point of the mixture is that temperature when the vapour pressure of mixture equals to the standard atmospheric pressure which is equal to 760mmHg

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(iii) From the graph; at 95°C and 760mmHg;
Vapour pressure of water = 640 mmHg
Vapour pressure of bromobenzene = 120 mmHg
Molecular mass of water (H_2O) = $(2 \times 1) + (1 \times 16) = 18$
Molecular mass of bromobenzene (C_6H_5Br) = $(6 \times 12) + (5 \times 1) + (1 \times 80) = 157$
Let; the percentage of bromobenzene in the distillate = x
Hence; percentage of water in distillate = $(100 - x)$

$$\frac{\%\ of\ \text{bromobenzene in distillate}}{\%\ of\ \text{water in distillate}} = \frac{v.pressure\ of\ C_6H_5Br \times Rmm\ of\ C_6H_5Br}{v.pressure\ of\ H_2O \times Rmm\ of\ H_2O}$$

$$\frac{x}{(100-x)} = \frac{120 \times 157}{640 \times 18}$$

Therefore, $x = 62.02\%$

(d) By solvent extraction

(e) -Determination of molecular masses of organic compounds
-Used in the purification of organic compounds
-Used to separate organic compounds from mixtures

Question. Three.

(a) (i) The product of the **molar** concentrations of the ions contained in a **saturated** solution of a **sparingly soluble ionic** compound raised to **appropriate powers** at a **given temperature** Eg;
The solubility product, Ksp of Barium sulphate is: $Ksp = [Ba^{2+}][SO_4^{2-}]$

(ii) The **precipitation (or reduction in solubility)** of a **sparingly soluble salt** from its **saturated solution** by addition of a solution of another more **soluble salt** containing a similar ion to one of the ions of the sparingly soluble salt.

(b) (i) -**Excess** magnesium hydroxide is added to a given volume of distilled water and the mixture **shaken** for some time until equilibrium is attained at a **given temperature**
The mixture is **filtered** and a **saturated solution** of magnesium hydroxide is obtained as **the filtrate.**
-A known volume of the filtrate is pipetted and titrated with a **standard solution** of hydrochloric acid using **phenolphthalein indicator**
Magnesium hydroxide solution reacts with hydrochloric acid according to the equation;
$Mg(OH)_2(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2O(l)$
- Using the equation above, the molar concentration of magnesium hydroxide is calculated ($x$moldm^{-3})
- Then from the quation of solubility of magnesium hydroxide;
$Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2\bar{O}H(aq)$;
The molar concentrations of magnesium ions and hydroxide are calculated and hence the solubility product of magnesium hydroxide is calculated using the expression;

$$Ksp = [Mg^{2+}][\bar{O}H]^2 = x(2x)^2 = 4x^3$$

Alternatively; by **conductrimetric measurements;**
-**Excess** magnesium hydroxide is shaken with a given volume of distilled water until equilibrium is attained at a **given temperature.**
-The mixture is **filtered** to obtain a **saturated solution of magnesium hydroxide as the filtrate**
-Using a conductivity cell, the electrolytic conductivity of the filtrare is measured.
-The molar conductivity of the magnesium ions and hydroxide ions at infinite dilution are obtained from tables in data books and these are used to determine the molar conductivity of magnesium hydroxide at infinite dilution.

$$\Lambda_o(Mg(OH)_2) = \Lambda_o(Mg^{2+}) + 2\Lambda_o(\bar{O}H)$$

-The molar concentration (solubility) of magnesium hydroxide is calculated using the formula;

$$\text{Concentration (solubility); } c = \frac{Electrolytic\ conductivity\ of\ magnesium\ hydroxide}{Molar\ conductivityof\ magnesium\ hydroxide\ at\ infinite\ dilution}$$

-The solubility product; Ksp of magnesium hydroxide is then calculated using the expression; $Ksp = [Mg^{2+}][\bar{O}H]^2 = c \times (2c)^2 = 4c^3$

(ii) -When the **ionic product is less than the solubility product** of the sparingly soluble salt, the solution is **unsaturated** and **more** of the sparingly soluble compound **dissolves** in the solution

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-When the **ionic product is greater than the solubility product** of the sparingly soluble salt, **precipitation** of the sparingly soluble salt occurs.
-However, if the **ionic product is equal to the** solubility product of the sparingly soluble salt, the **solution is saturated,** and **no dissolution** of salt occurs.

Note; Ionic product refers to the product of the molar concentrations of the ions contained in the solution of the sparingly soluble ionic compound raised to appropriate powers at a given temperature.

(c) (i) Equation of solubility of calcium sulphate;

$CaSO_4(s) \rightleftharpoons Ca^{2+}(aq) + SO_4^{2-}(aq)$

Hence; $[Ca^{2+}] = [SO_4^{2-}] = x moldm^{-3} = solubility\ of\ CaSO_4$

Thus; $Ksp = [Ca^{2+}]\,[SO_4^{2-}]$

$2.4 \times 10^{-5} = x^2$

$\therefore x = \sqrt{2.4 \times 10^{-5}} = 4.899 \times 10^{-3} moldm^{-3}$

$\therefore solubility\ of\ calcium\ sulphate = 4.899 \times 10^{-3} moldm^{-3}$

(ii) Let the solubility of $CaSO_4$ in sulphuric acid = $ymoldm^{-3}$

Hence; $[Ca^{2+}] = y$

$[SO_4^{2-}] = y + 0.5 \simeq 0.5 moldm^{-3}$ (since y is very small)

$Ksp = [Ca^{2+}]\,[SO_4^{2-}]$

$2.4 \times 10^{-5} = y \times 0.5$

$\therefore y = \frac{2.4 \times 10^{-5}}{0.5} = 4.8 \times 10^{-5} moldm^{-3}$

(d) - Constant temperature
-Solution should be saturated
-Salt should be sparingly soluble.

Question. Four.

(a) Carbon dioxide has the **lowest** melting point because it has a **simple molecular structure** whose molecules are held by **weak van der waals forces** which require **very little energy** to be broken
-Silicon dioxide and germanium dioxide have **higher melting points than carbon dioxide** because they have **giant covalent structures** in which the atoms are held by **strong covalent bonds** and thus require **a lot of heat energy** to be broken.
However the melting point of silicon dioxide is **higher** than that of germanium dioxide because silicon atoms in silicon dioxide have **smaller atomic radii** and hence form **stronger covalent bonds** with oxygen atoms than germanium atoms in germanium dioxide.
-Both tin (IV) oxide and lead (IV) oxide have **giant ionic structures** with **strong ionic bonds,** but the melting point of tin (IV) oxide is **higher** than that of lead (IV) oxide because tin (IV) ions in tin (IV) oxide have **smaller ionic radius** and therefore form **stronger ionic bonds** with the oxide ions than the lead (IV) ions in lead (IV) oxide

(b) Carbon dioxide is **acidic** and therefore reacts with only dilute alkalis to form a **carbonate** and **water**

$CO_2(g) + \bar{O}H(aq) \longrightarrow CO_3^{2-}(aq) + H_2O(l)$

-Silicon dioxide is also **acidic** and reacts with dilute alkalis to form a **silicate** and **water**

$SiO_2(s) + 2\bar{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + H_2O(l)$

-Germanium (IV) oxide, tin (IV) oxide and lead (IV) oxide are **amphoteric** and therefore **react with both acids and alkalis**. With dilute acids they form a **salt** and **water** only while with dilute alkalis, they form **complexes**.

ie $XO_2(s) + 2\bar{O}H(aq) \longrightarrow XO_3^{2-}(aq) + H_2O(l)$ (where X = Sn, Ge, and Pb)

However, silicon (IV) oxide reacts with hydrofluoric acid to form silicon tetrafluoride and water

$SiO_2(s) + 4HF(aq) \longrightarrow SiF_4(aq) + 2H_2O(l)$

(c) **Brown solid dissolved, Effervescence** occurred, and a **greenish – yellow** gas was evolved

$PbO_2(s) + 4HCl(aq) \longrightarrow PbCl_2(aq) + 2H_2O(l) + Cl_2(g)$

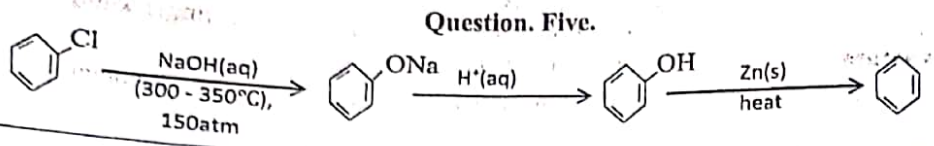
(d) Sulphur dioxide **reduces** lead (IV) oxide to **lead (II) Sulphate**

$PbO_2(s) + SO_2(g) \longrightarrow PbSO_4(s)$

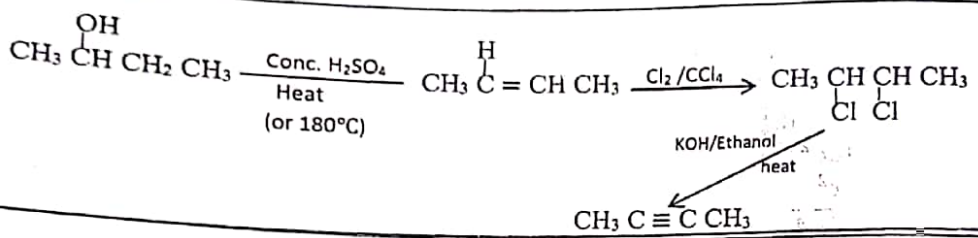
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Question. Five.

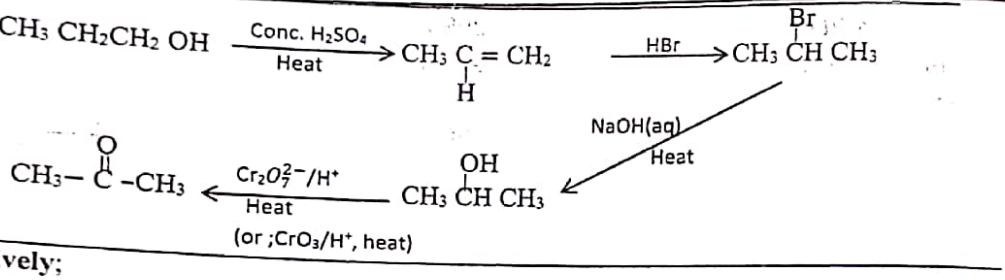
(a)



(b)

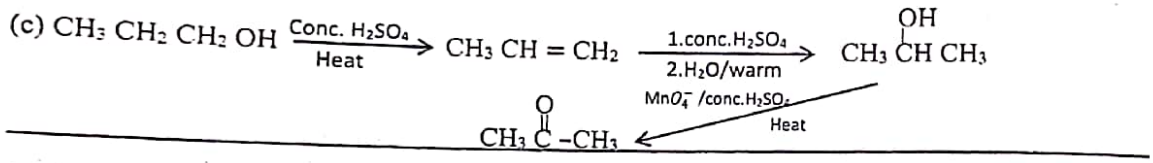


(c)

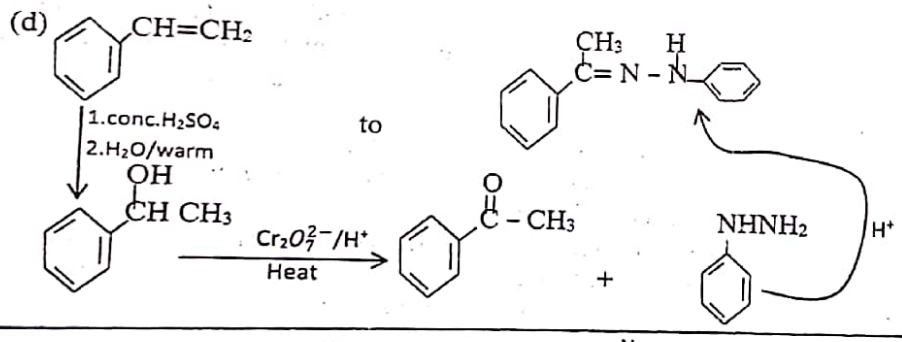


Alternatively;

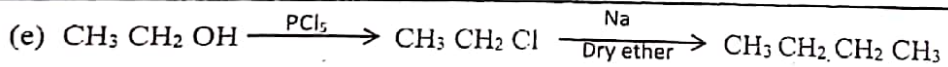
(c)



(d)



(e)



Question. Six.

(a)(i) Concentration of sulphur trioxide **would increase**. This is because the **equilibrium position shifts from left to right** since the **excess** sulphur dioxide **reacts** with oxygen to give **sulphur trioxide**

(ii) Concentration of sulphur trioxide **would decrease**. This is because increase in volume **favours the back ward reaction** which proceeds with a **decrease in pressure** and hence the **equilibrium positon shifts from right to left** since sulphur trioxide **decomposes** into **sulphur dioxide** and **oxygen**.

(iii) Concentration of sulphur trioxide **would increase**. This is because cooling of the reaction vessel favours the forward reaction which is exothermic and hence shifts the **equilibrium position from left to right.**

(b) Partial pressure of SO_3 at Equilibrium; $P_{SO_3} = 1 - (0.27 + 0.41) = 0.32atm$

$$Kp = \frac{(P_{SO_3})^2}{(P_{SO_2})^2 \times (P_{O_2})} = \frac{(0.32)^2}{(0.27)^2 \times (0.41)} = 3.43atm^{-1}$$

(c)(i) $SO_3(g) + H_2SO_4(l) \longrightarrow H_2S_2O_7(l)$

$H_2S_2O_7(l) + H_2O(l) \longrightarrow 2H_2SO_4(l)$

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(ii) Since density of $H_2SO_4 = 1.84g/cm^{-3}$,
Hence; 1cm^3 of sulphur acid weighs 1.84g
$\therefore$ 1000cm^3 of sulphuric acid weigh $\frac{1000\times1.84}{1}g = 1{,}840g$ of sulphuric acid

mass of 98% *sulphuric acid* $= \frac{98}{100} \times 1{,}840 = 1{,}803.2g$ of sulphuric acid

molecular mass of $H_2SO_4 = (2\times1) + (1\times32) + (4\times16) = 98g$

molarity of concentrated $H_2SO_4 = \frac{1{,}803.2}{98} = 18.4M$

18.4 moles of H_2SO_4 are contained in 1000cm^3 of solution

$\therefore$ 0.2mole of H_2SO_4 is contained in $\left(\frac{0.2}{18.4} \times 1000\right)$ cm^3 of solution

Thus; volume of concentrated H_2SO_4 =10.87cm^3

(d) (i) **Colourless solution** turns **brown** and **Effervescence of a colorless gas** occurred, because concentrated sulphuric acid **oxidizes** hydrobromic acid to **bromine** and the acid is **reduced to sulphur dioxide;**

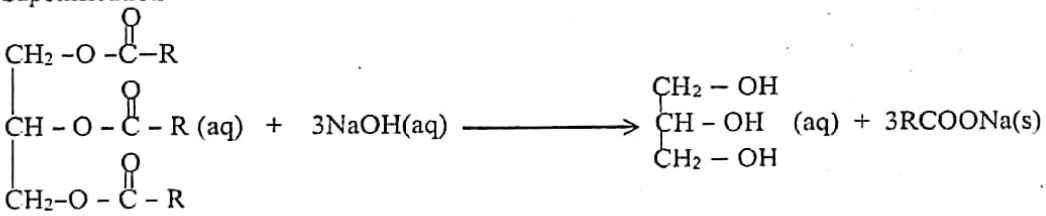
$H_2SO_4(l) + 2HBr(aq) \longrightarrow Br_2(aq) + SO_2(g) + 2H_2O(l)$

(ii) **Colurless solution** turns **brown** and **effervescence** of a **colourless gas** occurred, because concentrated sulphuric acid **oxidizes** hydroiodic acid to **iodine** and the acid is reduced to **sulphur dioxide**

$H_2SO_4(l) + 2HI(aq) \longrightarrow I_2(aq) + SO_2(g) + 2H_2O(l)$

Question. Seven.

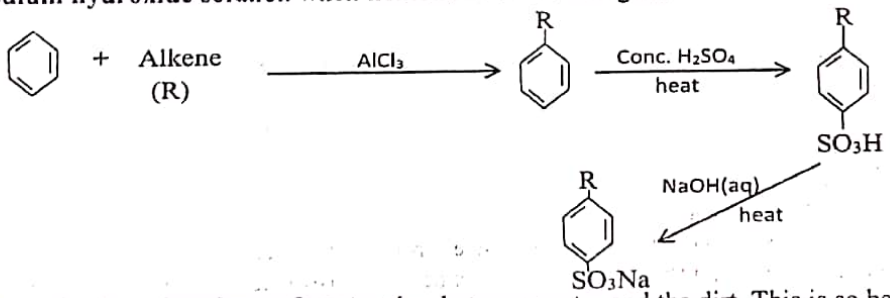
(a) (i) Saponification



(ii) Coconut oil, simsim oil, palm oil, cotton seed oil, Ground nut oil or an animal fat

(b) (i)The oil (palm oil) is mixed with **excess** concentrated **sodium hydroxide solution** and **heated** with constant **stirring** for a long time. Concentrated **sodium chloride** solution is added to **precipitate** the soap.

(ii) A **long chain alkene** is **reacted with benzene** in presence of **an acid** to form **alkyl benzene** which is then **heated** with **concentrated sulphuric acid** to form **sulphonic acid** which then reacts with **sodium hydroxide** solution when **heated** to form a detergent.



(iii) Soap acts by **lowering the surface tension** between water and the dirt. This is so because soap contains a **hydrophobic** (non polar) or water hating part which **dissolves (attracts) the dirt** and the **hydrophilic part** or water loving part which is **attracted to the water**. With **agitation the dirt is dispersed in the water**.

(c)(i) Soap is not effective when used with hard water since it reacts with calcium ions or magnesium ions in the hard water forming **scum** (calcium octadecanoate or magnesium octadecanoate)

(ii) -Soapless detergents are non **biodegradable** and hence cause **pollution** of water bodies.
-Detergents encourage the growth of algae in water bodies, and this is due to their phosphate components which are nutrients for algae.

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(a) $CuFeS_2$

Question. Eight.

(b) (i)- The ore is **crushed** into powder and mixed with water containing special oils called **frothing agents.**
- **Air is blown** into the mixture to form a **froth** which contains the ore. The froth comes to the surface while the earthly impurities are **wetted** by water and **sink** to the bottom.
- **An acid** is added to break the froth
- The ore is then **filtered off** and **dried**

(ii) $2CuFeS_2(s) + 4O_2(g) \longrightarrow Cu_2S(s) + FeO(s) + 3SO_2(g)$
$2Cu_2S(s) + 3O_2(g) \longrightarrow 2Cu_2O(s) + 2SO_2(g)$
$Cu_2S(s) + 2Cu_2O(s) \longrightarrow 6Cu(s) + SO_2(g)$

(iii) To remove the iron (II) oxide impurity as slag.

(iv) The impure copper obtained from the reduction process is made the **anode** and a pure copper plate made the **cathode** during **electrolysis of copper (II) sulphate solution.**
The impure copper anode **dissolves** in solution to form **copper (II) ions** which are then deposited at the cathode as pure copper;
At anode; $Cu(s) \longrightarrow Cu^{2+}(aq) + 2e$
At cathode; $Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$

(c) (i) The copper (II) ions in copper (II) sulphate solution **oxidize** the iodine ions in potassium iodide solution to iodine and the copper (II) ions are **reduced** to copper (I) iodide;
$2Cu^{2+}(aq) + 4I^-(aq) \longrightarrow I_2(aq) + Cu_2I_2(s)$

(ii) The copper (II) ions reacts with hydroxide ions from ammonia solution to form **copper(II) hydroxide** which reacts with the ammonia molecules to form a soluble complex of **tetraammine copper (II) ions;**
$Cu^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Cu(OH)_2(s)$
$Cu(OH)_2(s) + 4NH_3(aq) \longrightarrow Cu(NH_3)_4^{2+}(aq) + 2\bar{O}H(aq)$

(iii) The copper (II) ions react with the carbonate ions to form insoluble **copper (II) carbonate;**
$Cu^{2+}(aq) + CO_3^{2-}(aq) \longrightarrow CuCO_3(s)$

QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2017

1. (a) Complete the following equations for nuclear reactions.
(i) $^{27}_{14}Si \longrightarrow {}^{27}_{13}Al + \ldots\ldots\ldots\ldots$ (1 mark)
(ii) $^{241}_{95}Am + {}^{4}_{2}He \longrightarrow {}^{243}_{97}Bk + \ldots\ldots\ldots\ldots$ (1 mark)
(iii) $^{238}_{92}U + {}^{1}_{0}n \longrightarrow {}^{239}_{93}Np + \ldots\ldots\ldots\ldots$ (1 mark)

(b) In an experiment, the rate of radioactive decay of bromine decreased by 25°C in 96 minutes. Calculate the half life of bromine. (2 marks)

2. An alkene *R*, diffuses through a porous partition in 2 minutes. Under similar conditions, the same volume of oxygen diffuses in 1.75 minutes.
(a) (i) Calculate the formula mass of *R*.
(ii) Determine the molecular formula of *R*. (1½ marks)
(b) Write equations to show how *R* can be synthesized from propanone. (2 marks)

3. (a) In the manufacture of sulphuric acid, sulphur trioxide is not dissolved in water, but another solvent. (2 marks)
(i) State why water is not used as a solvent.
(ii) Write equation(s) to show the formation of sulphuric acid from sulphur trioxide. (1 mark)
(b) Write equation for the reaction between sulphuric acid and hydrogen bromide. (3 marks)

4. (a) State one colligative property of a dilute solution other than depression of freezing point or elevation of boiling point of a solvent. (1½ marks)
(b) Ethane-1-2 diol $HOCH_2CH_2OH$, is used as an antifreeze for water in car radiators, calculate the mass of ethane-1-2-diol that should be added to 1kg of water to prevent it from freezing at -10°C. (1 mark)
(*Freezing point depression constant for water* = 1.86°C. kg mol^{-1})

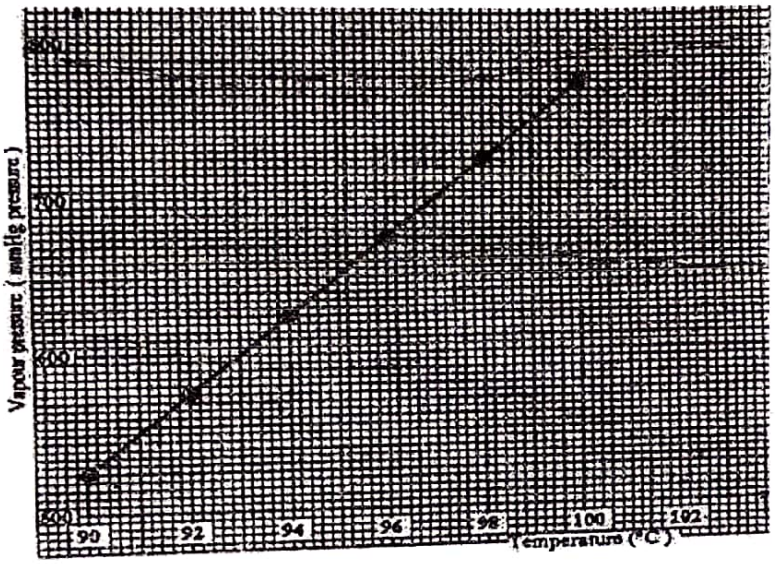
5. Nylon – 6, 6, $\left\{\overset{H}{\underset{|}{N}} - (CH_2)_6\,NHCO(CH_2)_4\,\overset{O}{\overset{\|}{C}}\right\}_n$ is a synthetic polymer formed by condensation polymerisation (3 marks)

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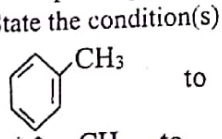
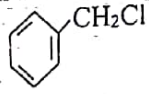
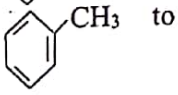
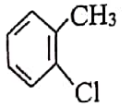
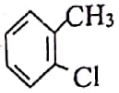
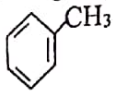
(a) State what is meant by the term condensation polymerization. (1 mark)
(b) Write the structural formulae of the monomers of nylon-6,6, (1 mark)
(c) Name:
(i) One natural polymer that is formed by condensation polymerization (1 mark)
(ii) The monomers of the polymer in (c) (i). (½ mark)
(d) State one use of the polymer you have named in (c) (i). (½ mark)

6. (a) State two properties in which chromium behaves as a transition element (1 mark)
(b) Write the equation for the reaction that takes place when chromium (III) sulphate is dissolved in water. (1½ marks)
(c) Magnesium ribbon was added to a solution of chromium (III) sulphate.
(i) State what was observed (1 mark)
(ii) Write equation for the reaction that took place. (1½ marks)

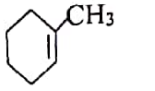
7. The graph below shows how the total vapour pressure of a mixture of water and nitrobenzene varies with temperature.



(a) State the temperature at which the mixture boils at 760mmHg pressure. (1 mark)
(b) The partial vapour pressure of nitrobenzene at the boiling point of the mixture is 20mmHg. Calculate the percentage of nitrobenzene by mass that will be obtained when the mixture is steam distilled at normal atmospheric pressure *(H = 1, C = 12, N = 14, O = 16)* (4 marks)

8. (a) State the condition(s) under which the following conversions can be effected.
(i)  to  (1 ½ marks)
(ii)  to  (1 ½ marks)
(b) Write a mechanism for the reaction leading to the formation of  from  (2 marks)

9. Explain the following observations: (3½ marks)
(a) Silicon (IV) chloride is hydrolysed by water whereas carbon tetrachloride is not. (2 marks)
(b) Lead (IV) chloride exists but lead (IV) bromide does not.

10. Complete each of the following equations and write the mechanism for the reaction. (2 ½ marks)
(a)  $\xrightarrow{HBr}$ .....
(3 ½ marks)
(b) $CH_3CO\,Br \xrightarrow[Heat]{CH_3CH_2NH_2}$ .....
(3 marks)
(c) $HCHO \xrightarrow{KCN/H^+(aq)}$ .....

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11. (a) State what is meant by the term buffer solution. (1 mark)
(b) Calculate the pH of the solution formed when 0.61g of benzoic acid is dissolved in $1dm^3$ of a 0.02M sodium benzoate (Ka of benzoic acid = 6.3×10^{-5} mol dm^{-3}) (2½ marks)
(c) Explain what would happen to the pH of the solution in (b) if a few drops of the following reagents were added:
(i) Potassium hydroxide solution. (3 marks)
(ii) Hydrochloric acid (2½ marks)

12. (a) When 0.1g of aluminium chloride was vaporized at 350°C and pressure of 1 atmosphere, $19.2cm^3$ of vapour was formed.
(i) Calculate the relative molecular mass of aluminium chloride. (2 marks)
(ii) Write the molecular formula of aluminium chloride in the gaseous state at 350°C. (1 mark)
(Al = 27, Cl = 35.5)
(b) Aluminium chloride is normally contaminated by traces of iron (III) chloride.
(i) Name one reagent that can be used to detect the presence of iron (III) ion in a contaminated solution of aluminium chloride. (1 mark)
(ii) State what would be observed if the contaminated aluminium chloride solution was treated with the reagent you have named in (b) (i). (½ mark)
(c) Water was added dropwise to aluminium chloride.
(i) State what was observed. (1 mark)
(ii) Write equation for the reaction that took place. (1½ marks)
(b) State one use of aluminium chloride in organic synthesis. (1½ marks)

13. (a) Draw the structure and name the shape of each of the species in the table below. (4½ marks)

Species	Structure	Shape
BF_3		
$SnCl_2$		
ClO_3^-		

(b) Write equation for the reaction between:
(i) boron trifluoride and ammonia (1½ marks)
(ii) acidified potassium iodide solution and aqueous sodium chlorate (V) solution (1½ marks)
(iii) tin (II) chloride and iron (III) ions (1½ marks)

14. (a) Write;
(i) equation for the ionization of methanoic acid in water. (1½ marks)
(ii) the expression for the acid dissociation constant Ka, for methanoic acid. (1 mark)
(c) The molar conductivities of some electrolytes at infinite dilution at 25°C are given in the table below.

Electrolyte	Molar conductivity at infinite dilution (Scm^3 mol^{-1})
Sodium chloride	113.0
Sodium methanoate	101.0
Sodium hydroxide	225.2
Hydrochloric acid	397.8

Calculate the molar conductivity of methanoic acid at infinite dilution. (3 marks)
(d) The molar conductivity of a 0.05M methanoic acid solution is $24.318Scm^2$ mol^{-1} at 25°C.
Calculate the;
(i) degree of ionization of methanoic acid at 25°C (1½ marks)
(ii) dissociation constant Ka of methanoic acid at 25°C (2 marks)

15. Name one functional group that can be identified using each of the following reagents. In each case state what would be observed and write equation for the reaction that would take place:
(a) Bromine water
Functional group (1 mark)
Observation (1 mark)
Equation (1 mark)
(b) 2, 4-dinitrophenyl hydrazine.
Functional group (1 mark)
Observation (1 mark)
Equation (1 mark)
(c) Sodium carbonate:
Functional group (1 mark)
Observation (1 mark)
Equation (1 mark)

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16. During the extraction of copper from pyrities, copper pryrites is crushed and agitated with water/oil mixture. Compressed air is bubbled through the mixture which is then filtered, roasted and finally impure molten copper is obtained.
(a) State the role of
(i) oil (1 mark) (ii) compressed air (1 mark)
(b) Write equation for the reaction that occurs when copper pyrites is roasted (1½ marks)
(c) Explain briefly how impure copper can be refined (4 marks)
(d) Explain why it is advantageous to have a sulphuric acid manufacturing plant near a copper extraction plant. (1½ marks)

17. (a) State what is meant by the term:
(i) order of a reaction. (1 mark) (ii) half life a reaction (1 mark)
(b) The table below shows the kinetic data obtained for hydrolysis of methyl ethanoate in acidic media.

$[CH_3COOCH_3]$ (mol dm^{-3})	0.241	0.161	0.109	0.073	0.046	0.034
Time (minutes)	0	60	120	180	240	320

plot a graph of concentration of methyl ethanoate against time (3 marks)
(c) Using the graph in (b), determine the
(i) half life of the reaction. (1½ marks)
(ii) order of the reaction with respect to CH_3COOCH_3. Give a reason for your answer (1 mark)
(d) Calculate the rate constant and indicate its units. (1½ marks)

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2017

1. (a) (i) $^{27}_{14}Si \longrightarrow {}^{27}_{13}Al + {}^{0}_{+1}e$

(ii) $^{241}_{95}Am + {}^{4}_{2}He \longrightarrow {}^{243}_{97}Bk + 2{}^{1}_{0}n$

(iii) $^{238}_{92}U + {}^{1}_{0}n \longrightarrow {}^{239}_{93}Np + {}^{0}_{-1}e$

(b) Let; the original amount of bromine, $No = 100\%$
and the amount left after decay: $Nt = (100 - 25) = 75\%$

$$time\ of\ decay; t = 96minutes$$

$$using; 2.303 \log\left(\frac{No}{Nt}\right) = \lambda t$$

Hence; decay constant; $\lambda = \frac{2.303 \log\left(\frac{100}{75}\right)}{96} = 2.997 \times 10^{-3} minute^{-1}$

Thus; Half life; $t½ = \frac{In2}{\lambda}$

$$= \frac{0.693}{2.997 \times 10^{-3}} = 231.23minutes$$

2. (a) (i) From Graham's law;

$$\frac{Rate\ of\ diffusion\ of\ O_2}{Rate\ of\ diffusion\ of\ R} = \sqrt{\frac{molecular\ mass\ of\ R; MR}{molecular\ mass\ of\ O_2; MO_2}}$$

Hence; $\frac{tR}{tO_2} = \sqrt{\frac{MR}{MO_2}}$

$$\frac{2}{1.75} = \sqrt{\frac{MR}{32}}$$

$$\therefore MR = \frac{4 \times 32}{(1.75)^2} = 41.8g$$

Note; Rate of diffusion of a gas $= \frac{volume\ of\ diffusing\ gas(V)}{time\ taken\ (t)}$

(ii) $C_n H_{2n} = 41.8$

$12n + 2n = 41.8$

$\therefore n = \frac{41.8}{14} = 3$

Hence; molecular formula of R is C_3H_6

(b) $CH_3\overset{O}{\overset{\|}{C}}-CH_3 \xrightarrow[\text{Dry ether}]{LiAlH_4} CH_3\overset{OH}{\overset{|}{C}}-CH_3 \xrightarrow[heat]{Conc.\ H_2SO_4} CH_3CH = CH_3$

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3. (a) (i) The reaction between sulphur trioxide and water is **highly exothermic** and produces **misty fumes** of sulphuric acid which can harm plant operators.

(ii) $SO_3(g) + H_2SO_4(l) \longrightarrow H_2S_2O_7(l)$

$H_2S_2O_7(l) + H_2O(l) \longrightarrow 2H_2SO_4(l)$

(b) $H_2SO_4(l) + 2HBr(g) \longrightarrow SO_2(g) + 2H_2O(l) + Br_2(aq)$

4. (a) Vapour pressure lowering of a solvent or osmotic pressure of solution

(b) Molecular mass of $HOCH_2\,CH_2\,OH = (2 \times 12) + (6 \times 1) + (2 \times 16) = 62g.$

freezing point depression $= 0 - (-10) = 10°C$

1.86°C is depression of freezing point caused by 62g of ethane-1, 2-diol

$\therefore$ 10°C is depression of freezing point caused by $\left(\frac{10\times62}{1.86}\right) = 333.3g$ **of ethane-1, 2-diol**

5. (a) Combination of two bifunctional monomers with elimination of small molecules such as water from monomers

(b) $H_2N(CH_2)_6\,NH_2$, $HCOOC(CH_2)_4\,COOH$

(c) (i) Starch, proteins

(ii) Starch – Glucose

Protein – Amino acids

(d) Starch – Provides energy

Proteins – Building of body tissues

6. (a) -Chromium forms many complexes

-Chromium has variable oxidation states

-Chromium forms coloured compounds

-Chromium can be used as acatalysi.

(b) $Cr_2(SO_4)_3(aq) + 6H_2O(l) \longrightarrow 2Cr(OH)_3(s) + 3H_2SO_4(aq)$

(c) (i) **Green precipitate** and **effervescence** of a **colourless gas.**

(ii) $2Cr^{3+}(aq) + 3Mg(s) + 6H_2O(l) \longrightarrow 2Cr(OH)_3(s) + 3Mg^{2+}(aq) + 3H_2(g)$

7. (a) 99.4°C

Note; This temperature is obtained by drawing a vertical line from the graph at 760mmHg to the temperature axis.

(b) Vapour pressure of water $= 760 - 20 = 740mmHg$

Molecular mass of nitro benzence; $C_6H_5\,NO_2 = (6 \times 12) + (5 \times 1) + (1 \times 14) + (2 \times 16)$

$= 123g$

Let the percentage of nitrobenzene be $x\%$

Hence; percentage of water $= (100 - x)\%$

$$\frac{\%\ of\ nitrobenzene\ in\ distillate}{\%\ of\ water\ in\ distillate} = \frac{v.pressure\ of\ nitrobenzene \times molar\ mass\ of\ nitrobenzene}{v.pressure\ of\ water \times molar\ mass\ of\ water}$$

$$\frac{x}{(100-x)} = \frac{20\times123}{740\times18}$$

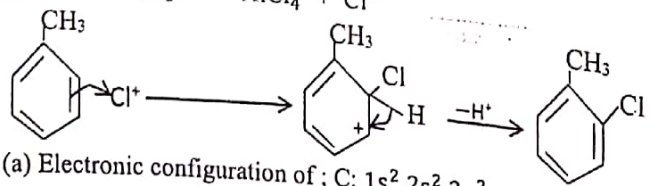
$$\frac{x}{100-x} = \frac{2460}{13320}$$

$$x = 15.6\%$$

8. (a)(i) Chlorine and ultra violet light.

(ii) Chlorine and aluminum chloride or (Iron (III) chloride or Iron) and **heat**

(b) $AlCl_3 + Cl_2 \longrightarrow AlCl_4^- + Cl^+$



9. (a) Electronic configuration of ; C; $1s^2\,2s^2\,2p^2$, Si; $1s^2\,2s^2\,2p^6\,3s^2\,3p^2$

The silicon atom in silicon (IV) chloride has accessible **vacant 3d-orbitals** which can **accommodate lone pairs** of electrons from water molecules.

However, the carbon atom in carbon tetrachloride **lacks the 2d-orbitals**

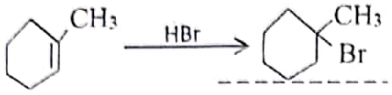
(b) The bromide ion has a **larger ionic radius** and therefore a **stronger reducing agent**

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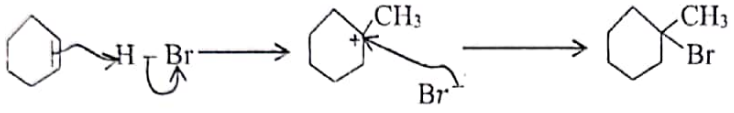
than the chloride ion. The bromide therefore **reduces** the lead(IV) ions to lead (II) ions while **chloride ions cannot**

$Pb^{4+}(l) + 2Br^{-}(l) \longrightarrow Pb^{2+}(s) + Br_2(l)$

10. (a)

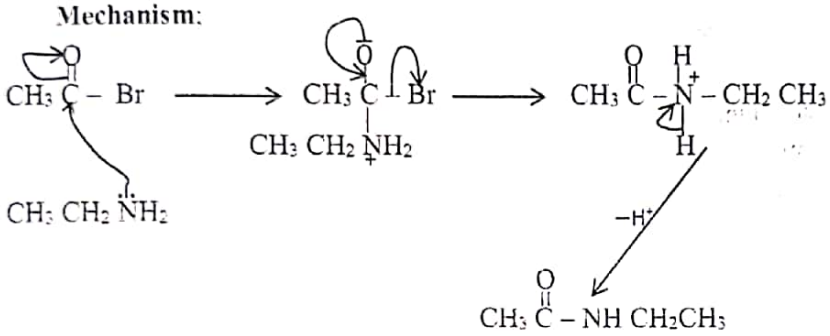


Mechanism;



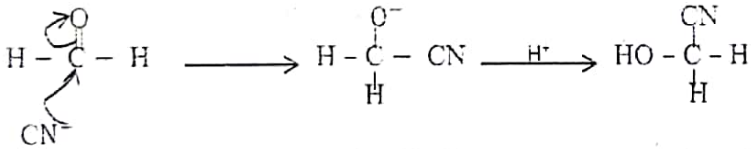
(b) $CH_3COBr \xrightarrow{CH_3CH_2NH_2} CH_3CONHCH_2CH_3$

Mechanism:



(c) $HCHO \xrightarrow{KCN/H^+(aq)} HO-\underset{H}{\overset{CN}{\underset{|}{\overset{|}{C}}}}-H$

Mechanism:



11. (a) A solution which **resists** change in pH when a **small** amount of acid or base is added.

(b) Molecular mass of benzoic acid; $C_6H_5COOH = (7 \times 12) + (6 \times 1) + (2 \times 16) = 122$

Molar concentration of $C_6H_5COOH = \frac{0.61}{122} = 0.005 moldm^{-3}$

$$pH = PKa + \log\frac{[salt]}{[acid]}$$

$$= -\log_{10}(6.3 \times 10^{-5}) + \log\left(\frac{0.02}{0.005}\right) \quad = 4.8$$

Alternatively;

From; $Ka = \frac{[C_6H_5CO\bar{O}][H^+]}{[C_6H_5COOH]}$

$[C_6H_5CO\bar{O}] = [salt]$ *and* $[C_6H_5COOH] = 0.005M$

Hence; $[H^+] = \frac{Ka[C_6H_5COOH]}{[C_6H_5CO\bar{O}]}$

$$= \frac{6.3\times10^{-5}\times0.005}{0.02} = 1.575 \times 10^{-5} moldm^{-3}$$

$$pH = -\log_{10}[H^+]$$

$$= \log(1.575 \times 10^{-5}) \quad = 4.8$$

(c) (i) pH of the solution would **remain constant**

This is because, the hydrogen ions in solution **react with** the hydroxide ions from potassium hydroxide added to form water i.e

$H^+(aq) + \bar{O}H(aq) \longrightarrow H_2O(l)$; As an attempt to restore the concentration of hydrogen ions, **more benzoic acid ionizes** i.e

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$C_6H_5COOH(aq) \rightleftharpoons C_6H_5CO\bar{O}(aq) + H^+(aq)$; And hence the pH remains constant

(ii) pH of the solution would **remain constant**, because the benzoate ions in solution **react with the hydrogen ions** from the acid added forming benzoic acid molecules, and thus the pH remains constant. i.e

$C_6H_5CO\bar{O}(aq) + H^+(aq) \longrightarrow C_6H_5COOH(aq)$;

12. (a) (i) Using $Pv = \frac{m}{mr}RT$

Molecular mass; $mr = \frac{mRT}{Pv}$

$= \frac{0.1\times8.31\times(350+273)}{101325\times19.2\times10^{-6}} = 266.12\ g$

Alternatively;

Using $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Volume of aluminium chloride at stp; $V_2 = \frac{P_1V_1T_2}{T_1P_2}$

$= \frac{1\times19.2\times273}{(350+273)\times1} = 8.37cm^3$

Thus; 8.37cm^3 of aluminium chloride weigh 0.1g.

$\therefore$ 22400cm^3 of aluminium chloride weigh $\frac{22400\times0.1}{8.37}g$

molecular mass of aluminium chloride $= 267.62g$

(ii) $(AlCl_3)_n = 266.12$

$27n + 3\times(35.5)n = 266.12$

$n = \frac{266.12}{133.5} = 2$

Therefore molecular formula is Al_2Cl_6

(b) (i) Potassium hexacyanoferrate (II) solution
or; Ammonia solution
or; Potassium thiocyanate solution

(ii) With Potassium hexa cyanoferrate (II) solution, a **dark blue** precipitate forms
With Ammonia solution a **brown precipitate** forms with potassium thio cyanate, solution, a **blood red** solution forms

(iii) $Fe^{3+}(aq) + Fe(CN)_6^{4-}(aq) \longrightarrow Fe[Fe(CN)_6]^-(s)$

$Fe^{3+}(aq) + 3\bar{O}H(aq) \longrightarrow Fe(OH)_3(s)$

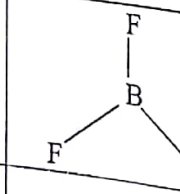
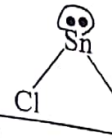
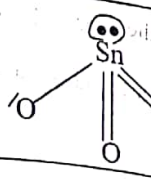
$Fe(H_2O)_6^{3+}(aq) + 3SCN^-(aq) \longrightarrow Fe(H_2O)_3(SCN)_3(aq) + 3H_2O(l)$

(c) (i) **White solid, dissolved** forming a **cloudy solution** and **misty fumes**

(ii) $Al(H_2O)_6^{3+}(aq) + H_2O(l) \rightleftharpoons [Al(H_2O)_5OH]^{2+}(aq) + H_3O^+(aq)$

(d) Used as a **catalyst** in **halogenations** and **alkylation** of benzene.

13. (a)

Species	Structure	Shape
BF_3		Trigonal planar
$SnCl_2$		V –Shape
ClO_3^-		Trigonal pyramidal

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(b) (i) $NH_3(g) + BF_3(g) \longrightarrow H_3N:\longrightarrow BF_3(s)$

(ii) $ClO_3^-(aq) + 6H^+(aq) + 6I^-(aq) \longrightarrow 3I_2(aq) + Cl^-(aq) + 3H_2O(l)$

(iii) $Sn^{2+}(aq) + 2Fe^{3+}(aq) \longrightarrow Sn^{4+}(aq) + 2Fe^{2+}(aq)$

(a) (i) $HCOOH(aq) \rightleftharpoons H^+(aq) + HCOO^-(aq)$

or $HCOOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCOO^-(aq)$

(ii) $Ka = \frac{[H^+][HCOO^-]}{[HCOOH]}$ or $Ka = \frac{[H_3O^+][HCOO^-]}{[HCOOH]}$

(b) Equation of reaction leading to formation of methanoic acid

$HCOONa(aq) + HCl(aq) \longrightarrow NaCl(aq) + HCOOH(aq)$

$\Lambda_o(HCOOH) = \Lambda_o(HCOONa) + \Lambda_o(HCl) - \Lambda_o(NaCl)$

$= 101.0 + 397.8 - 113.0$

$= 385.8(scm^2mol^{-1})$

Alternatively;

Consider the reaction;

$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$

$\Lambda_o(H_2O) = \Lambda_o(NaOH) + \Lambda_o(HCl) - \Lambda_o(NaCl)$

$= 225.2 + 397.8 - 113.0$

$= 510(scm^2mol^{-1})$

Also; $HCOONa(aq) + H_2O(l) \longrightarrow HCOOH(aq) + NaOH(aq)$

$\Lambda_o(HCOOH) = \Lambda_o(HCOONa) + \Lambda_o(H_2O) - \Lambda_o(NaOH)$

$= 101.0 + 510 - 225.2$

$= 385.8(scm^2mol^{-1})$

(c) (i) Degree of ionization; $\propto = \frac{\Lambda_c}{\Lambda_o}$ $\frac{\textit{molar conductivity at a given concntration}}{\textit{molar conductivity at infinite dilution}}$

$= \frac{24.318}{385.8} = \mathbf{0.063}$ or $\mathbf{6.3\%}$

(ii) $Ka = \frac{\propto^2 C}{1-\propto}$

$= \frac{(0.063)^2 \times 0.05}{1-0.063} = \mathbf{2.118 \times 10^{-4} moldm^{-3}}$

(a) Functional group; carbon to carbon double bond.

Observation; The **reddish-brown** bromine water turns **colourless**

Equation $>C=C< + Br_2(aq) \longrightarrow -\overset{Br}{\underset{|}{C}}-\overset{OH}{\underset{|}{C}}-$

(b) Functional group; carbonyl group

Observation –yellow or orange precipitate

Equation;



(c) Sodium carbonate

Functional group; Carboxyl group

Equation; $2(-COOH)(aq) + Na_2CO_3(aq) \longrightarrow 2(-COONa)(aq) + CO_2(g) + H_2O(l)$

(a) (i) To wet the ore there by making it float on the mixture

(ii) Compressed air agitates the water or the oil mixture

(b) $2CuFeS_2(s) + 4O_2(g) \longrightarrow Cu_2S(s) + 2FeO(s) + 3SO_2(g)$

(c) The **impure copper** is made the **anode** and a **pure copper** plate made the **cathode** during **electrolysis** of **copper(II) sulphate solution**.

The impure copper anode **dissolves** in solution to form **copper(II) ions** which are then deposited at the cathode as **pure copper**.

At anode; $Cu(s) \longrightarrow Cu^{2+}(aq) + 2e$

At cathode; $Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$

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(d) This is because, during copper extraction, **sulphur dioxide** is produced as a byproduct and this sulphur dioxide can then be **purified, dried** and mixed with oxygen in presence of **vanadium(V) oxide catalyst** at a **low temperature** and high pressure to **form sulphur trioxide** which can then be converted to sulphuric acid.

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

17. (a) (i) The sum of the powers of the **molar** concentrations of the reactants in the experimentally determined rate equation.

or; The power to which the molar concentration of a reactant is raised in the experimentally determined rate equation

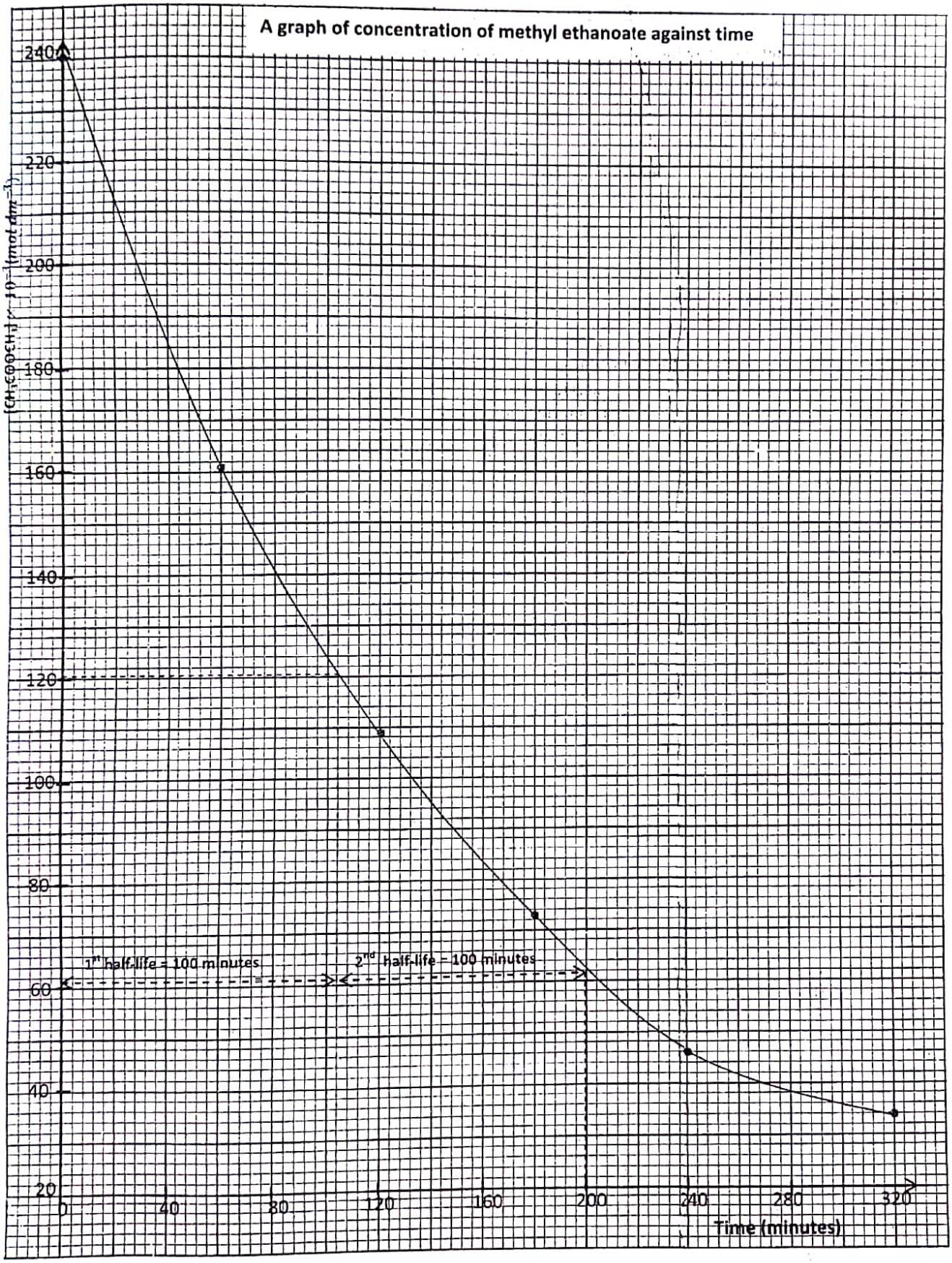
(ii) Time taken for half of the original amount of substance to react.

or: Time taken for the concentration of a reactant to reduce to half its original value.

(b)



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(c) (i) Half life of reaction $= \frac{1^{st}\ half-life + 2^{nd}\ half-life}{2}$

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$= \frac{100 + 100}{2} = 100$ minutes

(ii) **First order,** because the half life of the reaction is **constant**

(e) For a first order reaction;

$Kt_{½} = \ln 2$ (where k = rate constant and $t_{½}$ = half life)

Rate constant; $k = \frac{ln2}{t_{½}}$

$= \frac{0.693}{100} = 0.00693$ **minute^{-1}**

QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2017

Question one

(a) The rate of a chemical reaction can be affected by the concentration of the reactants. State two other factors that can affect the rate of a chemical reaction. (2 marks)

(b) Describe an experiment to determine the rate of decomposition of hydrogen peroxide. (7 marks)

(c) The table below shows variation in the concentration of sodium thiosulphate with time when a fixed volume of hydrochloric acid was added to sodium thiosulphate of various concentration.

Concentration of sodium thiosulphate (**mol dm^{-3}**)	0.2	0.16	0.12	0.08	0.04
Time, $t(s)$	24	29	39	60	138
$^{1}/_{Time}$, $^{1}/_{t}$ (s^{-1})					

(i) Copy the table and fill in the values of $^{1}/_{t}$ (2 marks)

(ii) Plot a graph of $^{1}/_{t}$ against concentration of sodium thiosulphate. (4 marks)

(iii) What is the other of the reaction? Give a reason for your answer. (2 marks)

(iv) Calculate the rate constant of the reaction and indicate its units. (2 marks)

(v) Determine the time taken for the concentration of sodium thiosulphate to decrease from 0.2 moldm^{-3} to 0.1 mol dm^{-3}. (1 mark)

Question Two

Magnesium, aluminium, silicon and sulphur are some of the elements in period 3 of the Periodic Table.

(a) (i) Draw and name the structures of magnesium oxide, silicon(IV) oxide and sulphur dioxide. *(06 marks)*

(ii) Name the type of bonding in each of the following; magnesium oxide, silicon(IV) oxide and sulphur dioxide. *(1½ marks)*

(b) Explain the variation in the nature of the oxides of the elements of period 3 of the Periodic Table. *(4½ marks)*

(c) Write equation where applicable to show the reaction of magnesium oxide, aluminium oxide and sulphur dioxide with excess:

(i) sodium hydroxide. *(03 marks)*

(ii) hydrochloric acid. *(03 marks)*

(d) Sulphur dioxide was bubbled through acidified potassium dichromate(VI) solution. State what was observed and write equation for the reaction that took place. *(02 marks)*

Question Three

(a) (i) Define the term **buffer solution.** *(01 mark)*

(ii) Describe how an acidic buffer solution of pH 3.5 can be prepared using methanoic acid of pKa value 3.75. *(4½ marks)*

(iii) Explain how an acidic buffer solution works. *(06 marks)*

(b) Benzoic acid ionises in water according to the following equation.

$C_6H_5CO_2H_{(aq)} + H_2O_{(l)} \rightleftharpoons C_6H_5CO_2^-{}_{(aq)} + H_3O^+_{(aq)}$

(i) Write an expression for the ionisation constant Ka for benzoic acid. (01 mark)

(ii) Using the expression in b(i), calculate the ratio of the concentration of benzoate ions to the

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concentration of benzoic acid in a solution of pH 4 and also in a solution of pH 6. *(Ka for benzoic acid = 6.3 × 10^{-5}mol dm^{-3})* (3½ marks)

(iii) At which of the two pH values would better buffering occur? Give a reason for your answer. (02 marks)

(c) State **one** biological and **one** industrial application of buffer solution. (02 marks)

Question four

(a) (i) Write an equation for the reaction in which 2-chloropropane can be obtained from propane. (1½ marks)

(ii) Outline a mechanism for the reaction leading to the formation of 2-chloropropane in (a)(i) above. (2½ marks)

(iii) Write equation to show how 2-chloropropane can be converted to propyne. (your answer should include reagents and conditions) (5 marks)

(b) (i) Name one reagent which can be used to differentiate between propyne and but-2-yne. (1 marks)

(ii) State what would be observed if propyne and but-2-yne were separately treated with the reagent you have named in (b)(i). (2 marks)

(iii) Write equation to illustrate your observation in (b) (ii). (1 mark)

(c) Write:

(i) equation(s) to show how 2-methylpropanoic acid can be prepared from 2-chloropropane. (2½ marks)

(ii) the mechanism for the reaction of 2-methylpropanoic acid with methanol in the presence of concentrated sulphuric acid. (4½ marks)

Question five

(a) When a mixture of water and methanol is distilled, a constant boiling mixture containing 85% methanol is obtained at 70°C. (*The boiling point of pure water and methanol are 100% and 75°C respectively.)*

(i) Draw a boiling point-composition diagram for the mixture of methanol and water (5 marks)

(ii) Explain the shape of your diagram. (4 marks)

(iii) Describe what would happen if a mixture containing less than 80% methanol was fractionally distilled. (3 marks)

(b) (i) Calculate the vapour pressure of a solution containing 18.5g of a non-volatile solute X in 30g of solvent Y at 298K. (*The molecular masses of X and Y are 280 and 74 respectively; the vapour pressure of Y is 1.2× $10^4 NM^{-2}$ at 298K*) (4 marks)

(ii) Explain the effect of increasing the concentration of X on the boiling point of Y. (4 marks)

Question six

(a) Describe how iron can be extracted from iron (III) carbonate ore. (your answer should include equations for the relevant reactions) (7 marks)

(b) Write equations and state the conditions for the reaction between iron and

(i) Oxygen (2 marks) (ii) Water (2½ marks)

(c) State how the following chlorides can be prepared in the laboratory in the anhydrous forms. (your answer should include equations)

(i) Iron (II) chloride. (2½ marks) (ii) Iron (III) chloride. (2½ marks)

(d) State what would be observed and write equation for the reaction that would take place if solutions containing iron (II) ions and iron (III) ions were separately treated with potassium thiocyanate (KSCN) solution. (3½ marks)

Question Seven

Explain each of the following observations and where applicable illustrate your answers with equations(s)

(a) Although benzene has carbon-carbon double bonds, it does not readily undergo addition reactions (3 marks)

(b) Ethanamide, CH_3CONH_2 is a weaker base than ethylamine. (3 marks)

(c) Magnesium ion reacts with hydrogen sulphide in alkaline medium to form a precipitate, whereas it does not form a precipitate in acidic medium (5½ marks)

(d) The boiling points of pentane and 2, 2-dimethylpropane are 36°C and 10°C respectively yet the two compounds have the same molecular masses. (4½ marks)

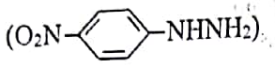
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(e) When lead (IV) oxide was added to a solution containing manganese (II) sulphate concentrated nitric acid and the mixture boiled, the colour of the solution change from pale pink to purple. (4 marks)

Question Eight

Write equation(s) and each case state the conditions and outline a mechanism for the reaction of

(a) Benzene with:
- (i) nitric acid, (4½ marks)
- (ii) sulphuric acid (4½ marks)
- (iii) (iii) but-1-ene. (4 marks)

(b) ethanal with:
- (i) 4-nitrophenylhrazine  (5 marks)
- (ii) Acidified potassium cyanide. (2 marks)

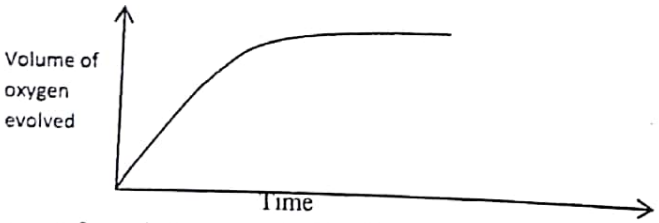
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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2017

Question. One.

(a) -Temperature,
-Catalyst
-Surface area or particle size of solid reactants

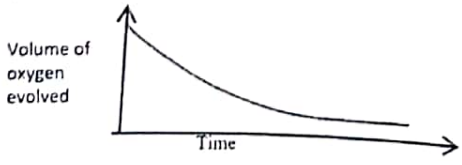
(b) -A **known volume** of a standard solution of hydrogen peroxide is placed in a reaction flask connected to a **gas syringe**.
- A small amount of catalyst, **iron (III) chloride** solution is added followed by a small amount of sodium hydroxide solution and a **stop clock started**
- The mixture is shaken and allowed to settle at a **constant temperature.**
-The **volume of oxygen** gas evolved is recorded at specific time intervals
- A **graph of volume of oxygen against time** is plotted and the shape below is obtained



-The rate of reaction at a specific time is determined by **drawing a tangent** on the curve at that point and the **gradient** of the curve at that point is **calculated** and is the rate of the reaction.

Alternatively;

-A **known volume** of standard solution of hydrogen peroxide is placed in reaction flask.
-A small amount of **iron (III) chloride** catalyst is added followed by a small amount of **sodium hydroxide solution** and a **stop clock started.**
-The mixture is **shaken** and allowed to settle at a **constant temperature.**
-After specific time intervals, dilute sulphuric acid is added to stop the decomposition of hydrogenperoxide.
-The reaction mixture is then titrated with a standard solution of **potassium manganate (VII)**
-The experiment is **repeated** several times by changing the time taken for the reaction to take place before the acid is added
-A **graph of volume potassium manganate (VII) solution used against time is plotted** and the shape below is obtained



-The rate of reaction is determined by **drawing a tangent** at a particular time and the **slope of the tangent is calculated** and is **equal to the rate of reaction**

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(c) (i)

Concentration of sodium thiosulphate ($moldm^{-3}$)	0.2	0.16	0.12	0.08	0.04
Time (s)	24	29	39	60	138
$\frac{1}{time}, \frac{1}{t}(s^{-1}) \times 10^{-3}$	42.0	34.5	26.0	17.0	7.2

(ii) See graph next page

(iii) First order reaction, because the graph is a **straight line through the origin**

(iv) Rate constant $= slope\ of\ the\ graph$

$$\text{Slope} = \frac{(38.5-8.5)\times10^{-3}}{(18.4-4.0)\times10^{-2}} = \mathbf{0.21 mol^{-1} dm^3 S^{-1}}$$

(v) Time at $0.2 moldm^{-3}$ is 24seconds (from table)

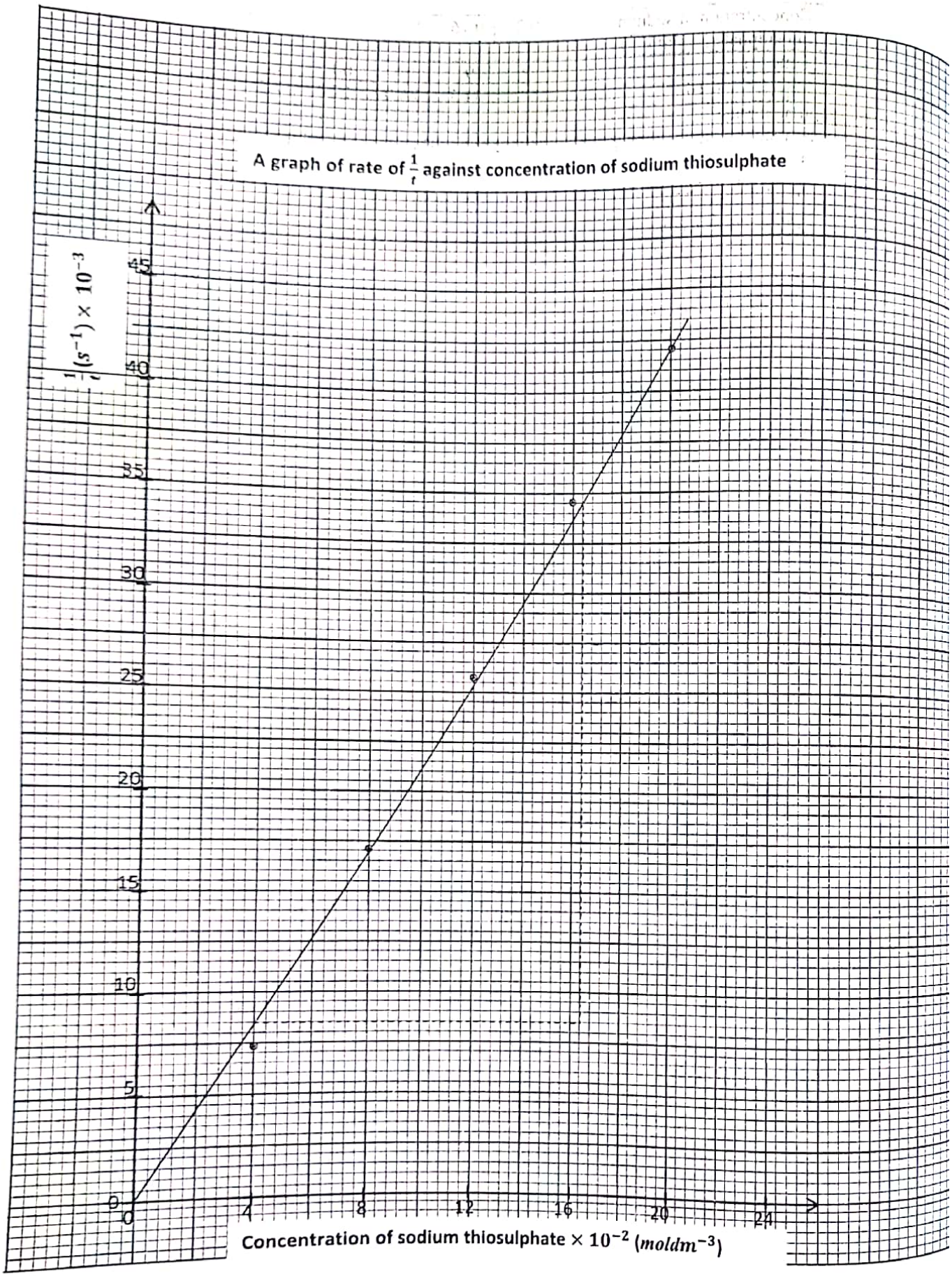
From the graph $= \frac{1}{t}\ at\ 0.1 moldm^{-3} = 0.021 second^{-1}$

Hence; time at $0.1 moldm^{-3} = \frac{1}{0.021} \cong 47.6 seconds$

Thus; time taken for the concentration of thiosulphate to reduce from $0.2 moldm^{-3}$ to $0.1 moldm^{-3}$;

$= 47.6 - 24 = 23.6\ seconds$

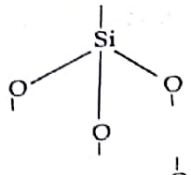
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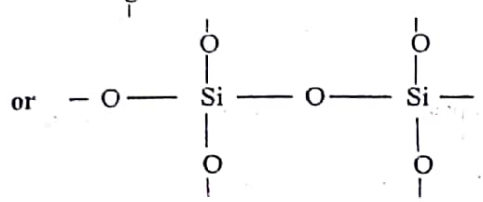
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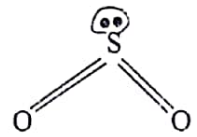
Question. Two.

(a) (i) $Mg^{2+}O^{2-}$ Giant ionic



Tetrahedral

or  Giant covalent or Giant atomic structure



Simple molecular or V-shape or bent-shape

(ii) Magnesium oxide – ionic bond or Electrovalent bond
Silicon (IV) oxide - covalent bond
Sulphaur dioxide - covalent bond

(b) Nature of the oxides changes from **basic, amphoteric** to **acidic** across the period
or; Nature of the oxides changes from **basic** to **acidic** across the period.
This is because across the period, **metallic character decreases** or electronegativity increases or electropositivity decreases or non metallic character increases.

(c) (i) $SO_2(g) + 2\bar{O}H(aq) \longrightarrow SO_3^{2-}(aq) + H_2O(l)$
$Al_2O_3(s) + 2\bar{O}H(aq) \longrightarrow 2AlO_2^-(aq) + H_2O(l)$
or; $Al_2O_3(s) + 6\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_6^{3-}(aq)$
$Al_2O_3(s) + 2\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_4^-(aq)$
(ii) $MgO(s) + 2H^+(aq) \longrightarrow Mg^{2+}(aq) + H_2O(l)$
$Al_2O_3(s) + 6H^+(aq) \longrightarrow 2Al^{3+}(aq) + 3H_2O(l)$

(d) The solution turned from orange to green.
$Cr_2O_7^{2-}(aq) + 2H^+(aq) + 3SO_2(g) \longrightarrow 2Cr^{3+}(aq) + 3SO_4^{2-}(aq) + H_2O(l)$

Question. Three.

(a) (i) A solution which **resists** change in pH when a **small** amount of acid or base is added to it.

(ii) $HCOOH(aq) \rightleftharpoons HCO\bar{O}(aq) + H^+(aq)$

$$Ka = \frac{[HCO\bar{O}][H^+]}{[HCOOH]}$$

$$\frac{Ka}{[H^+]} = \frac{[HCO\bar{O}]}{[HCOOH]}$$

$$Ka = log^{-1}(3.75) = 1.78 \times 10^{-4} moldm^{-3}$$

$$[H^+] = log^{-1}(-3.5) = 3.16 \times 10^{-4} moldm^{-3}$$

$$\frac{[HCO\bar{O}]}{[HCOOH]} = \frac{1.78 \times 10^{-4}}{3.76 \times 10^{-4}} = \frac{0.562}{1}$$

0.562 moles of sodium methanoate with 1.0mole of methanoic acid are dissolved in water to make one litre of solution

or; $\frac{[HCOOH]}{[HCO\bar{O}]} = \frac{3.16 \times 10^{-4}}{1.78 \times 10^{-4}} = \frac{1.78}{1}$

1.78moles of methanoic acid is mixed with 1mole of sodium methanoate and dissolved in water to make one litre of solution.

$$pH = PKa + log\left(\frac{[salt]}{[acid]}\right)$$

$$3.5 = 3.75 + \log\left(\frac{[salt]}{[acid]}\right)$$

$$\frac{[HCO\bar{O}]}{[HCOOH]} = \frac{0.562}{1}$$

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0.562 mole of sodium methanoate is mixed with 1.0moles of methanoic acid dissolved in water to make 1 litre of solution

(iii) An acidic buffer consists of a **weak acid** and its **salt** formed from a **strong base** e.g ethanoic acid and sodium ethanoate.

The salt is fully dissociated **ie**

$CH_3\,COONa(aq) \longrightarrow CH_3CO\bar{O}(aq) + Na^+(aq)$

A weak acid is partially ionized;

$CH_3\,COOH(aq) \rightleftharpoons CH_3\,CO\bar{O}(aq) + H^+(aq)$

or $CH_3\,COOH(aq) + H_2O(l) \rightleftharpoons CH_3\,CO\bar{O}(aq) + H_3O^+(aq)$

The ionization of the weak acid is **suppressed** by the anions from the salt. The solution contains high concentration of acid molecules and anions from the salt.

- When a **small amount of acid** is added, the hydrogen ions react with the ethanoate ions to form ethanoic acid molecules.

$CH_3\,CO\bar{O}(aq) + H^+(aq) \longrightarrow CH_3\,COOH(aq)$

-When a small amount of alkali is added, the hydroxide ions react with the weak acid to form the anions of the salt and water.

$CH_3\,COOH(aq) + \bar{O}H(aq) \longrightarrow CH_3\,CO\bar{O}(aq) + H_2O(l)$

or The hydroxide ions react with hydrogen ions to form water;

$H^+(aq) + \bar{O}H(aq) \longrightarrow H_2O(l)$

This causes **more ionization** of the weak acid molecules to replace the hydrogen ions

$CH_3\,COOH(aq) \rightleftharpoons CH_3CO\bar{O}(aq) + H^+(aq)$

(b)(i) $Ka = \frac{[C_6H_5\bar{O}_2][H_3O^+]}{[C_6H_5CO_2H]}$

(ii) $\frac{Ka}{[H_3O^+]} = \frac{[C_6H_5C\bar{O}_2]}{[C_6H_5CO_2H]}$

At $pH = 4;\ [H^+] = 1.0 \times 10^{-4} moldm^{-3}$

$$\frac{[C_6H_5\bar{O}_2]}{[C_6H_5CO_2H]} = \frac{6.3 \times 10^{-5}}{1.0 \times 10^{-6}} = 63$$

(iii) There is **better buffering** at pH 4 because the concentration of the salt is almost equal to the concentration of the acid

or Because the pH of solution is almost equal to the Pka of the acid;

$PKa = -\log(6.3 \times 10^{-5}) = 4.2$

(c) **Biological applications**

-maintainance of blood pH

Industrial applications

-Fermentation process

-manufacture of medicine

Question. Four.

(a)

(i) $CH_3\,CH_2\,CH_3 \xrightarrow{Cl_2/u.vlight} CH_3\,\underset{Cl}{CH}\,CH_3$

or; $CH_3\,CH_2\,CH_3 \xrightarrow[700°C]{Al_2O_3/Cr_2O_3} CH_3\,CH=CH_2 \xrightarrow{HCl} CH_3\,\underset{Cl}{CH}\,CH_3$

(ii) Mechanism for first option

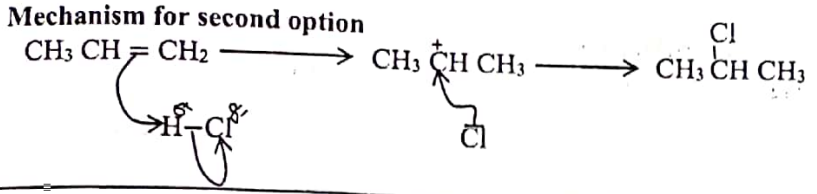
$Cl_2 \xrightarrow{Cl_2/u.vlight} 2Cl^{\bullet}$

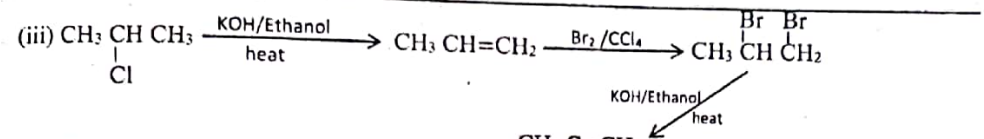
$CH_3\,CH_2\,CH_3 + Cl^{\bullet} \longrightarrow CH_3\,\overset{\bullet}{C}H\,CH_3 + HCl$

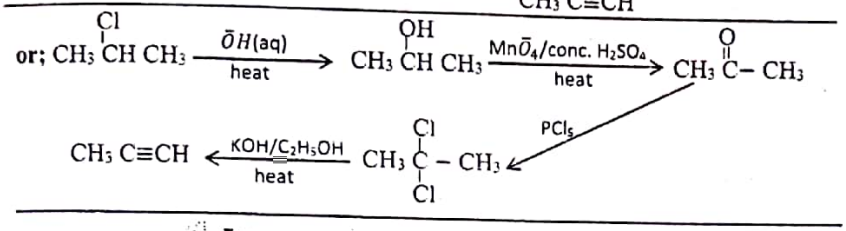
$CH_3\,\overset{\bullet}{C}H\,CH_3 + Cl_2 \longrightarrow CH_3\,\underset{Cl}{CH}\,CH_3 + Cl^{\bullet}$

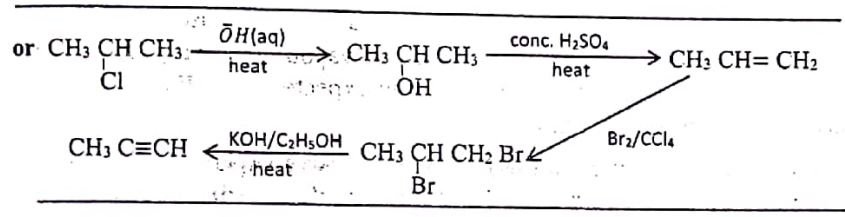
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Mechanism for second option









(b) (i) Ammoniacal silver nitrate solution
or; Ammoniacal copper (I) chloride solution

(ii) propyne –gives a **white precipitate** (with ammoniacal silver nitrate solution) and a **red precipitate** with ammoniacal copper (I) chloride solution

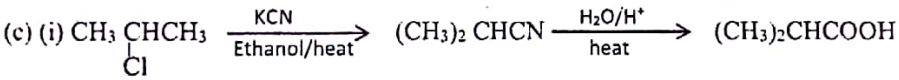
But-2-yne – gives **no observable change** with each of the reagents named in (b)(i)

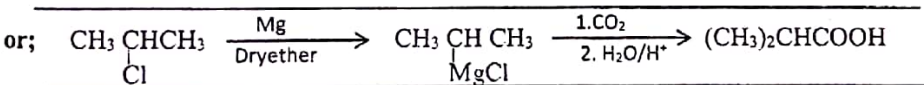
(iii) Equation of reaction with ammoniacal copper (I) chloride

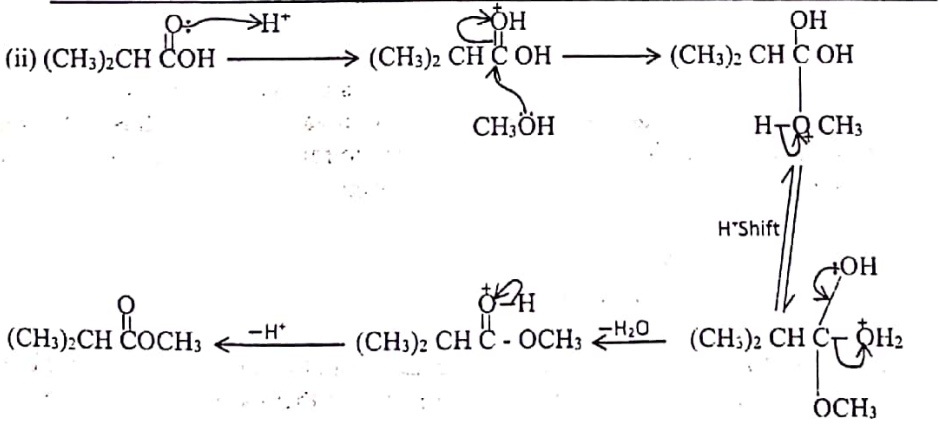
$$CH_3C{\equiv}CH + Cu^+ + NH_3 \longrightarrow CH_3C{\equiv}\bar{C}\,Cu^+ + NH_4^+$$

Equation of reaction with ammoniacal silver nitrate solution

$$CH_3C{\equiv}CH + Ag^+ + NH_3 \longrightarrow CH_3C{\equiv}\bar{C}\,Ag^+ + NH_4^+$$



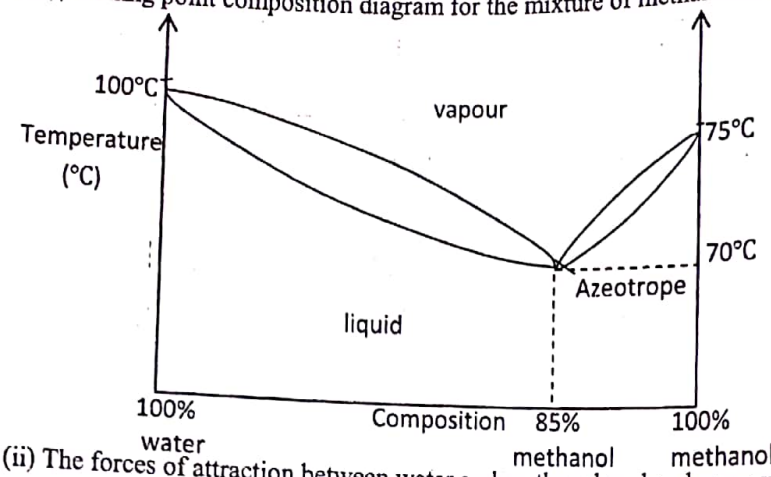




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Question. Five.

(a)(i) Boiling point composition diagram for the mixture of methanol and water



(ii) The forces of attraction between water and methanol molecules are **weaker** than those between pure molecules. The escaping tendency of the molecules in the mixture into vapour phase is **greater** than if the mixture is ideal. The vapour pressure of the mixture is higher than expected from Raoult's law. The mixture therefore **deviates positively** from Raoult's law.

(iii) The mixture **boils** to give a vapour which is **richer in methanol. Successive vapourisation and condensation** results into separation of **pure water** from the mixture **as the residue** and the **azeotropic mixture as the distillate.**

(b) (i) Moles of solute $X = \frac{18.5}{280} = 0.066 moles$

Moles of solvent $Y = \frac{30}{74} = 0.405 moles$

Total number of moles; $= 0.066 + 0.405 = 0.471 moles$

$V.P\ of\ solution = V.P\ of solute + V.P\ of solvent$

$V.P\ of\ solution = (v.pressure\ of\ Y) \times mole fraction\ of\ Y$

$= 1.2 \times 10^4 \times \frac{0.405}{(0.066+0.405)} \quad = 1.032 \times 10^4 NM^{-2}$

Or; $\frac{Psolvent - Psolution}{Psolvent} = Mole\ fraction\ of\ solute$ (P stands for vapour pressure)

$\frac{(1.2\times10^4) - Psolution}{1.2\times10^4} = \frac{0.066}{0.471}$

$Psolution = 1.032 \times 10^4 Nm^{-2}$

Or; $\frac{Psolvent - Psolution}{Psolvent} = \frac{mass\ of\ solute \times Rmm\ of\ solvent}{mass of\ solvent \times Rmm\ of\ solute}$

$\frac{1.2\times10^4 - Psolution}{1.2\times10^4} = \frac{18.5}{30} \times \frac{74}{280}$

$Psolution = 1.0044 \times 10^4 Nm^{-2}$

(ii) Increase in the concentration of X **increases the boiling point of Y**. this is because particles of X on the surface of solution **reduces the escaping tendency** of the solvent Y into vapour phase, thus **reducing the vapour pressure of the solution. More heat** is therefore required to raise the vapour pressure of the solution to **external atmospheric pressure**, hence a higher boiling point.

Question. Six.

(a) -Iron (II) carbonate is **roasted** in air to form **Iron (III) oxide**

$4FeCO_3(s) + O_2(g) \longrightarrow 2Fe_2O_3(s) + 4CO_2(g)$

-Iron (III) oxide, coke and lime stone are fed into the blast furnace from the top while **hot air** is blown into the furnace from the bottom, Iron (III) oxide is **reduced** to iron by either carbon monoxide or carbon;

$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(l) + 3CO_2(g)$

or $Fe_2O_3(s) + 3C(s) \longrightarrow 2Fe(l) + 3CO(g)$

-Lime stone decomposes to form **calcium oxide** which then reacts with the impurity which is silicon (IV) oxide to form **molten slag**

$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$

$CaO(s) + SiO_2(s) \longrightarrow CaSiO_3(l)$

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Molten iron is collected at the bottom of the furnace.

(b) (i) **Condition: Heated** Iron

Equation:

$3Fe(s) + 2O_2(g) \longrightarrow Fe_3O_4(s)$

or; $4Fe(s) + 3O_2(g) \longrightarrow 2Fe_2O_3(s)$

alternatively,

Condition: Moist oxygen

Equation:

$4Fe(s) + 2\times H_2O(l) + 3O_2(g) \longrightarrow 2Fe_2O_3 \cdot \times H_2O(s)$

(ii) **Conditions: Heat** and **Steam**

Equation:

$3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$

(c) (i) **Dry** hydrogen chloride gas is passed over **heated** Iron

$2Fe(s) + 2HCl(g) \longrightarrow FeCl_2(s) + H_2(g)$

(ii) **Dry** chlorine is passed over **heated** Iron

$2Fe(s) + 3Cl_2(g) \longrightarrow 2FeCl_3(s)$

or $2Fe(s) + 3Cl_2(g) \longrightarrow Fe_2Cl_6(g)$

(d) Fe^{2+}; Gives no observable change

Fe^{3+}; Gives a blood red **solution** (colourartion)

$Fe^{3+}(aq) + SCN^-(aq) \longrightarrow FeSCN^{2+}(aq)$

or; $Fe(H_2O)_6^{3+}(aq) + SCN^-(aq) \longrightarrow [Fe(H_2O)_3SCN]^{2+}(aq) + 3H_2O(l)$

or; $Fe(H_2O)_6^{3+}(aq) + 3SCN^-(aq) \longrightarrow [Fe(H_2O)_3(SCN)_3](aq) + 3H_2O(l)$

or; $Fe^{3+}(aq) + 3\ SCN^-(aq) \longrightarrow Fe(SCN)_3(aq)$

Question. Seven.

(a) The carbon-carbon double bonds (π −electrons) in benzene are **delocalized**. This makes benzene **more stable,** and hence unable to undergo addition reactions.

(b) The ethyl group in ethylamine has a **positive inductive** effect which **increases the availability of lone** pairs of electrons on nitrogen atom thus making ethylamine able to easily accept a proton. But;
In ethanamide the carbonyl group has a negative **inductive effect** which makes the lone pairs of electrons on nitrogen atom **less available** to accept a proton.

or;The lone pairs of electrons on the nitrogen atom **interacts with π- electrons** on the carbonyl group thus making the lone pair of electrons in the ethanamide less available to accept a proton.

(c) Hydrogen sulphide is a weak acid and hence ionizes as follows:

$H_2S(aq) \longrightarrow 2H^+(aq) + S^{2-}(aq)$

In alkaline solution, the hydroxide ions react with hydrogen ions to form water

$H^+(aq) + \bar{O}H(aq) \longrightarrow H_2O(l)$

This **promotes ionization** of hydrogen sulphide and increases the concentration of sulphide ions
The sulphide ions react with magnesium ions to form **insoluble magnesium sulphide**

$Mg^{2+}(aq) + S^{2-}(aq) \longrightarrow MgS(s)$

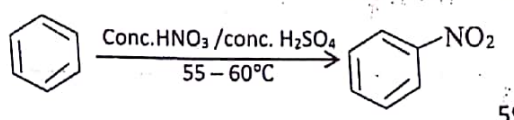
In acidic medium the ionization of hydrogen sulphide is **suppressed** and this makes the sulphide ion **concentration to be low**, hence not sufficient to **cause precipitation** of magnesium sulphide. (or The solubility product, Ksp of magnesium sulphide is not exceeded)

(d) Pentane molecules are **more closely packed** because they are in a **straight chain**. This makes the **vander waals** forces between the molecules **stronger** and hence require more heat energy to be broken.
2, 2-dimethyl propane molecules are **branched** and hence not **closely packed. The vander waals forces** between the molecules are **weaker** than those in Pentane, and thus require less heat energy to be broken.

(e) In the presence of concentrated nitric acid, lead (IV) oxide, **Oxidises** Manganese (II) ions to **manganate (VII)** ions

$2Mn^{2+}(aq) + 5PbO_2(s) + 4H^+(aq) \longrightarrow 5Pb^{2+}(aq) + 2MnO_4^-(aq) + 2H_2O(l)$

Question. Eight.

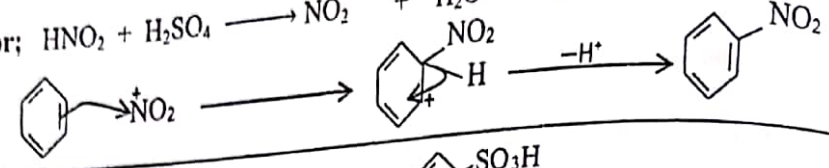
(a) (i) 

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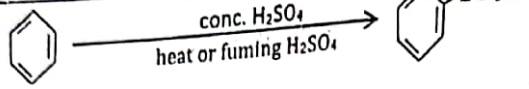
Mechanism

$2H_2SO_4 + HNO_3 \rightleftharpoons \overset{+}{N}O_2 + H_3O^+ + 2HSO_4^-$

or; $HNO_2 + H_2SO_4 \longrightarrow \overset{+}{N}O_2 + H_2O + HSO_4^-$



(ii)

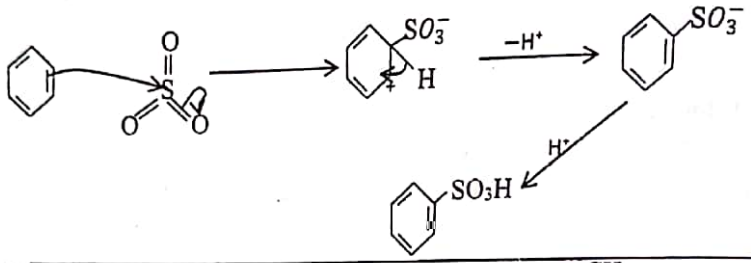


Mechanism;

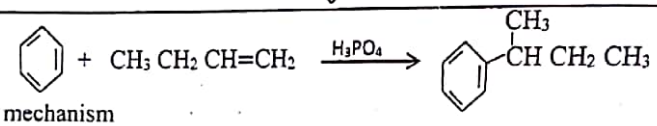
$2H_2SO_4 \rightleftharpoons SO_3 + H_3O^+ + HSO_4^-$

or; with fuming H_2SO_4

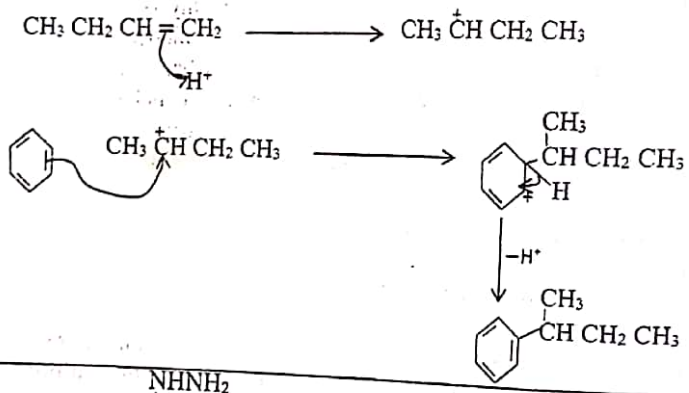
$H_2SO_4 \rightleftharpoons SO_3 + H_2O$



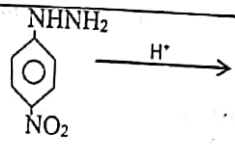
(iii)



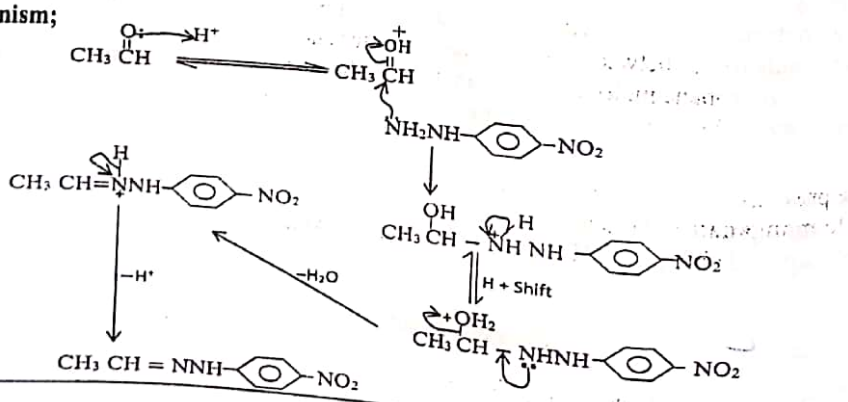
mechanism



(b) (i) CH_3CHO +



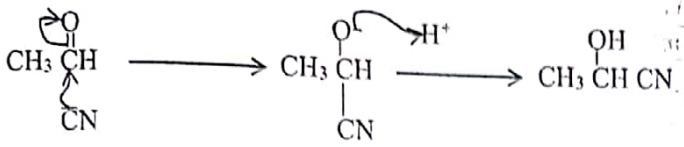
Mechanism;



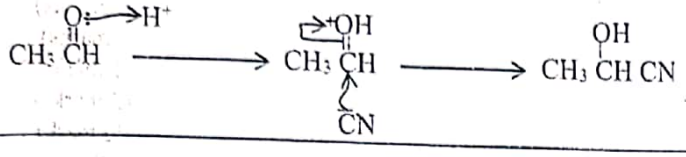
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(ii) $CH_3CHO + \bar{C}N \xrightarrow{H^+} CH_3\underset{OH}{\underset{|}{C}}HCN$

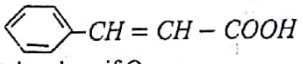
Mechanism;



or



QUESTIONS TO 'A' LEVEL CHEMISTRY PAPER 1 (P525/1), 2016

1. Complete the following equations for nuclear reactions
   (a) $^{239}_{94}Pu + {}^{4}_{2}He \longrightarrow$ .....+ $2{}^{1}_{0}n$ (1 mark)
   (b) .....$\longrightarrow {}^{234}_{90}Th + {}^{4}_{2}\alpha$ (1 mark)
   (c) $^{214}_{83}Bi \longrightarrow {}^{206}_{82}Pb +$ .....+ $2{}^{4}_{2}He$ (1 mark)
   (d) $^{250}_{98}Cf +$ .....$\longrightarrow {}^{257}_{103}Lw + 4{}^{1}_{0}n$ (1 mark)
2. The first three successive ionization energies of element Y are 549, 1064 and 4226 $klmol^{-1}$
   (a) Explain the trend in the variation of the ionization energies of Y. (3½ marks)
   (b) State the group in the Periodic Table to which Y belongs.
3. Complete the equation below and write the mechanism for the reaction.
   $CH_3CH = CH_2 + Br_2 \xrightarrow{H_2O(l)}$ (4 marks)
4. (a) Write
   (i) equation for the ionization of benzoic acid in water. (1½ marks)
   (ii) the expression for the ionization constant, K_a, of benzoic acid (1 mark)
   (b) Calculate the pH of a 0.1M solution of benzoic acid. ($K_a = 6.3 \times 10^{-3}\ mol\ dm^{-3}$) (3 mark)
5. (a) 10 cm^3 of hydrocarbon P. (C_xH_y) was exploded in 90cm^3 of oxygen. On cooling to room temperature, the residual gases occupied 70 cm^3. When the residual gases were passed through potassium hydroxide solution, the volume reduced to 40 cm^3.
   (i) Write equation for the reaction between P and oxygen
   (ii) Determine the molecular formula of P. (3 marks)
   (b) Write equations to show how P can be prepared from an alcohol. (2 marks)
6. When compound W was steam distilled at 86°C and 760mmHg pressure, the distillate contained 85% of water by mass, calculate the relative molecular mass of W.
   (The vapour pressure of water at 86°C and 760mmHg) (4 marks)
7. An organic compound Q has the structure 
   (a) Write equation for the reaction that would take place if Q was
   (i) Heated together with methanol in the presence of concentrated sulphuric acid (1 mark)
   (ii) Treated with aqueous solution of alkaline potassium manganate (VII). (1 mark)
   (iii) Treated with hydrogen bromide. (1 mark)
   (b) Write a mechanism for the reaction in (a) (iii) (2 marks)
8. (a) 2.0g of phosphorous raises the boiling point of 37.4g of carbon disulphide by 1.003°C, whereas 4.65g of sulphur raises the boiling of 100g of carbon disulphide by 0.42°C. calculate the
   (i) Boiling point constant of carbon disulphide.(Molar mass of sulphur is 256) (2 marks)
   (ii) Molar mass of phosphorous in carbon disulphide (2 marks)
   (b) Determine the molecular formula of phosphorous. (1½ marks)
9. (a) State two reasons why fluorine is more reactive than the other elements in group VII in the Periodic Table. (2 marks)
   (b) Write equation for the reaction between fluorine and
   (i) water (1½ marks)
   (ii) cold dilute sodium hydroxide solution (1½ marks)

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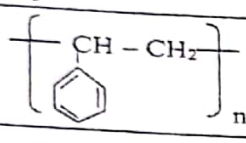
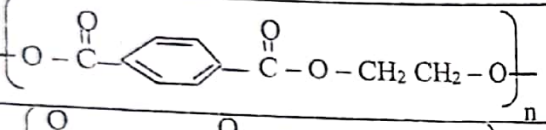
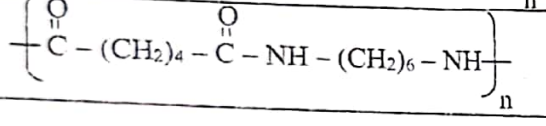
(iii) Hot concentrated sodium hydroxide solution (1½ marks)

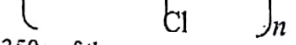
10. (a) Explain what is meant by molar conductivity.
(b) Molar conductivities at infinite dilution, Λ_∞ for some compounds at 25°C are given in the table below.

Compound	$\Lambda_\infty\ (\Omega^{-1}cm^2mol^{-1})$
$Na_2C_2O_4$	248
H_2SO_4	860
Na_2SO_4	260
$(NH_4)_2SO_4$	308

Calculate the molar conductivity at infinite dilution for
(i) $H_2C_2O_4$ (2 marks) (ii) $(NH_4)_2C_2O_4$ (2 marks)
(c) Explain your answer in (b) (3marks)
(d) State two applications of conductivity measurements. (1 mark)

11. (a) (i) State what is meant by the term thermosetting plastics. (2 marks)
(ii) Name one thermosetting plastic (½ mark)
(b) The structural formulae of some polymers are shown in the table below. For each polymer, write the names(s) of monomer(s) (2½ marks)

Polymer	Name of monomer (s)
	
	
	

(c) The structural formula of a polymer, Z is 

9.89×10^{-2} moles of Z was formed when 350g of the monomer was polymerized. Calculate the
(i) value of n (H = 1; C = 12; Cl = 35.5)
(ii) molar mass of the polymer (3 marks)

12. (a) (i) Write the electronic configuration of chromium atom. (1 mark)
(ii) State why chromium is classified as a transition element. (1 mark)
(b) Write the formulae of all the possible isomers of chromium (III) chloride -6- water, $CrCl_3 \cdot 6H_2O$. (½ mark)
(c) To an aqueous solution of chromium (III) chloride, was added ammonia solution drop-wise until in excess. (3 marks)
(i) State what was observed.
(ii) Write equations for the reactions that took place. (1½ marks)

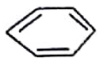
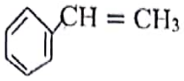
13. Name a reagent that can be used to distinguish between the following pairs of ions. Tn each case, state what would be observed if each ion is separately treated with the reagent you have named. (3 marks)
(a) $Ba^{2+}(aq)$ and $Ca^{2+}(aq)$ (3 mks) (b) $Br^-(aq)$ and $Cl^-(aq)$ (3 mks) (c)$CH_3CO_2^-(aq)$ and $Cr_2O_4^{2-}(aq)$ (3 mks)

14. Methane reacts with stream according to the following equation: $CH_4(g) + 2H_2O(l) \rightleftharpoons CO_2(g) + 4H_2(g)$
When 0.625 moles of methane and 3.0 moles of water were heated in a $4dm^3$ vassel, 2.0 moles of hydrogen was found to be present at equilibrium.
(a) (i) Write an expression for the equilibrium constant, K_c. (1 mark)
(ii) Calculate the value of K_c (3 marks)
(b) The enphalpies of formation of methane, water and carbon dioxide are $-76, -242\ and\ -394 kJmol^{-1}$ respectively.
(i) Calculate the enthalpy change for the forward reaction. (3 marks)
(ii) State the effect of increasing temperature on the value of K_c and give a reason for your answer.

15. State what would be observed and write equation for the reaction that would take place when
(a) Hydrogen sulphide gas is bubbled through an acidified solution of potassium dichromate (VI). (3 marks)
(b) A mixture of propanal and Fehling's solution is heated. (2 marks)
(c) A mixture of methanoic acid and ammoniacal silver (I) nitrate is heated (2 marks)
(d) Aqueous solution of iodine and sodium hydroxide is warmed with proanone. (2 marks)

16. Write equations to show how the following conversions can be carried out
(a) $CH_3CH = CH_3$ to $CH_3 - \underset{\underset{Cl}{|}}{\overset{\overset{Cl}{|}}{C}} - CH_3$ (2 ½ marks)

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(b)  to  (3 ½ marks)

(c) CH_3CH_2Cl to CH_3CONH_2 (3½ marks)

(a) (i) Write the formula and the name of one ore from which aluminium can be extracted. (1mark)

(ii) Name two main impurities in the ore you have named in (b) (i) (1 mark)

(b) In the extraction of aluminium, after the removal of the impurities, the ore is mixed with cryolite and then electrolysed to extract aluminium.

(i) State the purpose of adding cryolite. (1 mark)

(ii) Name the electrode used in the electrolysis (½ *mark*)

(iii) Write equation for the reaction that takes place at the cathode during the electrolysis

(c) Aluminium powder was added to dilute sodium hydroxide solution.

(i) State what was observed. (1½ marks)

(ii) Write equation for the reaction that took place. (1½ marks)

Dry chlorine was passed over heated aluminum. Write equation for the reaction that took place.

END

SOLUTIONS TO 'A' LEVEL CHEMISTRY PAPER 1(P525/1), 2016

(a) $^{239}_{94}Pu + {}^{4}_{2}He \longrightarrow {}^{241}_{96}Cm + 2{}^{1}_{0}n$

(b) $^{238}_{92}U \longrightarrow {}^{234}_{90}Th + \propto$

(c) $^{214}_{83}Bi \longrightarrow {}^{206}_{82}Pb + 3\,{}^{0}_{-1}e + 2{}^{4}_{2}He$

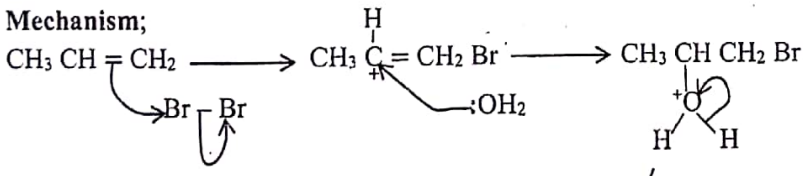
(d) $^{250}_{98}Cf + {}^{11}_{5}B \longrightarrow {}^{257}_{103}Lw + 4{}^{1}_{0}n$

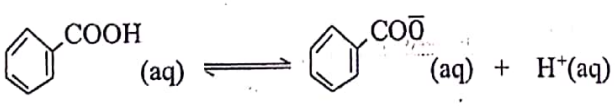
(a) The Ionization energy **increases from the first to the second and to the third ionization energy**
This is because as the **successive electron is removed**, the **number of protons** in the nucleus **becomes greater than the remaining electrons**, making the **effective nuclear charge to be high** and thus the remaining electrons experience **stronger nuclear attraction** and thus **a lot of energy** is needed to remove the outer electron.
However, there is a **larger difference** between the second and third ionization energies compared to the difference between the first and second ionization energies. This is because, the third electron is removed from an **inner energy level** which is **completely filled** will electrons and hence **energetically stable.**

(b) Group (II)

$CH_3CH=CH_2 + Br_2 \xrightarrow{H_2O(l)} CH_3\underset{\underset{OH}{|}}{CH}CH_2Br$

Mechanism;



(a) (i) 

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or $C_6H_5COOH(aq) + H_2O(l) \rightleftharpoons C_6H_5CO\bar{O}(aq) + H_3O^+(aq)$

(ii) $Ka = \dfrac{\left[\text{C}_6\text{H}_5\text{CO}\bar{\text{O}}\right][H^+]}{\left[\text{C}_6\text{H}_5\text{COOH}\right]}$ or $K_a = \dfrac{[C_6H_5CO\bar{O}][H_3O^+]}{[C_6H_5COOH]}$

(b) $\left[\text{C}_6\text{H}_5\text{CO}\bar{\text{O}}\right] = [H^+]$ and [benezoic acid]$= 0.1M$

Hence; $Ka = \dfrac{[H^+]^2}{\left[\text{C}_6\text{H}_5\text{COOH}\right]}$

$[H^+] = \sqrt{6.3 \times 10^{-5} \times 0.1} = 2.51 \times 10^{-3} moldm^{-3}$

But; $pH = -\log_{10}[H^+]$

$= -\log_{10} 2.51 \times 10^{-3} = 2.6$

5. (a) (i) $C_xH_y(g) + \left(x + \frac{y}{4}\right)O_2(g) \longrightarrow xCO_2(g) + \frac{y}{2}H_2O(l)$

(ii) $C_xH_y(g) + \left(x + \frac{y}{4}\right)O_2(g) \longrightarrow xCO_2(g) + \frac{y}{2}H_2O(l)$

$1cm^3 \quad \left(x + \frac{y}{4}\right)cm^3 \quad xcm^3$

$10cm^3 \quad 10\left(x + \frac{y}{4}\right)cm^3 \quad 10xcm^3$

Residual gases include CO_2 + excess O_2

Volume of CO_2 formed $= 70 - 40 = 30cm^3$

But; according to the equation, volume of CO_2 formed $= 10xcm^3$

Hence; $10x = 30$

$\therefore x = \frac{30}{10} = 3$

Volume of oxygen which reacted $= 90 - 40 = 50cm^3$

But; according to the equation, volume of oxygen which reacted $= 10\left(x + \frac{y}{4}\right)cm^3$

Hence; $10\left(x + \frac{y}{4}\right)cm^3 = 50$

$\therefore y = 8$

Molecular formula of P is C_3H_8

(b) $CH_3CH_2CH_2OH \xrightarrow[\text{heat}]{\text{Conc.}H_2SO_4} CH_3CH{=}CH_2 \xrightarrow[150°C]{H_2/Ni} CH_3CH_2CH_3$

or; $CH_3\underset{\underset{OH}{|}}{C}HCH_3 \xrightarrow[\text{heat}]{\text{Conc.}H_2SO_4} CH_3CH{=}CH_2 \xrightarrow[150°C]{H_2/Ni} CH_3CH_2CH_3$

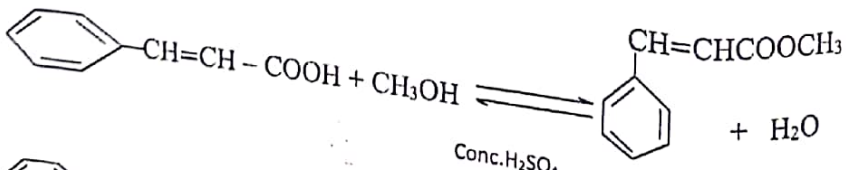
6. $\%\ of\ w\ in\ distillate = 100 - 85 = 15\%$

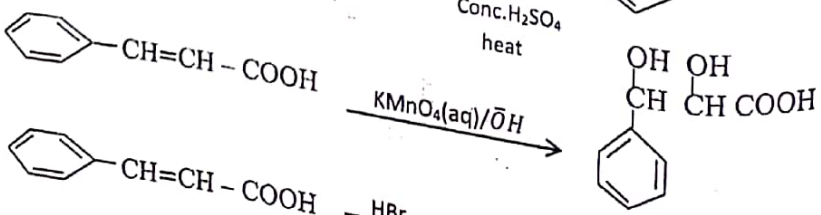
$vapour\ pressure\ of\ w = 760 - 740 = 20mmHg.$

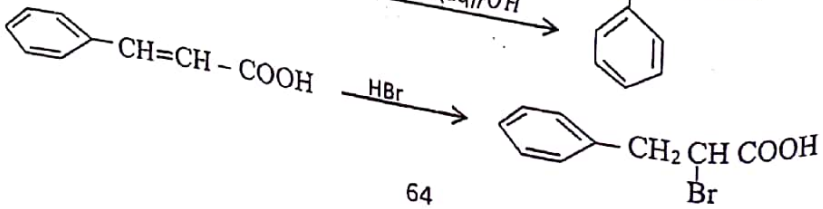
$\frac{\%\ of\ water\ in\ distillate}{\%\ of\ w\ in\ distillate} = \frac{vapour\ pressure\ of\ water \times Rmm\ of\ water}{vapour\ pressure\ of\ w \times Rmm\ of\ w}$

$\frac{85}{15} = \frac{740 \times 18}{15 \times Rmm\ of\ w}$

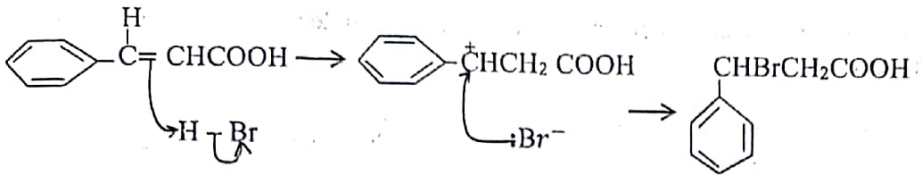
$Rmm\ of\ w = \frac{15 \times 740 \times 18}{85 \times 15} = 117.53$

7. (a) (i) 

(ii) 

(iii) 

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(b) 

8. (a)(i) 100g of CS_2 dissolved 4.65g of sulphur

$\therefore 1000g\ of\ CS_2\ \ dissolved\ \left(\frac{1000\times4.65}{100}\right) g\ of\ sulphur$

$Hence;\ \left(\frac{1000\times4.65}{100}\right) g\ of\ sulphur\ causes\ a\ boiling\ point\ rise\ of\ 0.42°C$

$\therefore 256g\ of\ sulphur\ cause\ a\ boiling\ point\ rise\ of\ \left(\frac{256\times0.42\times100}{1000\times4.65}\right) = \underline{2.31°C}$

$$Boiling\ point\ constant\ of\ CS_2 = 2.31°C mol^{-1} Kg^{-1}$$

(ii) $37.4g\ of\ CS_2\ dissolved\ 2.0g\ of\ phosphorous.$

$\therefore 1000g\ of\ CS_2\ dissolved\ \left(\frac{1000\times2.0}{37.4}\right) g\ of\ phosphorous$

$Hence;\ 1.003°C\ is\ rise\ in\ boiling\ point\ caused\ by\ \left(\frac{1000\times2.0}{37.4}\right) g\ of\ phosphorous$

$\therefore 2.31°C\ is\ rise\ in\ boiling\ point\ caused\ by\ \left(\frac{2.31\times1000\times2.0}{1.003\times37.4}\right) = 123.16\ g\ of\ phosphorous$

$$Molar\ mass\ of\ phosphorous = 123.16g$$

(c) $Pn = 123.16$

$31n = 123.16$

$n = \frac{123.16}{31} = 4$

Hence; molecular formula of phosphorous is P_4

9. (a) Fluorine has the smallest atomic radius
Fluorine has the highest positive electrode potential

(b) (i) $2F_2(g) + 2H_2O(l) \longrightarrow 4HF(g) + O_2(g)$

(ii) $2F_2(g) + 2NaOH(aq) \longrightarrow 2NaF(aq) + OF_2(g) + H_2O(l)$

or: $2F_2(g) + 2\bar{O}H(aq) \longrightarrow 2F^-(aq) + OF_2(g) + H_2O(l)$

(iii) $2F_2(g) + 4NaOH(aq) \longrightarrow 4NaF(aq) + 2H_2O(l) + O_2(g)$

Or; $2F_2(g) + 4\bar{O}H(aq) \longrightarrow 4F^-(aq) + 2H_2O(l) + O_2(g)$

10. (a) The conductance of an **aqueous** solution containing **one mole** of an electrolyte placed between two electrodes each of **unit cross-sectional area** and a **unit distance apart**

(b) (i) Equation of reaction leading to the formation of $H_2C_2O_4$;

$Na_2C_2O_4(aq) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + H_2C_2O_4(aq)$

Hence; $\Lambda_\infty(H_2C_2O_4) = \Lambda_\infty(Na_2C_2O_4) + \Lambda_\infty(H_2SO_4) - \Lambda_\infty(Na_2SO_4)$

$$= 248 + 860 - 260 = \mathbf{848\Omega^{-1}cm^2mol^{-1}}$$

(ii) Equation of reaction leading to formation of $(NH_4)_2C_2O_4$

$Na_2C_2O_4(aq) + (NH_4)_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + (NH_4)_2C_2O_4(aq)$

Thus; $\Lambda_\infty(NH_4)_2C_2O_4) = \Lambda_\infty(Na_2C_2O_4) + \Lambda_\infty(NH_4)_2SO_4) - \Lambda_\infty(Na_2SO_4)$

$$= 248 + 308 - 260 = \mathbf{296\Omega^{-1}cm^2mol^{-1}}$$

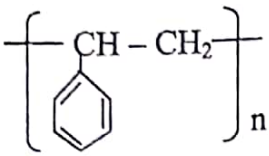
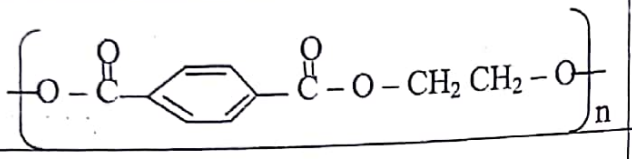
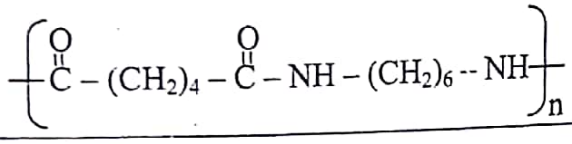
(c) The molar conductivity at infinite dilution for $H_2C_2O_4$ is **higher** than that for $(NH_4)_2C_2O_4$ because the hydrogen ions in $H_2C_2O_4$ have **higher conductivity** than the ammonium ions in $(NH_4)_2C_2O_4$

(d) - Determination of solubility of sparingly soluble salts
- Determination of solubility product of a sparingly soluble salt
- Determination of degree of ionization of a weak electrolyte
- Determination of ionization or dissociation constants for weak electrolyte

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11. (a) (i) Cross-linked polymers which cannot be remolded on heating and decompose without melting
(ii) Bakelite and melamine

(b)

Polymer	Name of monomer (s)
	Phenylethene
	Benzene-1, 4-dioic acid Ethane-1, 2-diol
	Hexane-1, 6-diamine Hexane-1, 6-dioylchloride

(c) (i) 9.89×10^{-2} moles of z are formed from 350g of monomer

$$\therefore 1 Mole\ of\ z\ is\ formed\ from \left(\frac{350}{9.89\times 10^{-2}}\right) = \mathbf{3538.9g\ of\ monomer}$$

Formula mass of monomer; $CH_2{=}CH\ \underset{Cl}{C}{=}\ CH_2$

$$= (4\times 12) + (5\times 1) + (1\times 35.5) = 88.5$$

Number of moles of monomers(value of n) $= \frac{3538.9}{88.5} = \underline{40}$

(ii) Molar mass of the polymer = molar mass of monomer × value of n
$= 88.5 \times 40 = \mathbf{3540g}$

12. (a) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$ or $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$
(ii) Chromium has partially filled 3d-orbitals

(b) $Cr(H_2O)_6Cl_3$, $[Cr(H_2O)_5Cl]Cl_2\cdot H_2O$, $[Cr(H_2O)_4Cl_2]Cl\cdot 2H_2O$ and $[Cr(H_2O)_3Cl_3]\cdot 3H_2O$

(c) (i) A **green precipitate, soluble** in excess ammonia solution forming a **green solution**

(ii) $Cr^{3+}(aq) + 3\bar{O}H(aq) \longrightarrow Cr(OH)_3(s)$
$Cr(OH)_3(s) + 6NH_3(aq) \longrightarrow Cr(NH_3)_6^{3+}(aq) + 3\bar{O}H(aq)$

13. (a) **Reagent** – Potassium chromate (VI) solution and ethanoic acid
Observation: Ba^{2+} give a yellow precipitate insoluble in ethanoic acid
Ca^{2+} give a yellow precipitate soluble in ethanoic acid

(b) **Reagent** – Silver nitrate solution
Observation: Br^- give a pale yellow precipitate
Cl^- give a white precipitate

(c) **Reagent – Hot** acidified Potassium manganate (VII) **solution**
Observation: $CH_3C\bar{O}_2$ – gives no observable change
$C_2O_4^{2-}$ – **purple** solution turns **colourless** and **Effervescence** of a **colourless gas** occurs.

14. (a)(i) $Kc = \frac{[CO_2][H_2]^4}{[CH_4][H_2O]^2}$

(ii) Let; moles of methane which reacted at equilibrium $= x$

	$CH_4(g)$	+ $2H_2O(l)$ ⇌	$CO_2(g)$	+ $4H_2(g)$
Moles initially	0.625	3.0	0	0
Moles at Equilibrium;	$0.625-x$	$3-2x$	x	$4x$

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Hence; $4x = 2$

$x = \frac{2}{4} = 0.5mole$

Equilibrium concentrations are;

$[H_2] = \frac{2.0}{4} = 0.5molm^{-3}$

$[CO_2] = \frac{x}{4} = \frac{0.5}{4} = 0.125moldm^{-3}$

$[CH_4] = \frac{0.625-0.5}{4} = 0.03125moldm^{-3}$

$[H_2O] = \frac{3-(2\times0.5)}{4} = 0.5moldm^{-3}$

Hence; $Kc = \frac{0.125\times(0.5)^4}{0.03125\times(0.5)^2}$

$= 1.0mol^2dm^{-6}$

(b) (i) $\Sigma\Delta Hf(reactants) = \Delta Hf(CH_4) + 2\Delta Hf(H_2O)$

$= -76 + 2(-242) \quad = \mathbf{-560KJmol^{-1}}$

$\Sigma\Delta Hf(products) = \Delta Hf(CO_2) + 4\Delta Hf(H_2)$

$= -394 + 4(0) \quad = \mathbf{-394KJmol^{-1}}$

Enthalpy change for the forward reaction = $\Sigma\Delta Hf(products) - \Sigma\Delta Hf(reactant)$

$= -394 - (-560) = \mathbf{+166KJmol^{-1}}$

Note; Elements such as hydrogen have **zero** enthalpy of formation

Alternatively; $C(s) + 2H_2(g) \longrightarrow CH_4(g)$; $\Delta H_1 = -76KJmol^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(g)$; $\Delta H_2 = -242KJmol^{-1}$

$C(s) + O_2 \longrightarrow CO_2(g)$; $\Delta H_3 = -394KJmol^{-1}$

Required; $CH_4(g) + 2H_2O(l) \quad CO_2(g) + 4H_2(g)$; ΔHr =?

Thus; $\Delta Hr = \Delta H_3 - \Delta H_1 - 2\Delta H_2$

$= -394 - (-76) - 2(-242) = \mathbf{+166\ KJmol^{-1}}$

(ii) The value of **Kc increases** because the enthalpy of the forward reaction is **endothermic**

5. (a) Obervation; - The **orange** solution turns **green** and a **yellow precipitate** is formed.

Equation; $Cr_2O_7^{2-}(aq) + 3H_2S(g) + 8H^+(aq) \longrightarrow 2Cr^{3+}(aq) + 3S(s) + 7H_2O(l)$

(b) Observation –Reddish –brown precipitate.

Equation: $CH_3CH_2CHO(aq) + 2Cu^{2+}(aq) + NaOH(aq) + H_2O(l) \longrightarrow CH_3CH_2COONa(aq) + Cu_2O(s) + 4H^+(aq)$

(c) Observation –Silver mirror

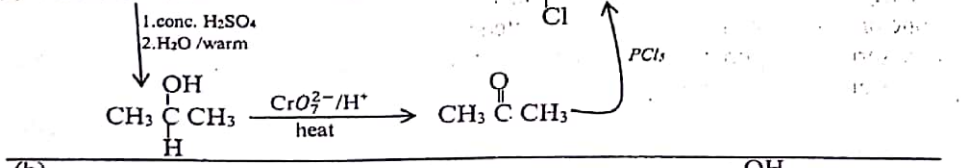
Equation; $HCOOH(aq) + 2Ag^+(aq) + 2NH_3(aq) \longrightarrow CO_2(g) + 2Ag(s) + 2NH_4(aq)$

(d) Observation – yellow precipitate

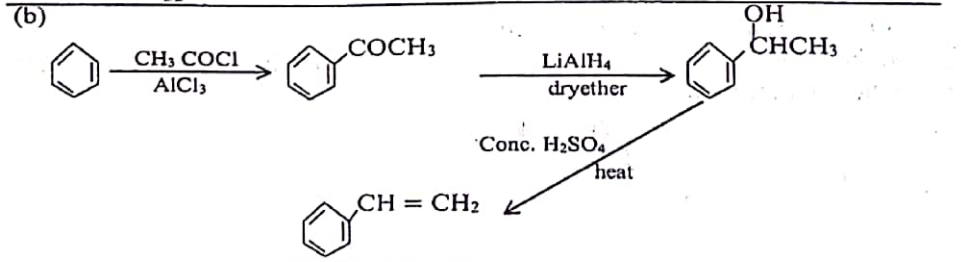
Equation; $CH_3COCH_3(aq) + 3I_2(aq) + 4\bar{O}H(aq) \longrightarrow CHI_3(s) + CH_3CO\bar{O}(aq) + 3I^-(aq) + 3H_2O(l)$

Or $CH_3COCH_3 \xrightarrow[\text{warm}]{I_2/NaOH(aq)} CHI_3(s) + CH_3COONa$

16. (a) $CH_3CH = CH_2$ **to** $CH_3C(Cl)(Cl)CH_3$



(b)



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(c) $CH_3CH_2Cl \xrightarrow[\text{Heat}]{NaOH(aq)} CH_3CH_2OH \xrightarrow[\text{Heat}]{MnO_4^-/conc.H_2SO_4} CH_3COOH \xrightarrow{PCl_5} CH_3COCl \xrightarrow{Conc.\ NH_3} CH_3CONH_2$

17. (a)(i) $Al_2O_3 \cdot 2H_2O$; Bauxite (ii) Iron (III) oxide, silicon (IV) oxide
(b)(i) To lower the melting point of aluminium oxide (ii) Graphite
(iii) $Al^{3+}(l) + 3e \longrightarrow Al(l)$
(c) (i) Aluminium **dissolved** with **effervescence** and a **colourless gas** was evolved.
(ii) $2Al(s) + 2NaOH(aq) + 6H_2O(l) \longrightarrow 2NaAl(OH)_4(aq) + 3H_2(g)$
or; $2Al(s) + 2\bar{O}H(aq) + 6H_2O(l) \longrightarrow 2Al(OH)_4^-(aq) + 3H_2(g)$
or; $2Al(s) + 2\bar{O}H(aq) + 2H_2O(l) \longrightarrow 2AlO_2^-(aq) + 3H_2(g)$
or; $2Al(s) + 2NaOH(aq) + 2H_2O(l) \longrightarrow 2NaAlO_2(aq) + 3H_2(g)$
(d) $2Al(s) + 3Cl_2(g) \longrightarrow 2AlCl_3(s)$
(d) $2Al(s) + 3Cl_2(g) \longrightarrow 2AlCl_3(s)$

QUESTIONS TO 'A' LEVEL CHEMISTRY PAPER 2 (P525/2), 2016

1. (a) (i) State Kohlrauch's law of independent migration. (1 mark)
(ii) 272g of anhydrous zinc chloride was dissolved in water and the solution made up to one litre. The electrolytic conductivity of the solution was found to be $5.176 \times 10^{-3}\ \Omega^{-1}$ at 25°C
Determine the molar conductivity of chloride ions at this temperature.
(Zn = 65; Cl =35.5; The molar conductivity of zinc chloride at infinite dilutions 106 $\Omega^{-1}mol^{-1}$)

(b) (i) Draw sketch graphs to show how molar conductivity of the following compounds vary with concentration. (4 marks)
- Copper(II) sulphate
- Hydrochloric acid (2 marks)

(ii) Explain the shape of the graphs you have sketched in (b)(i) (6 marks)

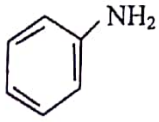
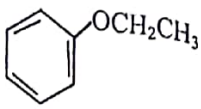
(c) The table below shows how the conductivity of lithium chloride in water at 25°C varies with dilution, $\frac{1}{c}$, where c is concentration

Dilution ($mol^{-1}dm^{-1}$)	2000	1000	500	200	100	20
Molar conductivity, $\Lambda(\Omega^{-1}cm^2mol^{-1})$	113.2	112.5	111.5	109.4	107.3	100.1

(i) Plot a graph of molar conductivity of lithium chloride against dilution, $\frac{1}{c}$ at 25°C. (4 marks)
(ii) Explain the shape of the graph (2 marks)
(iii) Using the graph, estimate the molar conductivity of lithium chloride at infinite dilution at 25°C (2 marks)

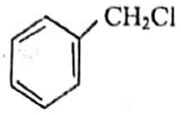
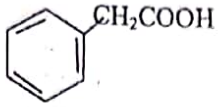
2. (a) Write the electronic configuration of zinc. (The atomic number of zinc is 30) (1 mark)
(b) State
(i) two reasons why zinc is not considered as a typical transition element. (1 mark)
(ii) one property in which zinc behaves as a transition element. (1 mark)
(c) (i) Name one ore from which zinc can be extracted and write its formula. (2 marks)
(ii) Briefly describe how pure zinc can be obtained from the ore you have named in (c)(i) (1 mark)
(d) Describe the reactions of zinc with (2 marks)
(i) air
(ii) sodium hydroxide (7marks)
(Your answer should include equations for the reaction)

3. Write equations to show how the flowing conversions can be carried out. In each case, indicate the reagents and conditions for the reactions. (5 marks)

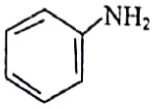
(a)  to  (2 marks)

(5½ marks)

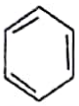
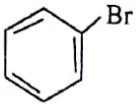
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(b)  to  (3 marks)

(c) $CH_3CH=CHCH$ to $CH_3CH_2\overset{O}{\overset{\|}{C}}CH_3$ (3 marks)

(d)  to  (4 marks)

(e) $CH_3CH = CH_2$ to $CH_3CH \equiv CH$ (3 marks)

(f)  to  (4 marks)

4. (a) Describe an experiment that can be carried out to determine the relative molecular mass of benzoic acid in benzene by depression of freezing point method. (Your answer should include a diagram of apparatus that can be used and the treatment of the results.) (10 marks)
   (b) State four limitations of the depression of freezing point as a method for determination of molecular mass of a substance. (4 marks)
   (c) A solution containing 0.368g of methanoic acid (HCOOH) in 50g of benzene, froze at 5.093°C. Calculate the molecular mass of methanoic acid. (The freezing point of benzene is 5.533°C; The Freezing point constant of benzene is 5.5°C $mol^{-1}Kg^{-1}$) (4 marks)
   (d) Comment on your answer in (a)
   (The molecular mass of methanoic acid is 46) (2 marks)
5. (a) An organic compound P contains 35.04% carbon, 6.56% hydrogen and 58.40% bromine. Calculate the empirical formula of P. (H = 1; C = 12; Br = 79.9) (2 marks)
   (b) The vapour pressure of P was found to be 68.
   (i) Identify Q. (2 marks)
   (ii) Write the names and structural formula of all the possible isomers of P. (4 marks)
   (c) When P was reacted with sodium hydroxide, a compound E was formed. When a solution of anhydrous zinc chloride in concentrated hydrochloric acid, was added to Q, it turned cloudy within 10 minutes.
   (i) Identify Q (1 mark)
   (ii) Write the mechanism for the reaction between P and sodium hydroxide and state the condition(s) for the reaction to take place. (2 marks)
   (d) Explain the difference in the reactivity of P and bromobenzene with sodium hydroxide.(4 marks)
   (e) Write equation(s) to show how O can be synthesized from butan-1-ol. (3 marks)
6. (a) Sulphur trioxide decomposes according to the following equation when heated.
   $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$ ΔH = +ve
   (i) State the conditions for the reaction (2 marks)
   (ii) Write an expression for the equilibrium constant for the reaction, Kp (1 mark)
   (b) When sulphur trioxide was heated in a closed vessel, at 270°C and 0.25 atmospheres, 46% of sulphur trioxide was decomposed at equilibrium. Calculate the value of Kp. (5 marks)
   (c) Calculate the heat of the decomposition of sulphur trioxide. (The heat of formation of sulphur trioxide are -297Kjmol^{-1} and -392 Kjmol^{-1} respectively). (4 marks)
   (d) Explain how the position of the equilibrium, value of the equilibrium constant and the rate of attainment of the equilibrium would be affected if
   (i) the temperature of the reaction was increased (3 marks)
   (ii) the pressure of the reaction was decreased (3 marks)
   (iii) a catalyst was added to reaction mixture. (2 marks)
7. The atomic numbers and the boiling points of elements in period 3 of the periodic table are shown below.

Element	Na	Mg	Al	Si	P	S	Cl	Ar
Atomic number	11	12	13	14	15	16	17	18
Boiling point	1250	1400	2750	2900	500	550	400	0

   (a) (i) Plot a graph boiling point against atomic number (3 marks)
   (ii) Explain the shape of the graph you have drawn in (a)(i). (6 marks)
   (b) Describe how magnesium, aluminum and silicon react with

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(i) Hydrochloric acid. (ii) Sodium hydroxide (iii) Water (11 marks)
(*Your answer should include equations for the relevant reactions*)

8. Explain the following observations. (write equations where necessary)
(a) When ammonia solution is added to a solution containing aluminium ions, a white precipitate is formed, whereas in the presence of ammonium chloride no [precipitate is formed. (3 marks)
(b) Methyl orange indicator, pH range 3.6 to 4.4, is a suitable indicator in titration of ammonia solution with hydrochloric acid but not suitable for titration of sodium hydroxide solution with ethanoic acid. (5 marks)
(c) When ammonium sulphate is dissolved in water, the solution turns litmus red where as a solution of sodium sulphate has no effect on litmus. (3 marks)
(d) The boiling point of ethanol is much higher than that of methoxymethane (diethyl ether) although both have the same molecular mass. (2 marks)
(e) When acidified potassium dichromate(VI) solution is added to aqueous solution of potassium iodide, the solution turns brown. (3 ½ marks)
(f) When Alpha particles are directed at a thin gold foil, most of them pass through undeflected. (3 ½ marks)

END

SOLUTIONS TO 'A' LEVEL CHEMISTRY PAPER 2 (P525/2) 2016

Question. One.

(a) (i) States that; The molar conductivity of an electrolyte at infinite dilution equals to the algebraic **sum** of the molar conductivities of the **constituent ions** of the electrolyte at infinite dilution at a **constant temperature.**

(ii) Formula mass of $ZnCl_2 = (1 \times 65) + (2 \times 35.5) = 136$

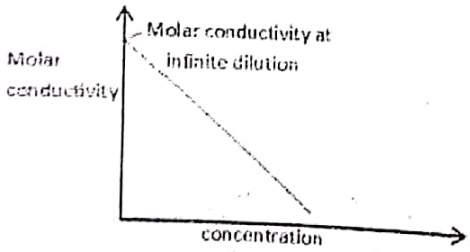
Molar concentration of $ZnCl_2 = \frac{2.72}{136} = 0.02 moldm^{-3}$

Molar conductivity of $0.02MZnCl_2(aq) = \frac{1000K}{C}$

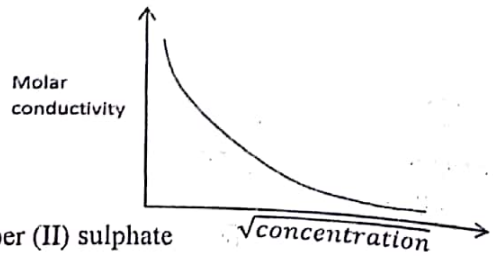
$= \frac{1000 \times 5.176 \times 10^{-3}}{0.02} = 258.8\Omega^{-1}cm^2mol^{-1}$

Note – The candidates **could not proceed**, the question is **not clear** because the molar conductivity of zinc ions is **missing**

(b)(i) **A sketch graph showing variation of molar conductivity of copper (II) sulphate with concentration**



A sketch graph showing variation of molar conductivity of hydrofluoric acid with concentration



(ii) Copper (II) sulphate

Molar conductivity **decreases with increase in concentration** of copper (II) sulphate solution and this is due to **increase** in the **number of oppositely charged** conducting ions from copper (II) sulphate solution which is a **strong electrolyte.**

The ions get **close** together resulting into **increased ionic interference** (dragging effect) which

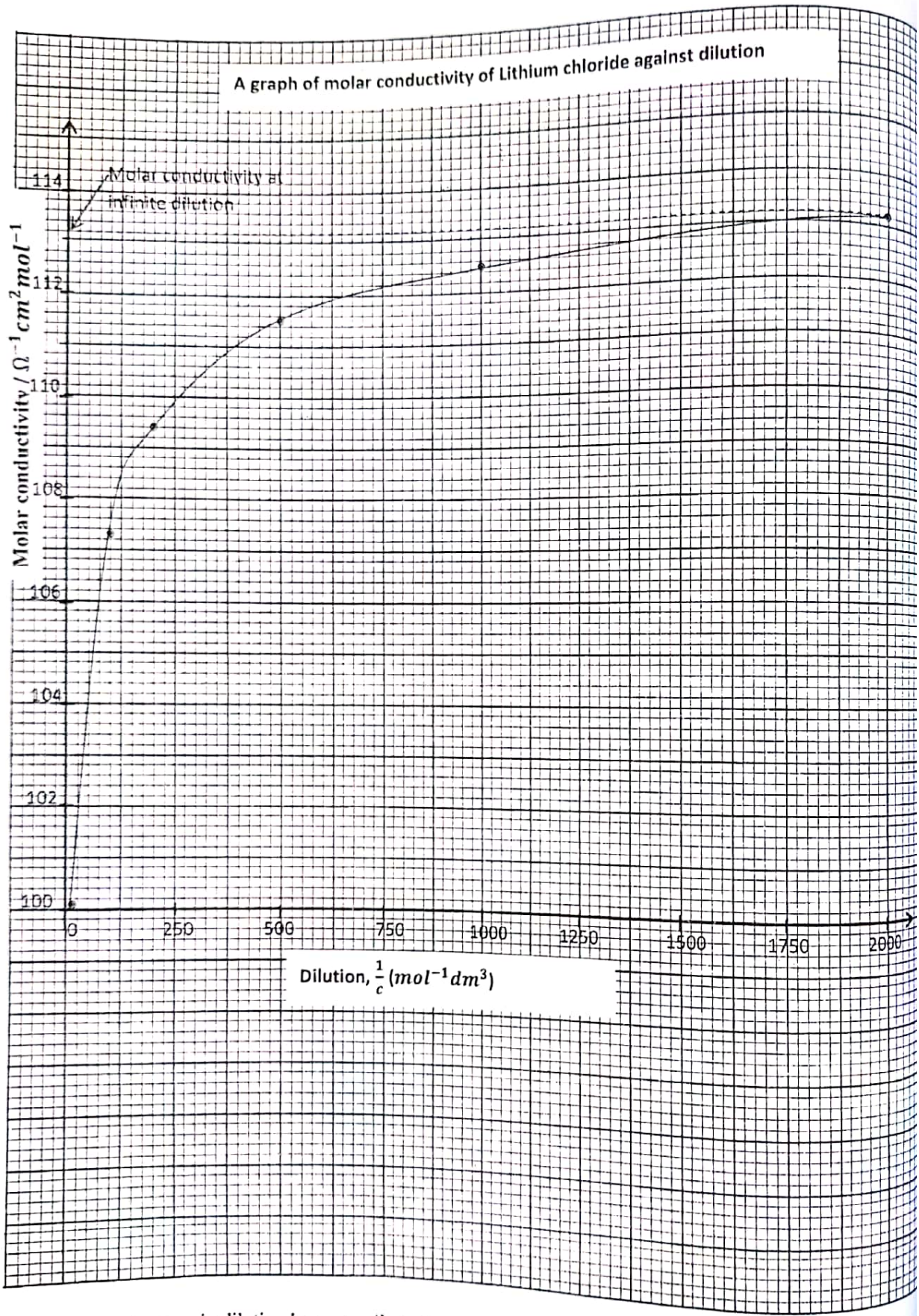
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reduces the mobility of the ions

Hydrofluoric acid;

Hydrofluoric acid is a **weak electrolyte** whose molar **conductivity decreases with increase in concentration** because of the **decrease in the degree of ionization** which results into **reduction in the number of conductivity ions** per unit volume.

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(ii) Increase in dilution **increases the molar conductivity** of lithium chloride which **is a strong electrolyte.** As dilution increases, the **ions are far apart** and this **reduces the**

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ionic interference (dragging effect) resulting into **increase in the mobility** of the conducting ions.

(iii) $113.2\Omega^{-1}cm^2mol^{-1}$ (check from graph)

Question. Two.

(a) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$ *or* $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}$

(b) (i) Zinc atoms or ions have completely filled 3d-orbitals
Zinc does not form coloured compounds

(ii) Zinc forms complex compounds

(c) (i) Zinc blende: ZnS

(ii) -The ore, Zinc blende is **crushed** and **agitated** with **water** containing **frothing agents**.
-**Air is blown** into the mixture, and **a froth** is formed which contains the ore.
-The froth **floats** on top while the impurities in the ore **sink** to the bottom.
-Dilute **sulphuric acid** is added to **break the froth**
-The ore is then **filtered off** and **dried.**
-The purified ore is then **roasted** in air to form **zinc oxide** and sulphur dioxide.

$$2ZnS(s) + 3O_2(g) \longrightarrow 2ZnO(s) + 2SO_2(g)$$

-Zinc oxide is then mixed with **lime stone** and **coke** and fed into the blast furnace from the top and **hot air** is fed into the same furnace from the bottom.
-The zinc oxide is **reduced by the coke** to crude zinc

$$ZnO(s) + C(s) \longrightarrow Zn(l) + CO(g)$$

-Crude zinc in liquid form is then **purified** by **fractional distillation**

Note; The other ore from zinc can be extracted is calamine ($ZnCO_3$)

(d) (i) **Heated** zinc reacts with **dry air** to form **zinc oxide**

$$2Zn(s) + O_2(g) \longrightarrow ZnO(s)$$

Zinc rects slowly with **most** air to form **basic zinc carbonate**

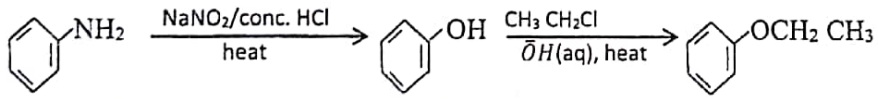
$$Zn(s) + H_2O(l) + O_2(g) + CO_2(g) \longrightarrow ZnCO_3 \cdot Zn(OH)_2(s)$$

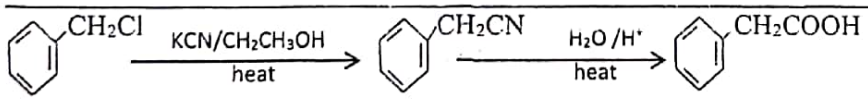
(ii) Zinc reacts with **hot concentrated** sodium hydroxide solution to form **sodium zincate** and **hydrogen gas.**

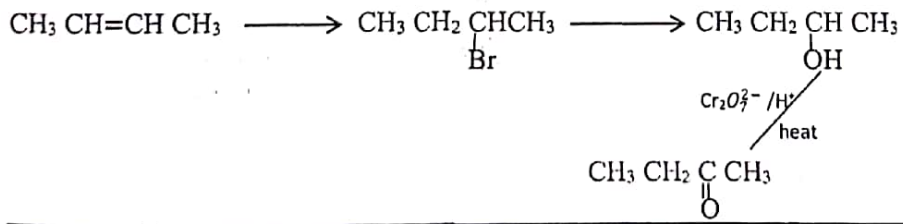
$$Zn(s) + 2NaOH(aq) + 2H_2O(l) \longrightarrow Na_2Zn(OH)_4(aq) + H_2(g)$$

or; $Zn(s) + 2\bar{O}H(aq) + 2H_2O(l) \longrightarrow Zn(OH)_4^{2-}(aq) + H_2(g)$

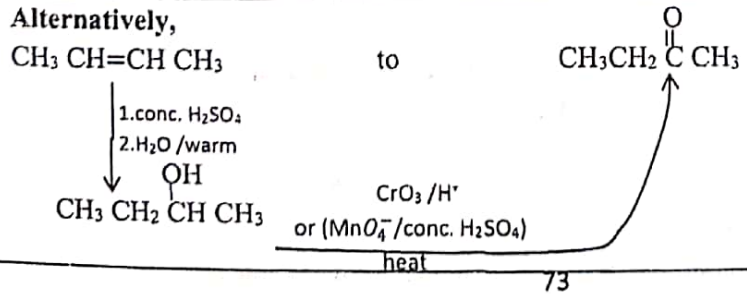
Question. Three.

(a) 

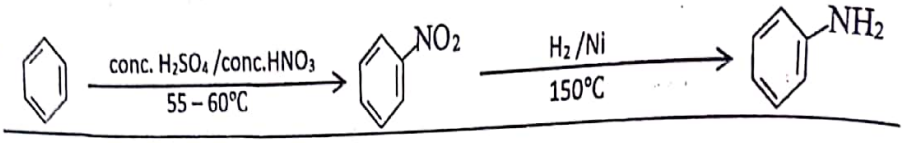
(b) 

(c) 

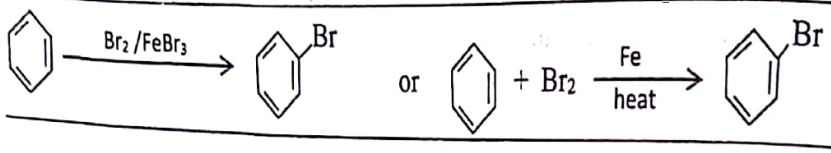
Alternatively,



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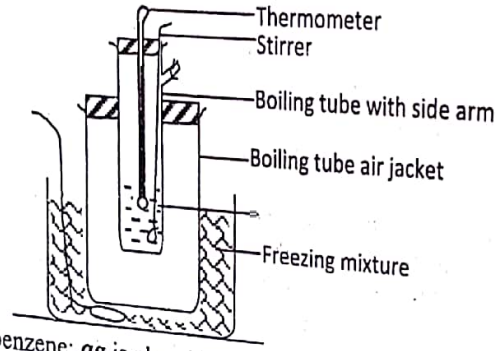
(d) 

(e) $CH_3CH{=}CH_2 \xrightarrow[CCl_4]{Cl_2} CH_3\underset{Cl}{CH}\underset{Cl}{CH_2} \xrightarrow[heat]{KOH/Ethanol} CH_3C{\equiv}CH$

(f) 

Question. Four.

(a)



A **known mass** of benzene; ag is placed in a boiling tube with a side arm.
The tube is fitted with a **stirrer** and a **thermometer**
The tube is fitted into another empty boiling tube to act as an **air jacket** to minimize super cooling
The whole set up is placed in a **freezing mixture** which is being **stirred** to distribute the heat evenly
The steady temperature at which the benzene starts to freeze is measured and noted as T_0°C and this is the **freezing point of benzene**
The tube with the side arm is removed from the freezing mixture and the **benzene allowed to melt.**
A **known mass** of benzoic acid, bg is added to the benzene through the side arm.
The mixture is stirred in order for the benzoic acid to dissolve in benzene.
The tube is returned to the freezing mixture and the solution allowed to cool as it is being stirred
The steady temperature at which the solution starts to freeze is noted at T_1°C and this is the **freezing point of solution.**

Treatment of results;

Freezing point depression = $(T_0 - T_1)$°C

Let; the freezing point depression constant of benzene = Kf

Thus; a grams of benzene dissolve bg of benzoic acid

And; 1000grams of benzene dissolved $\left(\frac{1000\times b}{a}\right) g$ of benzoic acid

So; $(T_0 - T_1)$°C is depression in freezing point caused by $\left(\frac{1000\times b}{a}\right) g$ of benzoic acid

∴ Kf is depression of freezing point caused by $\left(\frac{Kf}{(T_0-T_1)} \times \frac{1000\times b}{a}\right) g$ of benzoic acid

Therefore; relative molecular mass of benzoic acid is $\left(\frac{Kf}{(T_0-T_1)} \times \frac{1000\times b}{a}\right)$

(b) – The solute should be dilute
- The solution should be non volatile
- Solute should not associate or dissociate in the solvent
- Solute should not react with the solvent
- When the solution freezes, the pure solvent alone must separate out as a solid

(c) Freezing point depression = $5.533 - 5.093 = 0.44$°C

50g of benzene dissolved 0.368g of methanoic acid

∴ 1000g of benzene dissolved $\left(\frac{1000\times 0.368}{50}\right) = 7.36$**g of methanoic acid**

0.44°C is depression in freezing point caused by 7.36g of methanoic acid

∴ 5.5°C is depression in freezing point caused by $\left(\frac{5.5\times 7.36}{0.44}\right) =$ **92g of methanoic acid**

Hence; molecular mass of methanoic acid = 92g

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(d) The calculated molecular mass of methanoic acid is twice the actual or true (theoretical)value because methanoic acid associates or dimerises in benzene.

Question. Five.

(a) Composition of P;

	C		H		Br
Number of moles;	$\frac{35.94}{12}$		$\frac{6.56}{1}$		$\frac{58.40}{79.9}$
	2.92		6.56		0.73
Mole ratio;	$\frac{2.92}{0.73}$		$\frac{6.56}{0.73}$		$\frac{0.73}{0.73}$
	4	:	9	:	1

Emperical formula of P is C_4H_9Br.

(b) (i) Molecular mass $= 2 \times 68 = 136$

$(C_4H_9Br)n = 136$

$(4 \times 12) + (9 \times 1) + (1 \times 79.9)n = 136$

$\therefore n = 1$

Hence; molecular formula of P is C_4H_9Br.

(ii) 1-bromobutane, $CH_3\,CH_2\,CH_2\,CH_2\,Br$

2- bromobutane, $CH_3\,CH_2\,\underset{\displaystyle Br}{\underset{|}{C}}H\,CH_3$

2-bromo-2-methylpropane, $CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle Br}{\overset{|}{\underset{|}{C}}}}-CH_3$

1-bromo-2-methylpropane, $CH_3\,\underset{\displaystyle CH_3}{\underset{|}{C}}H-CH_2Br$

(c) (i) Butan-2-ol or $CH_3\,CH_2\,\underset{\displaystyle OH}{\underset{|}{C}}H\,CH_3$

(ii) $CH_3\,CH_2\,\overset{\displaystyle Br}{\overset{|}{C}}H\,CH_3 \longrightarrow CH_3\,CH_2\,\underset{\displaystyle OH}{\underset{|}{C}}H\,CH_3 + Br^-$ ($:\bar{O}H$)

Conditions for the reaction: Aqueous sodium hydroxide solution and **heat**

(d) Bromo benzene **does not easily react** with sodium hydroxide because the **lone pair of electrons** on the **electronegative** bromine atom **interacts** with the **delocalized electrons** of the benzene ring. This makes the **carbon - bromine bond less polar and hence stronger** and therefore **not easily broken.** But, 2-bromobutane (P) **easily reacts** with sodium hydroxide solution, this is because the **electronegative** bromine atom makes the **carbon-bromine bond to be polar** with carbon having a **partial positive charge** and thus **electrophilic** and hence easily attacked by the **nucleophilic hydroxide ion** of sodium hydroxide.

(e) $CH_3\,CH_2\,CH_2\,CH_2OH \xrightarrow[\text{Heat}]{\text{Conc. } H_2SO_4} CH_3\,CH{=}CHCH_3 \xrightarrow{HBr} CH_3\,CH_2\,\underset{\displaystyle Br}{\underset{|}{C}}H\,CH_3$

(or 180°C)

Question. Six.

(a) (i) High temperature

Low pressure

Use of vanadium (V) oxide catalyst

(ii) $Kp = \frac{(P_{SO_2})^2 \times (P_{O_2})}{(P_{SO_3})^2}$

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(b) Let; The degree of decomposition of SO_3 $=\propto$

	$2SO_3(g)$	$\rightleftharpoons$	$2SO_2(g)$	+	$O_2(g)$
Initially;	2 moles		0		0
Equilibrium moles;	$2-2\propto$		$2\propto$		$\propto$

Hence; $\propto = \frac{46}{100} = 0.46$

Moles of SO_3 at equilibrium $= 2 - (2 \times 0.46) = 1.08$moles
Moles of SO_2 at equilibrium $= 2 \times 0.46 = 0.92$moles
Moles of O_2 at equilibrium $= 0.46$moles
Total number of moles at equilibrium $= 1.08 + 0.92 + 0.46 = 2.46$moles

Partial pressure of SO_3; $P_{SO_3} = \left(\frac{1.08}{2.46} \times 0.25\right) = 0.10976$atm

Partial pressure of SO_2 $P_{SO_2} = \left(\frac{0.92}{2.46} \times 0.25\right) = 0.0935$atm

Partial pressure of O_2; $P_{O_2} = \left(\frac{0.46}{2.46} \times 0.25\right) = 0.0467$atm

$Kp = \frac{(0.0935)^2 \times 0.0467}{(0.10976)^2} = 3.4 \times 10^{-2}$atm

(c) $\sum \Delta Hformation(products) = 2\Delta Hf(SO_2) + \Delta Hf(O_2)$
$= (2 \times -297) + 0 = -594 KJmol^{-1}$

$\sum \Delta Hformation(reactants) = 2\Delta Hf(SO_3)$
$= 2 \times -392 = -784 KJmol^{-1}$

Hence; $\Delta Hdecomposition\ of\ SO_3 = \sum \Delta Hf(products) - \sum \Delta Hf(reactants)$
$= -594 - (-784) = +190 KJmol^{-1}$

(d) (i) Equilibrium position would **shift from left to right** because the **forward reaction is endothermic** Equilibrium constant value would **increase** because of **increased partial pressure** of sulphur dioxide and oxygen while that of sulphur trioxide **decreased.**
The rate of attainment of equilibrium **increases** because of the **increased kinetic energy** of the gas molecules which results into **increased frequency** of collisions of the gas molecules.

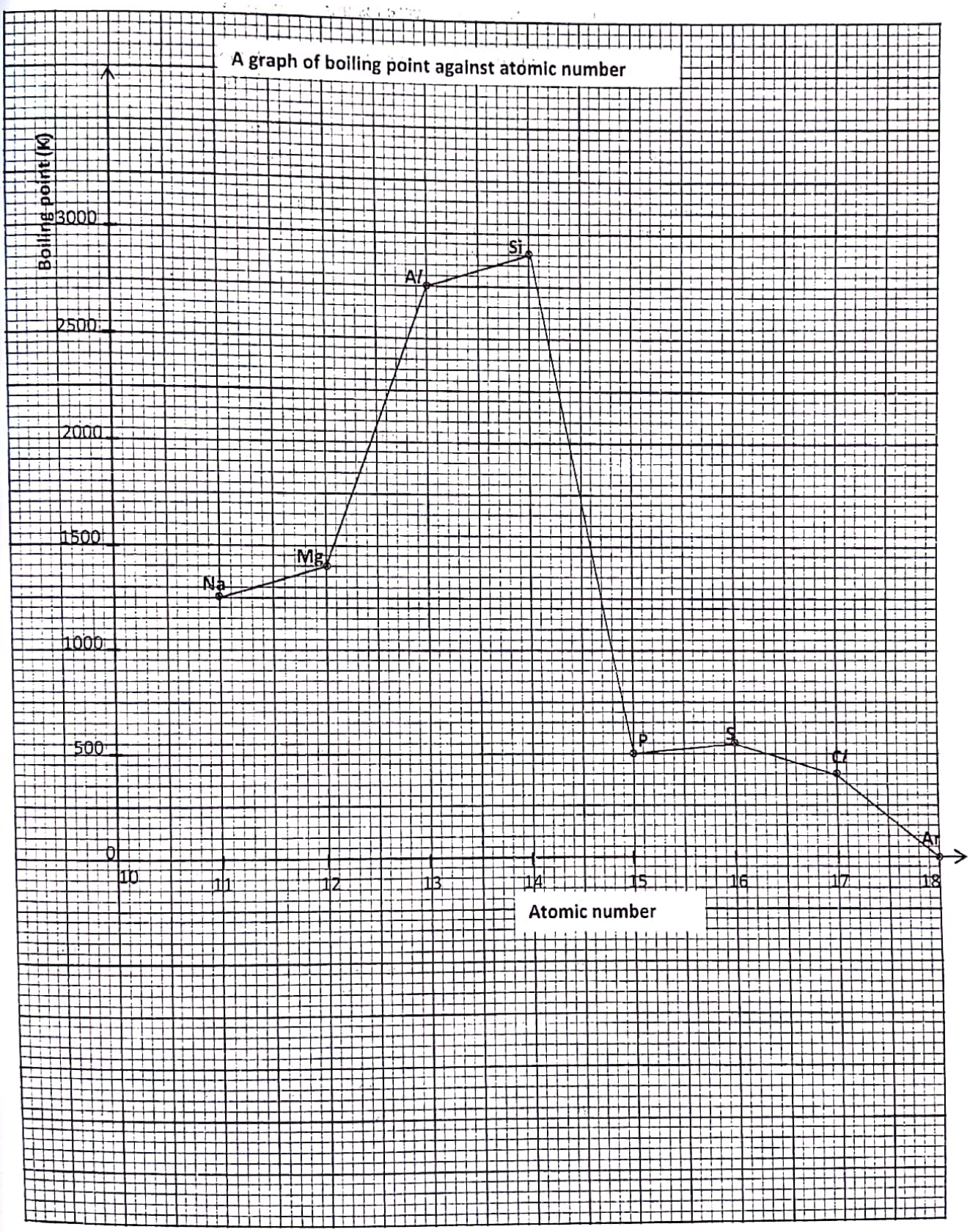
(ii) The equilibrium position would **shift from left to right** because the forward reaction proceeds with an **increase in volume**; the value of the equilibrium constant **remains constant** while the rate of attainment of equilibrium **decreases** because of **decrease in the frequency of collisions of the** gas molecules

(iii) The equilibrium position and equilibrium constant are **not affected** because the catalyst **increases the rate of** both the forward and back ward reaction in the **same way** but the rate of attainment of equilibrium **increases** because the catalyst **lowers the activation** energy of the reaction.

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Question. Seven.

(a)(i)



(ii) The boiling points of the elements **increases from sodium to silicon** and then **decreases from silicon to argon**. Sodium, magnesium and aluminum are **metals with giant metallic structures** and

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whose atoms are held together by **strong metallic bonds**, hence the relatively high boiling points. However from sodium to aluminum the **atomic radius decreases** and the **number of electrons** the metal contributes per atom to the charge cloud towards metallic bond formation increase resulting into **strong metallic bonds, thus the increase in boiling point.**

Silicon is a non metal and adopts a **giant covalent structure** in which the silicon atoms are **held together** by **strong covalent bonds** and these require **much heat energy** to be broken, hence the highest boiling point of silicon.

Phosphorus, sulphur, chlorine and argon are non metals and have **simple molecular structures** whose molecules are held together by **weak vander waal's forces** whose strength increases with **increase in the molecular mass** of the molecule

The molecular mass increases from phosphorus to sulphur and decreases from sulphur to argon since phosphorus exists as a **tetra atomic molecule** (P_4), sulphur as an **octa atomic molecule** (S_8), chlorine as **diatomic molecule** (Cl_2) and argon as a **mono atomic molecule**

(b) (i) Magnesium and aluminium react with **dilute** hydrochloric acid to form a metal **chloride** and **hydrogen gas**

$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$

$Al(s) + 3HCl(aq) \longrightarrow AlCl_3(aq) + \frac{3}{2}H_2(g)$

Silicon **does not** react with hydrochloric acid

(ii) Magnesium **does not react** with sodium hydroxide solution. Aluminium and silicon react with **hot** and **concentrated** sodium hydroxide solution to form **sodium aluminate** and **sodium silicate** respectively and **hydrogen gas**

$2Al(s) + 2\overline{O}H(aq) + 6H_2O(l) \longrightarrow 2Al(OH)_4^-(aq) + 3H_2(g)$

$Si(s) + 2\overline{O}H(aq) + H_2O(l) \longrightarrow SiO_3^{2-}(aq) + 2H_2(g)$

(iii) **Heated** magnesium reacts with **steam** to form **magnesium oxide** and **hydrogen gas**

$Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$

Heated silicon reacts with **steam** to form **silicon (IV) oxide** and **hydrogen gas**

$Si(s) + 2H_2O(g) \longrightarrow SiO_2(s) + 2H_2(g)$

Aluminium **does not react** with water **under any condition**

Question. Eight.

(a) Ammonia solution is a **weak base** which is **only slightly ionized** to produce **hydroxide ions** which **react** with aluminium ions to form **white insoluble aluminium hydroxide**

$NH_3(aq) + H_2O(l) \rightleftharpoons \overset{+}{N}H_4(aq) + \overline{O}H(aq)$

$Al^{3+}(aq) + 3\overline{O}H(aq) \longrightarrow Al(OH)_3(s)$

However, in presence of ammonium chloride, the ammonium chloride solution being a **strong electrolyte completely dissociates** and this **increases the concentration of ammonium ions** in solution **ie**

$NH_4Cl(aq) \longrightarrow \overset{+}{N}H_4(aq) + Cl^-(aq)$

This **suppresses** the ionization of ammonia solution and thus **reduces the concentration of hydroxide ions** making the ionic product (product of the molar concentrations of aluminium ions and hydroxide ions) to be **less than the solubility product** of aluminium hydroxide and hence **no precipitation** occurs.

Precipitation occurs when the ionic product becomes greater than the solubility product.

(b) Titration of ammonia solution which is a **weak base** and hydrochloric acid which is a **strong acid** results into these two reacting to form **ammonium chloride salt** which under goes **hydrolysis** to produce **hydroxonium ions** that make the solution at end point **acidic** with a **low pH** that is within the working range of methyl orange indicator.

$\overset{+}{N}H_4(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$

From, NH_4Cl

However, titration of sodium hydroxide which is a **strong base** with ethanoic acid **which is a weak acid** results into a reaction leading to the formation of **sodium ethanoate salt** which under goes **hydrolysis** to produce **hydroxide ions** which

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make the solution at end point **alkaline** with a **high pH value** that is **outside** the working range of methyl orange indicator

$CH_3\,CO\bar{O}(aq) + H_2O(l) \rightleftharpoons CH_2\,COOH(aq) + \bar{O}H(aq)$

from CH_3COONa

(c) Ammonium sulphate is a **salt of weak base and strong acid** and therefore under goes **hydrolysis** producing **hydrogen ions** or (hydroxonium ions) which make the solution **acidic** and hence turns litmus red

$\overset{+}{N}H_4(aq) + H_2O(l) \rightleftharpoons NH_4OH(aq) + H^+(aq)$

or; $\overset{+}{N}H_4(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$

However, sodium sulphate is **a salt of strong base and strong acid** and hence **does not undergo hydrolysis** hence making the solution **neutral** and hence with no effect on litmus

(d) In ethanol, the **electronegative** oxygen atom makes the oxygen-hydrogen bond to be **polar** and thus ethanol molecules associate through **intermolecular hydrogen bonds** which are **strong** and **require a lot of heat energy** to be broken. But; in methoxy methane (dimethyl ether), there is **no oxygen-hydrogen bond** and hence the molecules are **non polar** and associate through **weak vander Waal's forces** which **require less heat energy** to be broken.

(e) The dichromate (VI) ion **oxides** the iodide ions to **iodine**

$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6I^-(aq) \longrightarrow 2Cr^{3+}(aq) + 7H_2O(l) + 3I_2(aq)$

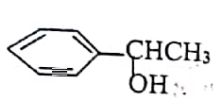
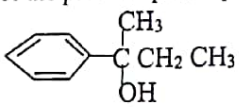
(f) Alpha particles are **positively charged** and the gold atoms contain **protons** in their nuclei which are also **positively** charged and so the repulsion between the alpha particles and protons causes deflection

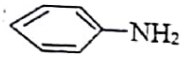
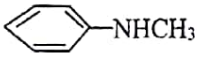
However, since the nucleus which contains protons occupies a **very small part of the** atom, most of the alpha particles experience zero repulsion and hence **pass undeflected.**

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QUESTIONS TO 'A' LEVEL CHEMISTRY PAPER 1(P525/1) 2015

1. (a) Complete the following equation for nuclear reactions.
   (i) $^{27}_{14}Si \longrightarrow {}^{27}_{13}Al + \ldots\ldots\ldots\ldots$ (1 mark)
   (ii) $^{236}_{92}U + {}^{1}_{0}n \longrightarrow 2{}^{1}_{0}n + \gamma + {}^{147}_{60}Nd + \ldots\ldots\ldots\ldots$ (1 mark)
   (b) When a radioactive isotope was left to stand, it decayed by 12.5% of this original value is 45 days.
   Calculate the half life of the radioactive isotope. (2½ marks)
2. Compound Y contains 31.1% sulphur, the reat being chlorine. (Y = 103)
   (a) Determine the molecular formula of Y (2 marks)
   (b) Draw the structure and name the shape of a molecule of Y. (1½ marks)
   (c) Comment on the polarity of the molecule of Y. (1 mark)
3. Name the reagent that can be used to distinguish between the following pairs of compounds and state what would be observed in each case if each number of the pair is separately treated with the reagent you have name

   (a)  and  (3 marks)

   (b)  and  (3 marks)

4. (a)Figure 1 shows the energy for the reaction between nitrogen monoxide and oxygen.

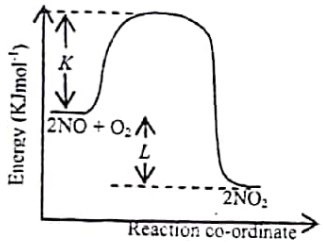


Fig.1

   (i) Identify K and L (½ mark)
   (ii) State whether the reaction is endothermic or exothermic. (½ mark)
   (iii) Give a reason for your answer in (a) (ii) (½ mark)
   (b) The experimental results in the table below were obtained for the reaction in (a).

Initial concentration (mol dm^{-3})		Rate of reaction (mol dm^{-3} s^{-1})
NO	O_2	
0.03	0.03	2.7×10^{-5}
0.03	0.06	5.4×10^{-5}
0.06	0.03	10.8×10^{-5}

   (i) Deduce the order of the reaction with respect to nitrogen monoxide.
   Oxygen (1 mark)
   (ii) write the rate equation for the reaction (1 mrak)
   (c) Calculate the; (½ mark)
   (i) Overall order of the reaction
   (ii) Rate constant (K) for the reaction and state its units
5. (a) Write equation for the reaction between chlorine and (1½ marks)
   (i) Hydrogen sulphate solution
   (ii) Hot concentrated sodium hydroxide solution. (1½ marks)
   (b) State what was observed in (a) (i) and (ii) (1½ marks)
   (c) In which one of the reactions in (a) is chlorine behaving as an oxidizing agent? (1 mark)
6. Polystyrene is formed by polymerization of phenylethene.
   (a) (i) Write the structural formula of polystyrene.
   (ii) Name the type of polymerization involved in the formation of polystyrene. (1 mark)
   (b) The osmotic pressure of a solution containing 5.5g of polystyrene in 1dm^3 of benzene is 1.05×10^{-3} (½ mark)
   atmospheres at 20°C.
   (i) Calculate the relative molecular mass of polystyrene.(R = 0.082 atm K^1 mol^{-1}) (2 marks)

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(ii) Determine the number of monomers that formed the polystyrene. (1 mark)

7. Carbon monoxide reacts with hydrogen to from methanol according to the following equation.

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)\ \Delta H^{\theta} = -92kJ\ mol^{-1}$

(a) Write the expression for the equilibrium constant, K_c for the reaction (1 mark)

(b) When I mole of carbon monoxide was mixed with 2 moles of hydrogen and the reaction carried out at 200°C, 1.6 moles of hydrogen remained in the equilicrium mixture.
Calculate the value for the equilibrium constant, K_c. (3 marks)

8. (a) (i) State the conditions for the reaction between benzene and sulphuric acid. (1 mark)

(ii) Outline a mechanism for the reaction in (a) (i) (3 marks)

(b) Write equation(s) to show how the products in (a) (ii) can be converted to hydroxybenzene. (3 marks)

9. State what would be observed and write equation for the reaction that would take place when sodium hydroxide solution is added drop-wise until in excess to

(a) Lead nitrate solution (3 marks)

(b) Nickel chloride solution. (2 mark)

10. Complete the following equations and in each case write the accepted mechanism for the reaction.

(a) $CH_3CH_2\overset{\overset{O}{\|}}{C}-H + NaHSO_3 \longrightarrow$ (3 marks)

(b) $\overset{CH_3}{\underset{|}{C}}=CH_2 \xrightarrow{HI}$ (3 marks)

(c) $CH_3\underset{Br}{\underset{|}{CH}}-\underset{Br}{\underset{|}{CH}}CH_3 \xrightarrow[heat]{CH_3CH_2\bar{O}Na^+/CH_3CH_2OH}$ (3 marks)

11. (a) State what is meant by the term enthalpy of solution (1 mark)

(b) The table below shows the heats of hydration and lattice energies of lithium chloride and sodium chloride.

Salt	Enthalpy of hydration ($kJmol^{-1}$)	Lattice energy ($kJmol^{-1}$)
LiCl	−882	+848
NaCl	−765	+788

Calculate the heat of solution of

(i) Lithium chloride. (1½ marks)

(ii) Sodium chloride. (1 mark)

(iii) State how you would expect the solubility of the two salts to vary with temperature and give reasons for your answers. (2½ marks)

(c) Explain how hydration energy affects the solubility of salts in water (3 marks)

12. (a) State how the following anhydrous chlorides can be prepared.

(i) Aluminium chloride. (1 mark)

(ii) Phosphorus (III) chloride. (1½ marks)

(b) Write equations for the reaction between water and the chlorides in (a)

(i) Aluminium chloride (1½ marks)

(ii) Phosphorus (III) chloride. (1½ marks)

(c) Dilute sodium hydroxide solution was added drop-wise until in excess to a solution of aluminium chloride in water.

(i) State what was observed (1 mark)

(ii) Write equation(s) for the reaction(s) that took place. (2½ mark)

13. A hydrocarbon Y contains 85.7% carbon and has a density of $2.5gl^{-1}$ at s.t.p.

(a) Calculate the empirical formula of Y. (2 marks)

(b) Determine the molecular formula of Y (2 marks)

(c) Write the structural formulae of all the possible open chain isomers of Y. (1½ marks)

(d) (i) Ozonolysis of Y and subsequent work-up gave one compound. Identify Y. (½ mark)

(ii) Write an equation to show how Y can be synthesized from butan-2-ol and indicate a mechanism for the reaction. (3 marks)

14. (a) State the oxidation state and co-ordidation number of the metal in each of the following compounds. (2 mks)

Compound	Oxidation state	Co-ordination number
$[Cr(H_2O)_6]^{3+}(Cl^-)_3$		
$[Ni(CO)_4]$		

(b) Ions of a metal M react with excess ammonia to form a complex according to the following equation.

$M^+(aq) + nNH_3(aq) \rightleftharpoons [M(NH_3)n]^+(aq)$

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25 cm^3 of ammonia solution was added to 25cm^3 of a 0.1M aqueous solution of metal M ions, followed by 50cm^3 of trichloromethane. The mixture was shaken and allowed to each equilibrium at 20°C. The aqueous layer required 27.5cm^3 of 1.0M nitric acid and the trichloromethane layer required 18.0 cm^3 of 0.05M nitric acid for complete neutralization. Calculate the;

(i) Concentration of ammonia in trichloromethane layer. (1½ marks)

(ii) Concentration of ammonia that formed the complex with M^+ ions. (Distribution coefficient of ammonaia between water and trichloromethane is 25 at 20°C) (3 marks)

(iii) Determine the value of n in the complex (2½ marks)

15. The table below shows the atomic radius and the first ionization energy of some elements in period (III) of the Periodic Table.

Element	Na	Mg	Al	Si	P	S	Cl
Atomic radius (nmm)	0.186	0.160	0.143	0.117	0.110	0.104	0.099
First ionization energy ($kJmol^{-1}$)	496	738	577	787	1060	1000	1251

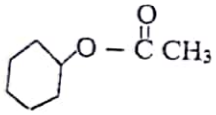
(a) (i) State how atomic radius of elements varies across the period (1 mark)

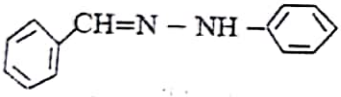
(ii) Explain your answer in (a) (i). (3 marks)

(b) (i) Explain how atomic radius affects the first ionization energy. (2 marks)

(ii) Why is the first ionization energy of aluminium lower than that of magnesium? (3 marks)

16. Write equations to show how the following compounds can be systhesised.

(a)  from  (3 ½ marks)

(b)  from  (3 marks)

(c) $CH_3 - \overset{O}{\overset{\|}{C}} - CH_3$ from $CH_3CH = CH_2$ (3 marks)

17. (a) (i) Write the name and the formula of the principal ore of copper. (1 mark)

(ii) State a method which can be used to concentrate the ore you have named in (a) (i). (½ mark)

(b) The concentrated ore (a) (i) was converted to copper (I) sulphide.

(i) State how the conversion was carried out. (1 mark)

(ii) Write an equation for the reaction that led to the formation of the sulphide (1½ marks)

(c) The copper (I) sulphide in (b) was mixed with silicon dioxide the mixture heated in the absence of air.

(i) State the purpose of adding silicon dioxide (1 mark)

(ii) Write an equation for the reaction that takes place during the process. (1½ marks)

(d) State how copper (I) sulphide is converted to impure copper and write eqtion for the reaction that takes place. (2½ marks)

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1 (P525/1) 2015

1. (a) (i) $^{27}_{14}Si \longrightarrow {}^{27}_{13}Al + {}^{0}_{1}e$

(ii) $^{236}_{92}U + {}^{1}_{0}n \longrightarrow 2{}^{1}_{0}n + \gamma + {}^{147}_{60}Nd + {}^{88}_{32}Ge$

(b) Let; the original value be; $No = 100\%$

Amount left after decay; $Nt = 100 - 12.5 = 87.5\%$

Time of decay; $t = 45days$

$$using;\ \lambda t = 2.303 \log_{10}\left(\frac{No}{Nt}\right)$$

$$\lambda = \frac{2.303 \log\left(\frac{100}{87.5}\right)}{42}$$

Decay constant; $\lambda = 2.967 \times 10^{-3} day^{-1}$

Therefore; half life; $t½ = \frac{ln2}{\lambda}$

$$= \frac{0.693}{2.967 \times 10^{-3}} = 233.5days$$

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2. (a) % of chlorine in Y= 100 − 31.1 = 68.9%

Composition of Y;

	S		Cl
moles;	$\frac{31.1}{32.0}$		$\frac{68.9}{35.5}$
	0.972		1.941
mole ratio;	$\frac{0.972}{0.972}$	:	$\frac{1.941}{0.972}$
	1		2

Empercial formula of Y is SCl_2

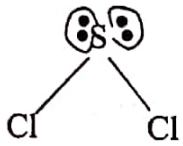
Hence, $(SCl_2)_n = 103$

$(1\times 32)n + (2\times 35.5)n = 103$

$103n = 103$

$n = 1$

Therefore molecular formula of Y is **SCl_2**

(b) 

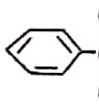
V-shape or bent shape

(c) The molecule of Y is **polar** since the **dipole moments do not cancel out.**

3. (a) **Reagent** – solution of concentrated hydrochloric acid and anhydrous zinc chloride.

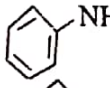
Observation;

 - forms a **cloudy solution** (or two layers) within 5-10minutes

 -forms a **cloudy solution** (or two layers) immediately.

(b) **Reagent**; concentrated hydrochloric acid and sodium nitrite.

Observation;

 -forms a colourless solution



-forms a yellow oily liquid

4. (a) (i) K-Activation energy for the forward reaction

L-Enthalpy of reaction

(ii) The reaction is **Exothermic**

(iii) The enthalpy of reaction is **negative** since the products are at a lower energy level than the reactants.

(b) (i) **Nitrogen monoxide**

Deducing order of reaction by inspection method;

When the concentration of oxygen is **constant** while the concentration of nitrogen monoxide **doubled**, the rate of reaction **increases by four times** (quadruples) indicating that order of reaction with respect to nitrogen monoxide is **second order.**

Alternatively;Deducing order of reaction by calculation method

Let; the order of reaction with respect to $NO = x$

Hence; $\left(\frac{0.06}{0.03}\right)^x = \left(\frac{10.8\times10^{-5}}{2.7\times10^{-5}}\right)$

$2^x = 2^2$ *hence* $x = 2$; *Therefore order of reaction with respect to NO is* ***second order***

Order of reaction with respect to Oxygen

When the concentration of nitrogen monoxide is **constant** and the concentration of oxygen **doubled** the rate of reaction **doubles** indicating that the reaction is **first order** with respect to oxygen.

Alternatively; By calculation;

Let; the order of reaction with respect to $O_2 = y$

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Hence; $\left(\frac{0.06}{0.03}\right)^{y} = \left(\frac{5.5\times10^{-5}}{2.7\times10^{-5}}\right)$

$2^{y} = 2^{1}$

$y = 1$; *Thus the order of reaction with respect to oxygen is* **first oder.**

(ii) Rate = $K[NO]^2[O_2]$

(c) (i) Overall order of reaction = 2 + 1 = 3

(ii) Rate constant; $K = \frac{Rate\ of\ reaction}{[NO]^2[O_2]}$

$= \frac{2.7\times10^{-5}}{(0.03)^2(0.03)}$ = $\mathbf{1.0 mol^2 dm^6 S^{-1}}$

5. (a) (i) $H_2S(aq) + Cl_2(g) \longrightarrow S(s) + 2HCl(aq)$

(ii) $6NaOH(aq) + 3Cl_2(g) \longrightarrow NaClO_3(aq) + 5NaCl(aq) + 3H_2O(l)$

or; $6\bar{O}H(aq) + 3Cl_2(g) \longrightarrow Cl\bar{O}_3(aq) + 5Cl^-(aq) + 3H_2O(l)$

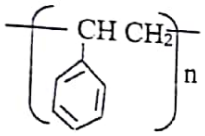
(b) In; (a)(i) A **yellow precipitate** formed

(a)(ii) The **greenish – yellow** gas dissolved to form a **colourless solution**

(c) In (a) (i)

Note; In (a)(i) chlorine has oxidized hydrogen sulphide to sulphur and the chlorine its self reduced to hydrochloric acid.

6. (a) (i)



(ii) Addition polymerization

(b) (i) Using; $\pi v = \frac{m}{mr}RT$

Hence; $mr = \frac{mRT}{\pi v}$

$= \frac{5.5\times8.314\times(20+273)}{1.05\times10^{-3}\times10^{-3}}$ = 125870.9

(ii) Molar mass of monomer, phenylethene ($C_6H_5CH{=}CH_2$)

$= (8\times12) + (8\times1) = 104$

Hence; Number of monomers = $\frac{molecular\ mass\ of\ polymer}{molecular\ mass\ of\ monomer}$

$= \frac{125870.9}{104}$ = **1210 monomers**

7. (a) $Kc = \frac{[CH_3OH]}{[CO][H_2]^2}$

(b) Let; moles of CO(g) which reacted at equilibrium = x

	CO(g)	+	$2H_2(g)$	⇌	$CH_3OH(g)$
Initially;	1mole		2moles		0
At Equilibrium;	$(1-x)$moles		$(2-2x)$moles		$x$mole

Hence; $2 - 2x = 1.6$

$x = 0.2$

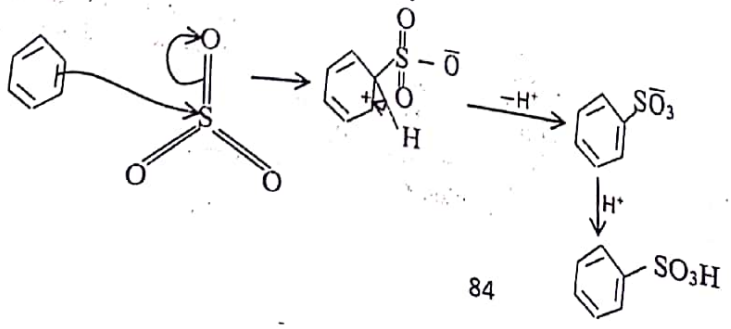
Thus; $[CO] = 1 - 0.2 = 0.8$M(Assumed that volume of system is $1dm^3$)

$[CH_3OH] = 0.2M$

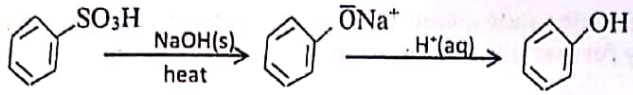
$Kc = \frac{0.2}{(0.8)\times(1.6)^2}$ = $\mathbf{9.77\times10^{-2} mol^{-2} dm^6}$

8. (a)(i) **Concentrated** or **fuming** sulphuric acid and **heat** or **reflux**

(ii) $2H_2SO_4 \rightleftharpoons SO_3 + H_3O^+ + HSO_4^-$



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(b) 

(a) **Observation; White precipitate, soluble** in excess sodium hydroxide solution forming a **clear colourless solution**

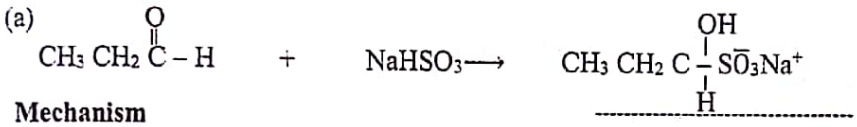
Equation; $Pb^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Pb(OH)_2(s)$

$Pb(OH)(s) + 2\bar{O}H(aq) \longrightarrow Pb(OH)_4^{2-}(aq)$

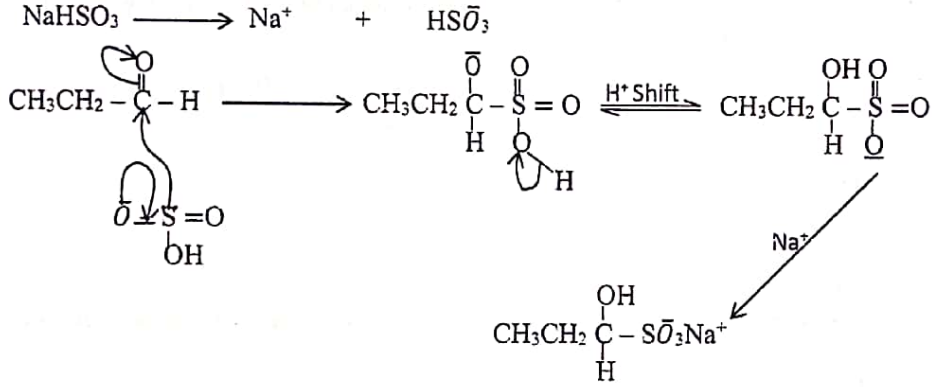
or $Pb^{2+}(aq) + 4OH^- \longrightarrow Pb(OH)_4^{2-}(aq)$

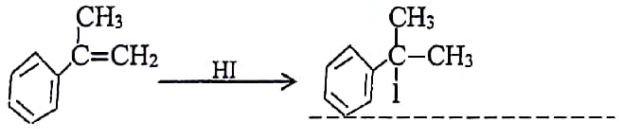
(b) **Observation; Green precipitate, insoluble** in excess sodium hydroxide solution

Equation; $Ni^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Ni(OH)_2(s)$

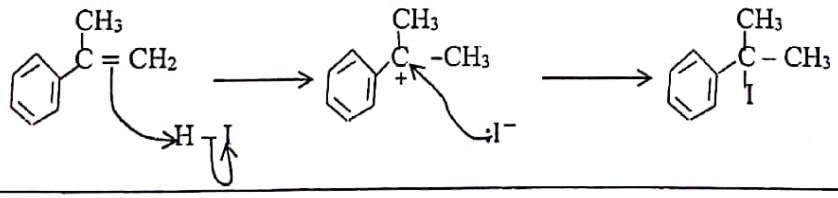
(a) 

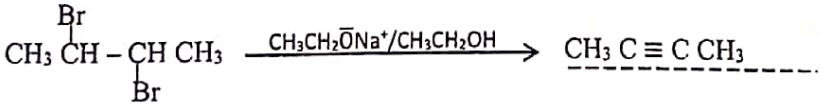
Mechanism



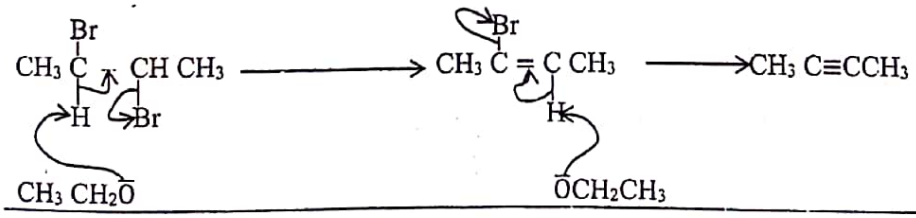
(b) 

Mechanism;



(c) 

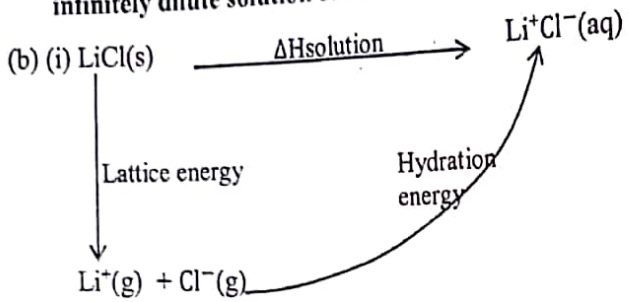
Mechanism;



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11. (a) The **heat change** when **one mole** of an **ionic solute** dissolves in enough **water molecules** to form an **infinitely dilute solution** such that any **further dilution causes no more heat change.**

(b) (i)



Thus; ΔHsolution (LiCl) = Lattice energy + hydration energy

$= +848 + (-882) \quad = -34 KJmol^{-1}$

(ii) $\Delta Hsolution\ (NaCl) = +788 + (-765) = +23\ KJmol^{-1}$

(iii) Solubility of Lithium chloride would **decrease** with increase in temperature because the enthalpy of solution of lithium chloride is **negative** (exothermic)

Solubility of sodium chloride would **increase** with **increase** in temperature because the heat of solution of sodium chloride is **positive** (endothermic)

(c) When the hydration energy of the salt is **greater** than its lattice energy, the **enthalpy of solution** of the **salt becomes negative** and the **solubility of the salt in water is high**

12. (a)(i) Passing **dry chlorine** over **heated** aluminum

(ii) **Heating** phosphorus in a limited **dry** chlorine.

(b) (i) $3AlCl_3(s) + 3H_2O(l) \longrightarrow Al(OH)_3(s) + 3HCl(aq)$

(ii) $PCl_3(s) + 3H_2O(l) \longrightarrow H_3PO_3(aq) + 3HCl(aq)$

(c) (i) **White precipitate, soluble** in excess sodium hydroxide solution forming a **colourless solution**

(ii) $Al^{3+}(aq) + 3\bar{O}H(aq) \longrightarrow Al(OH)_2(s)$

$Al(OH)_3(s) + \bar{O}H(aq) \longrightarrow Al(OH)_4^-(aq)$

Or, $Al^{3+}(aq) + \bar{O}H(aq) \longrightarrow Al(OH)_4^-(aq)$

13. (a) % of hydrogen in Y = 100 − 85.7 = 14.3%

Composition of Y;

	C		H
moles;	$\frac{85.7}{12}$		$\frac{14.3}{1}$
	7.142		14.3
mole ratio;	$\frac{7.142}{7.142}$		$\frac{14.3}{7.142}$
	1	:	2

Empercial formula of Y is CH_2

(b) 1Liter of Y weighs 2.5g.

$\therefore 22.4 litres\ of\ Y weigh\ \frac{22.4\times2.5}{1} g = 56g$

Molecular mass of Y $= 56g$

Hence; $(CH_2)n = 56$

$(1 \times 12)n + (2 \times 1)n = 56$

$n = \frac{56}{14} = 4$

Therefore, molecular formula of Y is C_4H_8

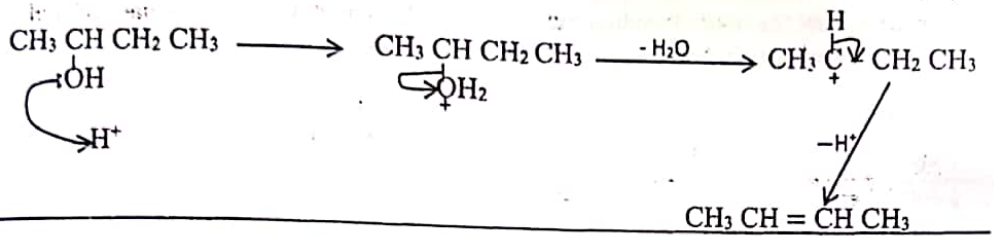
(c) $CH_3CH{=}CHCH_3$, $CH_3CH_2CH{=}CH_2$ and $CH_3C(CH_3){=}CH_2$

(d)(i) $CH_3CH = CHCH_3$

(ii) $CH_3\underset{\underset{OH}{|}}{C}HCH_2CH_3 \xrightarrow[180°C]{Conc.H_2SO_4} CH_3CH{=}CHCH_3$

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Mechanism;



(a)

Compound	Oxidation state	Co-ordination number
$[Cr(H_2O)_6]^{3+}(Cl^-)_3$	+3	6
$[Ni(CO)_4]$	0	4

(b) (i) Moles of HNO_3 that reacted with NH_3 in the $CHCl_3$ layer = $\left(\frac{18.0\times0.05}{1000}\right)$moles

So: $50cm^3\ of\ CHCl_3\ layer\ contain\ \left(\frac{18.0\times0.05}{1000}\right)moles\ of\ NH_3$

$\therefore 1000cm^3\ of\ CHCl_3\ layer\ contain\ \left(\frac{1000\times18.0\times0.05}{1000\times50}\right)moles\ of\ NH_3$

concentration ofNH_3 in $CHCl_3 = 0.018M$

(ii) Moles of HNO_3 which reacted with NH_3 in aqueous layer = $\left(\frac{27.5}{1000}\times1.0\right)moles$

Since mole ratio of HNO_3 : NH_3 = 1:1, hence,

$$moles\ of\ NH_3\ in\ aqueous\ layer = \left(\frac{27.5}{1000}\times1.0\right)moles$$

$$Thus, 50cm^3\ of\ aqueous\ layer\ contain\ \left(\frac{27.5\times1.0}{1000}\right)moles\ of\ NH_3$$

$$\therefore 1000cm^3\ of\ aqueous\ layer\ contain\ \left(\frac{1000\times27.5\times1.0}{50\times1000}\right)moles\ of\ NH_3$$

Hence; Total concentration of NH_3 in aqueous layer = $0.55M$

(both complexed NH_3 and free NH_3)

$$\text{Since; } K_D = \frac{[free\ NH_3]\ in\ aqueous\ layer}{[NH_3]\ in\ CHCl_3}$$

Therefore; [free NH_3] in aqueous layer = $K_D \times [NH_3]\ in\ CHCl_3$

$= 25 \times 0.018 = \mathbf{0.45M}$

Hence; concentration NH_3 that formed a complex with M^+ ions = $0.55 - 0.45 = \mathbf{0.1M}$

(iii) Moles of M^+ ions in $25cm^3$ of aqueous solution = $\left(\frac{25}{1000}\times0.1\right)moles$

$$50cm^3\ of\ aqueous\ layer\ contain\ \left(\frac{25\times0.1}{1000}\right)moles\ of\ M^+(aq)$$

$$\therefore 1000cm^3\ of\ aqueous\ layer\ contain\ \left(\frac{1000\times25\times0.1}{50\times1000}\right)moles\ of M^+(aq)$$

Hence; concentration of M^+ in aqueous layer = $0.05M$

Thus; 0.1moles of NH_3 complexes with 0.05mole of M^+

$$n\ moles\ of\ NH_3\ complexes\ with\ 1\ mole\ of\ M^+$$

$$Therefore; n = \frac{0.1}{0.05} = 2$$

(a) (i) Atomic radius **decreases** across the period **from sodium to chlorine.**

(ii) From sodium to chlorine, there is **increase in the number of protons** in the nucleus of an atom which **increases the nuclear charge**. The number of electrons on the **same** outer most energy level also **increases**, which **increases the screening effect.**
However, the increase in nuclear charge **outweighs** the increase in screening effect.
Therefore, the **effective nuclear charge increases** and then the outer most energy level electrons experience **stronger nuclear attraction** thus resulting into **decrease in atomic radius.**

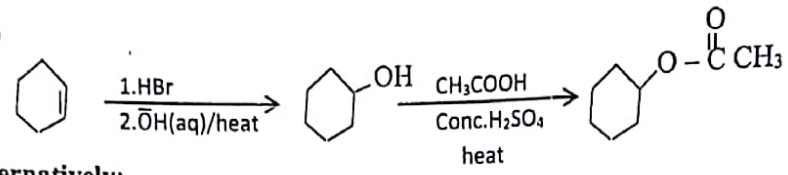
(c) (i) The **smaller** the atomic radius, the **nearer** are the outer most electrons to the nucleus, and thus, these electrons experience **greater nuclear attraction** resulting into **higher first ionization** energy.

(ii) Electronic configurations; Al – $\mathbf{1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1}$; Mg– $\mathbf{1s^2\ 2s^2\ 2p^6\ 3s^2}$
In aluminium the outer 3p-subenergy level contains **one electron** and therefore is **unstable** and

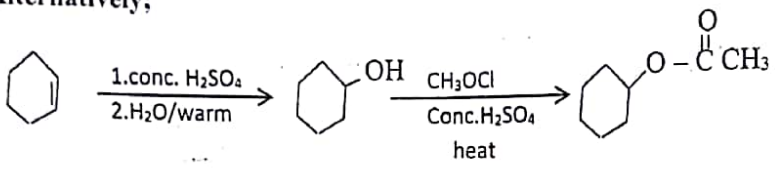
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hence **little amount of energy** is required to remove an electron from it.
However in magnesium, the outer 3s-subenergy is **filled with electrons** and thus **energetically stable**, hence **a lot of energy** is required to **remove an electron** from it

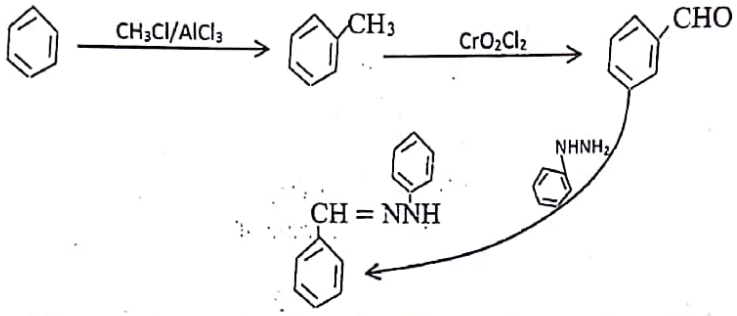
16. (a)



Alternatively;

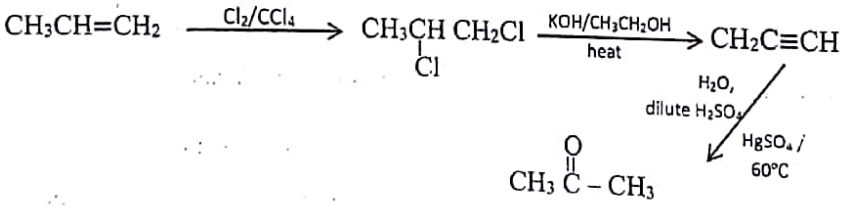


(b)

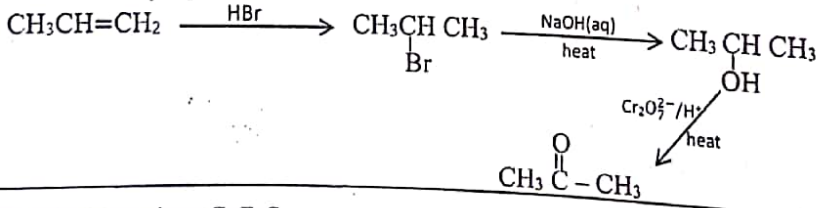


(c) $CH_3CH=CH_2$ —(1.conc. H_2SO_4, 2.H_2O/warm)→ $CH_3CH(OH)CH_3$ —($Cr_2O_7^{2-}/H^+$ or CrO_3/H^+ or MnO_4^-/conc.H_2SO_4, heat)→ CH_3COCH_3

Alternatively;



Alternatively;



---

17. (a) (i) Copper pyrites; $CuFeS_2$
(ii) Froth floatation
(b) (i) The ore was roasted in air
(ii) $2\,CuFeS_2(s) + 4O_2(g) \longrightarrow Cu_2S(s) + 2FeO(s) + 3SO_2(g)$
(c) (i) To convert the Iron (II) oxide to Iron(II) silicate which is slag.
(ii) $FeO(s) + SiO_2(s) \longrightarrow FeSiO_3(l)$
(d) Copper (I) sulphide is heated in limited air
$Cu_2S(s) + O_2(g) \longrightarrow 2Cu(l) + SO_2(g)$

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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2015

1. (a) Define the term buffer solution (1 mark)
   (b) Explain the action of an acid buffer. (5 marks)
   (c) $50cm^3$ of 0.05M ethanoic acid was added to $50cm^3$ of a 0.02M sodium hydroxide solution.
   (i) Write an equation for the reaction that took (1 mark)
   (ii) Calculate the pH of the resultant solution at 25°C. (The acid dissociation constant Ka. of ethanoic acid is 1.8×10^{-5} at 25°C). (5 marks)
   (d) To 50 cm^3 of a 0.02M ethanoic acid was added to an equal volume of 0.02M potassium hydroxide solution.
   (i) Calculate the pH of the resultant solution (1 mark)
   (ii) Explain your answer in (d)(i) (3 marks)
2. (a) What is meant by the term
   (i) Complex ion? (1 mark)
   (ii) Oxidation state? (1 mark)
   (b) Explain why transition metals can
   (i) form complex ions (4 marks)
   (ii) exist in various oxidation states (2 ½ marks)
   (c) State what would be observed and write equations for the reactions that would take place if ammonia solution was added dropwise until in excess to the following ions and the mixture allowed to stand for some time.
   (i) $Mn^{2-}(aq)$ (4 ½ marks) (ii) $Fe^{3+}(aq)$ (2 ½ marks) (iii) $Ni^{2+}(aq)$ (4 ½ marks)
3. Write the names or structural formulae of one pair of compounds with two functional groups which can be distinguished using the following reagents. In each case, state what would be observed if each member of the pair was separately treated with the reagent and write an equation for any reaction that would take place
   (a) Ammonical silver nitrate (4 marks)
   (b) Bromine water (4 marks)
   (c) Acidified potassium dichromate(VI) (4 marks)
   (d) Iodine in the presence of sodium hydroxide (4 marks)
   (e) 2,4-dinitrophenylhydrazine (4 marks)
4. (a) State Raoult's law (1 mark)
   (b) A mixture of liquid Y and Z obeys Raoult's law. If the vapour pressure of Y and Z are $9.50KNm^{-2}$ and $3.20KNm^{-2}$ respectively at 20°C.
   (i) Calculate the composition of then vapour containing 0.5 mol of each liquid at 20°C. (4 marks)
   (ii) State which of the two liquids is more volatile. Give a reason for your answer. (2 marks)
   (c) The b oiling points of liquids Y and Z are 368°C and 395°C respectively.
   (i) Sketch a labelled boiling point –composition diagram of the mixture of the liquids. (3 marks)
   (ii) Using the diagram, describe how pure liquid Z can be obtained from a mixture containing 50%Z (5 marks)
   (d) Explain why some liquids show negative deviation from Raoult's law. (3 marks)
   (e) If the mixture of liquids Y and Z in (b) was to deviate negatively from Raoults's law, sketch a labelled boiling point – composition diagram for the mixture. (2 marks)
5. The boiling points and atomic radii of fluorine, chlorine, bromine and iodine are shown in the table below.

Element	Fluorine	Chlorine	Bromine	Iodine
Boiling point (°C)	-188	-35	59	184
Atomic radii (nm)	0.072	0.099	0.114	0.133

   (a) Explain the trend in the
   (i) atomic radius of the elements (2 ½ marks)
   (ii) boiling points of the elements (2 ½ marks)
   (b) Illustrating your answers with equations compare how chlorine and fluorine react with;
   (i) water (4 marks)
   (ii) sodium hydroxide (8 marks)
   (c) $10.0cm^3$ of a sample of commercial bleach containing chlorine was diluted to $250cm^3$ with water. $25.0cm^3$ of this solution was transferred into a conical flask and potassium iodide solution added to liberate iodine. The iodine mixture required 23.2 cm^3 of a 0.1M sodium thiosulphate solution for complete reaction. Calculate the molar concentration of chlorine in the commercial bleach.
   Sodium thiosulphate reacts with iodine solution according to the following equation:
   $2S_2O_3^{2-}(aq) + I_2(aq) \longrightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

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and chlorine reacts with iodine according to the following equation:

$Cl_2(aq) + 2I^-(aq) \longrightarrow 2Cl^-(aq) + I_2(aq)$ (3 marks)

6. (a) Define the term

(i) molar conductivity (1 mark)

(ii) electrolytic conductivity (1 mark)

(b) The table below shows molar conductivities, Λ, of potassium chloride and ethanoic acid at different Concentrations.

$(concentration)^{1/2} (mol\ dm^{-3})^{1/2}$	0.01	0.02	0.03	0.04	0.074	0.106	0.132
Λ, for KCl($\Omega\ cm^2\ mol^{-1}$)	147.0	145.0	142.0	140.0	132.0	128.0	127.0
Λ, for CH_3COOH($\Omega\ cm^2\ mol^{-1}$)	70.0	49.0	33.0	24.0	10.0	6.0	4.0

(i) On the same axes draw graphs of molar conductivity against square root of concentration, for both potassium chloride and ethanoic acid. (3 marks)

(ii) State the shapes of the graph in (b)(i) and explain your answer. (5 marks)

(c) The electrolytic conductivity of a solution containing 6.66g of ethanoic acid in one litre is $5.21 \times 10^{-2}\ \Omega^{-1}m^{-1}$ at 25°C.

Calculate the dissociation constant Ka of ethanoic acid at 25°C. (*The molar conductivities of hydrochloric acid, sodium chloride and sodium ethanoate are* 426×10^{-4}, 126×10^{-4} *and* $91 \times 10^{-4}\ \Omega^{-1}m^2mol^{-1}$ *respectively at infinite dilution*) (6 marks)

(d) To a solution of hydrochloric acid was added small amount of sodium hydroxide solution at a time until in excess. State how the conductivity varied and explain your answer. (4 marks)

7. (a) Discuss the reactions of ethanol with sulphuric acid. In each case outline a mechanism for the reaction that took place. (13 marks)

(b) Write equations to show how the following compounds can be synthesized from ethanol;

(i) Propanone

(ii) Ethyne

8. Explain the following observations (4 marks)

(a) Sodium methanoate solution reacts with silver nitrate solution to form a grey precipitate whereas with sodium ethanonate there is no observable change. (3 marks)

(b) When sodium hydroxide solution was added to chromium(III) chloride solution dropwise until excess, a green precipitate was formed that dissolved in excess sodium hydroxide solution to form a green solution. (5½ marks)

(c) Sodium ion is smaller than sodium atom whereas a chloride ion is larger than a chlorine atom. (4 marks)

(d) When ammonium sulphate solution was added separately to equimolar solution containing calcium and barium ions, fewer drops were required to form a white precipitate with barium ions than with calcium ions. (3 ½ marks)

(e) Lithium carbonate decomposition when heated strongly whereas sodium carbonate does not. (4 marks)

END

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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2 (P525/2) 2015

Question. One.

(a) A solution that **resists** a change in pH when a **small** amount of acid or base is added

(b) An acid buffer is made up of a **weak acid** and its **salt with a strong base**

On addition of a **small** amount of acid, the hydrogen ions from the added acid **react with the acid anions** in the buffer solution to form unionized acid molecules; hence the **pH remains almost constant,** ie

$H^+(aq) + A^-(aq) \longrightarrow HA(aq)$

from added acid *acid anions*

On addition of a **small amount of alkali,** the hydroxide ions from the alkali added react with the hydrogen ions present in the buffer to produce water molecules.

$H^+(aq) + \bar{O}H(aq) \longrightarrow H_2O(l)$

The acid molecules therefore undergo ionization to produce more hydrogen ions so as to keep the **pH constant**

$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$

Alternatively;

On addition of a **small** amount of alkali the hydroxide ions from the added alkali react with the acid molecules to produce the salt and water, hence keeping the pH constant

$HA(aq) + \bar{O}H(aq) \longrightarrow H_2O(l) + A^-(aq)$

(c) (i) $CH_3COOH(aq) + NaOH(aq) \longrightarrow CH_3CO\bar{O}Na^+(aq) + H_2O(l)$

or $CH_3COOH(aq) + \bar{O}H(aq) \longrightarrow CH_3CO\bar{O}(aq) + H_2O(l)$

(ii) Moles of ethanoic acid in $50cm^3 = \frac{0.05\times50}{1000} = 0.0025$

Moles of NaOH in $50cm^3 = \frac{0.02\times50}{1000} = \mathbf{0.001}$

Moles of NaOH which reacted = 0.001 (since mole ratio of NaOH : CH_3COOH = 1 : 1)

Moles of CH_3COOH which reacted = 0.001

Moles of excess acid = $0.0025 - 0.001 = \mathbf{0.0015}$

Moles of salt formed = $0.001 (since\ mole\ ratio\ NaOH:salt = 1:1)$

Volume of resultant solution = $50 + 50 = 100cm^3$

Concentration of acid in resultant solution = $\frac{0.0015}{100} \times 1000 = \mathbf{0.015}M$

Concentration of salt in resultant solution = $\frac{0.001}{100} \times 1000 = \mathbf{0.01}M$

Ethanoic acid in solution ionizes as follws;

$CH_3COOH(aq) \rightleftharpoons CH_3CO\bar{O}(aq) + H^+(aq)$

$$Ka = \frac{[CH_3CO\bar{O}][H^+]}{[CH_3COOH]}$$

$$[H^+] = \frac{Ka[CH_3COOH]}{[CH_3CO\bar{O}]}, \text{ where } [CH_3CO\bar{O}] = [CH_3COONa] = 0.01M$$

$$= \frac{1.8\times10^{-5}\times0.015}{0.01} = 2.7\times10^{-5}$$

$$pH = -\log 2.7\times10^{-5} = \mathbf{4.57}$$

Or; $pH = pKa + \log\frac{[SALT]}{[ACID]}$

$$= -\log(1.8\times10^{-5}) + \log\left(\frac{0.01}{0.015}\right) = \mathbf{4.57}$$

(d) (i) moles of ethanoic acid in $50cm^3 = \frac{0.02\times50}{1000} = 0.001$

∴ moles of potassium ethanoate salt = $0.001 (since\ mole\ ratio\ of\ acid:salt = 1:1)$

Volume of resultant solution = $50 + 50 = 100cm^3$

Concentration of potassium ethanoate salt in resultant solution = $\frac{0.001\times1000}{100} = 0.01M$

Equation of hydrolysis

$CH_3CO\bar{O}(aq) + H_2O(l) \rightleftharpoons CH_3COOH(l) + \bar{O}H(aq)$

$$Kh = \frac{[CH_3COOH][\bar{O}H]}{[CH_3CO\bar{O}]}$$

Assuming; $[CH_3COOH] = [\bar{O}H]$

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$$[CH_3C\bar{O}\bar{O}] = [SALT]$$

$$Kh = \frac{[\bar{O}H]^2}{[SALT]}, \quad \text{also;} \quad Kh = \frac{Kw}{Ka} = \frac{1.0\times10^{-14}}{1.8\times10^{-5}} = \mathbf{5.56 \times 10^{-10}}$$

Hence $[\bar{O}H] = \sqrt{Kh[SALT]}$

$$= \sqrt{5.56 \times 10^{-10} \times 0.01} = \mathbf{2.36 \times 10^{-6}M}$$

$$[H^+] = \frac{Kw}{[\bar{O}H]} = \frac{1.0\times10^{-14}}{2.36\times10^{-6}} = 4.24 \times 10^{-9}M$$

$$pH = -\log 4.24 \times 10^{-9}M = \mathbf{8.37}$$

Or; $pOH = -\log[\bar{O}H]$

$$pOH = -\log(2.36 \times 10^{-6}) = \mathbf{5.63}$$

$$pH = 14 - pOH = 14 - 5.63 = \mathbf{8.37}$$

(ii) pH is **greater than seven** because the potassium ethanoate salt formed undergoes **hydrolysis** to form an **alkaline** solution

$CH_3C\bar{O}O(aq) + H_2O(l) \rightleftharpoons CH_3COOH(l) + \bar{O}H(aq)$

Question. Two.

(a) (i) A complex ion is a **positively** charged or **negatively** charged species containing a central metal cation linked to atoms or groups of atoms (called ligands) through **dative bonds**

(ii) The **net charge** that would remain on an atom in a compound if all the other atoms bonded to it were to be removed

or; The measure of the extent to which an atom has been oxidized or reduced in a compound.

or; The charge on an atom in a compound if the compound is assumed to be ionic

(b) (i) Transition metals form ions with **high charge density** (polarizing power) which enables them to **attract ligands** and form strong bonds with them

Transition metals also have **vacant 3d-orbitals** which **accept the lone pairs of electrons** from liqands to form co-ordinate bonds

(ii) Transition metals can **lose electrons from both the 4s and 3d subenergy levels**

Since the two subenergy levels, the 4s and 3d have almost the same energy.

(c) (i) Observation; **white precipitate, insoluble** in excess ammonia solution but turns **brown** on standing.

$Mn^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Mn(OH)_2(s)$

Then; $2Mn(OH)_2(s) + \frac{1}{2}O_2(g) \longrightarrow Mn_2O_3 \cdot 2H_2O(l)$

or; $2Mn(OH)_2(s) + \frac{1}{2}O_2(g) \longrightarrow Mn_2O_3(s) + 2H_2O(l)$

or; $2Mn(OH)_2(s) + \frac{1}{2}O_2(g) \longrightarrow 2MnO_2 \cdot H_2O(s)$

(ii) Observation; **Brown precipitate, insoluble** in excess ammonia solution

$Fe^{3+}(aq) + 3\bar{O}H(aq) \longrightarrow Fe(OH)_3(s)$

(iii) Observation; **Green precipitate, soluble** in excess ammonia solution to form a **blue solution**

$Ni^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Ni(OH)_2(s)$

Then; $Ni(OH)_2(s) + 6NH_3(aq) \longrightarrow [Ni(NH_3)_6]^{2+}(aq) + 2\bar{O}H(aq)$

Question. Three.

(a) $CH_3\overset{\overset{O}{\|}}{C}CH_3$ and $CH_3\text{-}CH_2\overset{\overset{O}{\|}}{C}-H$

Or; Propanone and propanal

Observation; $CH_3\overset{\overset{O}{\|}}{C}CH_3$ -gives **no observable change**

$CH_3\text{-}CH_2\overset{\overset{O}{\|}}{C}-H$ -gives a **silver mirror** appearance

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Equation;

$$CH_3CH_2\overset{\overset{O}{\|}}{C}-H \xrightarrow{Ag^+/NH_3} CH_3CH_2COO^- + Ag(s)$$

or; $$CH_3CH_2\overset{\overset{O}{\|}}{C}-H \xrightarrow{Ag^+/NH_3} CH_3CH_2COOH + Ag(s)$$

Alternatively

$HCOOH$ and CH_3COOH (or any other organic acid)

Or; methanoic acid and Ethanoic acid

Observation

$HCOOH$ -gives a **silver mirror** appearance

CH_3COOH -gives **no observable change**

Equation;

$$HCOOH \xrightarrow{Ag^+/NH_3} CO_2(g) + Ag(s)$$

Alternatively

Terminal alkynes eg ($CH_3C\equiv CH$) and non terminal alkynes eg ($CH_3CH_2C\equiv CCH_3$) or propyne and pent-2-yne

Observations

Terminal alkynes –gives a **white precipitate**

Non terminal alkynes –show **no observable change**

Equation;

$$CH_3C\equiv CH \xrightarrow{Ag\ /NH_3} CH_3C\equiv CAg(s) + H^+(aq)$$

(b) CH_3CH_3 and $H_2C=CH_2$ (or any other alkene)

Or; Ethane(or any other alkane) and Ethene (or any alkene)

Observation;

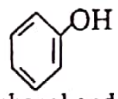
CH_3CH_3 -gives **no observable change**

$H_2C=CH_2$ -turns the **brown** bromine water **colourless**

Equation;

$$H_2C=CH_2 \xrightarrow{Br_2/H_2O} CH_2BrCH_2OH$$

Alternatively



and



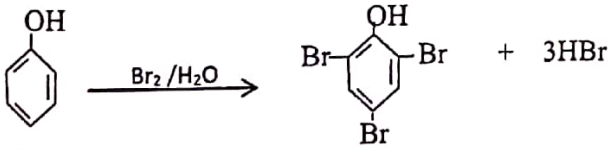
or; phenol and chloro benzene

Observation

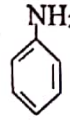
Phenol – brown solution turned to a **white precipitate**

Chloro benzene –gives **no observable change**

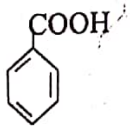
Equation;



Alternatively



and



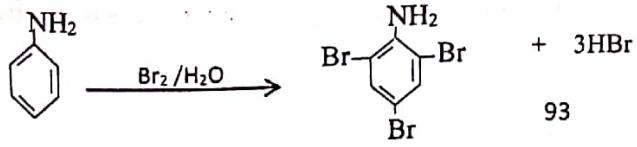
or; Amino benzene and benzoic acid

Observation;

Amino benzene – **white precipitate** formed

Benzoic acid – **No observable** change

Equation;



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(c) Aldehyde and ketone
or; primary alcohol and Tertiary alcohol
or; secondary alcohol and Tertiary alcohol
or; methanoic acid and any other carboxylic acid eg ethanoic acid
or; methyl benzene and chloro benzene
Observation;
Aldehyde, primary alcohol, secondary alcohol, methanoic acid and methyl benzene would turn acidified potassium dichromate (VI) solution **from orange to green.**
Ketone, Tertiary alcohol, other carboxylic acids except (methanoic acid) and chloro benzene would give **no observable change**
Equations

$$RCHO \xrightarrow{Cr_2O_7^{2-}/H^+} RCOOH$$

aldehyde

$$RCH_2OH \xrightarrow{Cr_2O_7^{2-}/H^+} RCOOH \text{ (or } RCHO)$$

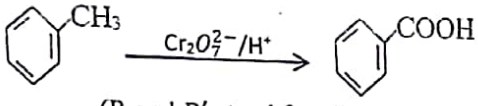
Primary alcohol

$$R-\underset{H}{\overset{OH}{\underset{|}{\overset{|}{C}}}}-R' \xrightarrow{Cr_2O_7^{2-}/H^+} RCOR'$$

Secondary alcohol

$$HCOOH \xrightarrow{Cr_2O_7^{2-}/H^+} CO_2$$

Methanoic acid



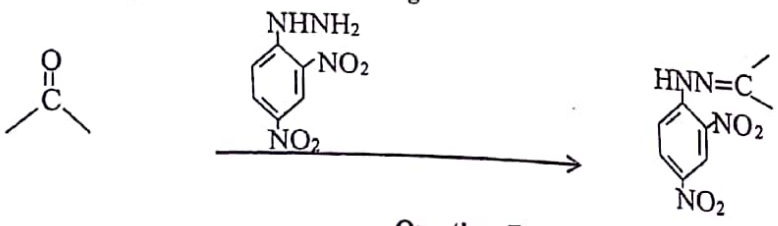
(R and R' stand for alkyl groups)

(d) CH_3CH_2OH and CH_3CH_2CHO
or; Ethanol and propanal
Observation;
CH_3CH_2OH -gives a **yellow precipitate**
CH_3CH_2CHO -gives **no observable change**
Equation;

$$CH_3CH_2OH \xrightarrow{I_2/NaOH} CHI_3 + HCO\bar{O}$$

I_2 /NaOH

(e) Carbonyl compounds and alcohols
Observation
Carbonyl compounds –give a **yellow precipitate**
Alcohols – give **no observable change**



Question. Four.

(a) The partial vapour pressure of a **volatile** component of an **ideal** solution is the product of its mole fraction and vapour pressure of the pure component at a **given temperature**
or
Partial vapour pressure of a **volatile** component of an **ideal solution** at a **given temperature** is directly proportional to its mole fraction

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or

The mole fraction of a non-volatile solute in a solution is equal to the relative lowering of the vapour pressure of the solvent by the solute at a **given temperature**

(b) (i) partial vapour pressure of y; $Py = 0.5 \times 9.50 = 4.75KNm^{-2}$

Partial vapour pressure of z; $Pz = 0.5 \times 3.20 = 1.6KNm^{-2}$

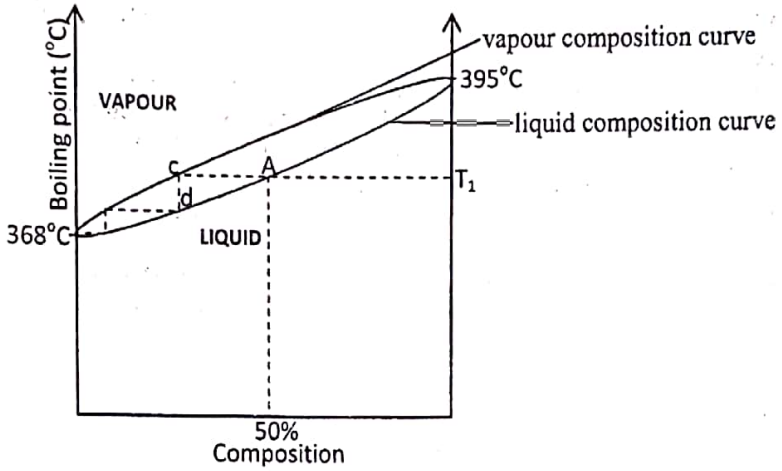
Mole fraction of Y *in vapour* $= \frac{4.75}{(1.6+4.75)} = 0.748 = 74.8\%$

Mole fraction of Z *in vapour* $= \frac{1.6}{6.35} = 0.252 = 25.2\%$

(ii) Y is more volatile

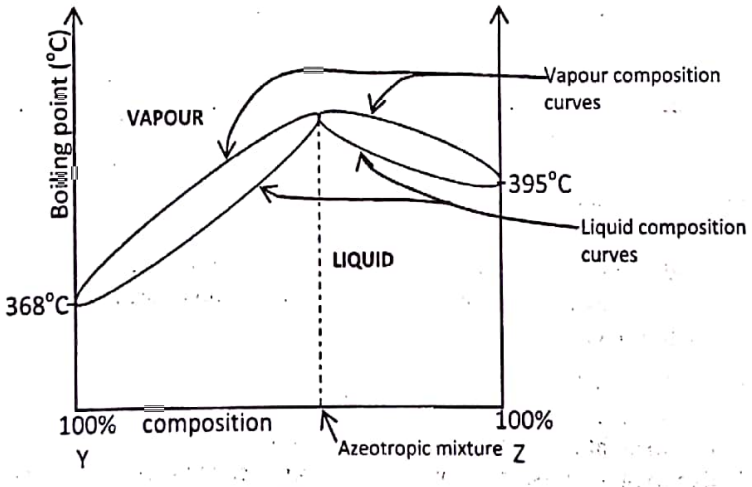
Reason; it has a higher vapour pressure at a given temperature.

(c) (i)



(ii) Aliquid mixture A (compoision 50% Z) is **heated**, it boils at a temperature T_1 giving off a vapour of composition C containing a higher proportion of the more volatile component Y. on condensation of the vapour, the liquid mixture d is formed with the same composition as the vapour. Repeacted distillation gives **pure Y** as the final distillate and **pure Z** as the final residue.

(d) This is due to the forces of attraction between unlike molecules being **greater** than those between the like molecules. This leads to a **reduction** in the tendency of the molecules in solution to vapourise, hence a **lower vapour pressure** than predicted by Raoult's law, and hence the solution shows a negative deviationfrom Raout's law



Question. Five.

(a) (i) The atomic radius **increases from fluorine to iodine**. From fluorine to iodine, from one element to the next, there is **increase in the number of protons** in the nucleus of an atom which **increases the nuclear charge**. There is also **increase in the number of full inner energy levels of electrons** which **increases the screening effect.**

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However, the increase in screening effect **outweighs** the increase in nuclear charge and therefore the **effective nuclear charge decreases** which results into **decrease in the nuclear attraction** for the outer energy levels electrons hence the increase in atomic radius.

(ii) Boiling points increase from fluorine to iodine. This is because of the **increase in atomic mass** of the halogen atom which **increases the relative molecular mass** of the halogen molecule and this results into **increase in the strength of the vander waal's forces** hence the increase in boiling point.

(b) (i) Fluorine reacts with water to give **hydrofluoric acid** and **oxygen.**

$F_2(g) + H_2O(l) \longrightarrow 2HF(aq) + \frac{1}{2}O_2(g)$

Chlorine **slightly** reacts with water to form **hydrochloric acid** and **chloric (I) acid**

$Cl_2(g) + H_2O(l) \rightleftharpoons HCl(aq) + HClO(aq)$

(ii) With **cold dilute** sodium hydroxide solution, fluorine reacts to form **sodium fluoride, oxygen difluoride** and **water**.

$2F_2(g) + 2NaOH(aq) \longrightarrow 2NaF(aq) + OF_2(g) + H_2O(l)$

Chlorine reacts to form **sodium chloride, water** and **sodium chlorate (I)**

$Cl_2(g) + 2NaOH(aq) \longrightarrow NaCl(aq) + NaClO(g) + H_2O(l)$

With **hot concentrated** sodium hydroxide solution;

Fluorine reacts to form **sodium fluoride, oxygen** and **water.**

$F_2(g) + 2NaOH(aq) \longrightarrow 2NaF(aq) + \frac{1}{2}O_2(g) + H_2O(l)$

Chlorine reacts to form **sodium chloride, sodium chlorate (V)** and **water.**

$3Cl_2(g) + 6NaOH(aq) \longrightarrow 5NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$

(c) Moles of $S_2O_3^{2-}$ in $23.2cm^3 = \frac{23.2\times0.1}{1000} = 2.32 \times 10^{-3}$

Since; mole ratio of $S_2O_3^{2-} : I_2 = 2:1$

Then; Moles of I_2 which reacted with $S_2O_3^{2-} = \frac{1}{2} \times \left(\frac{23.2\times0.1}{1000}\right) = 1.16 \times 10^{-3}$

Moles of $Cl_2 = 1.16 \times 10^{-3}$

$25cm^3$ of diluted bleaching solution contains 1.16×10^{-3} moles of chlorine

$250cm^3$ of diluted bleaching solution contains $\frac{1.16\times10^{-3}}{25} \times 250$ moles of chlorine

$= 1.16 \times 10^{-2}$ moles

$\therefore 10cm^3$ of concentrated solution of commercial bleach contain 1.16×10^{-2} moles of Cl_2

$\therefore 1000cm^3$ of concentrated solution of commercial bleach contain $\frac{1.16\times10^{-2}\times1000}{10}$ moles of Cl_2

$= 1.16 moles$ moles of chlorine

$\therefore$ Molar concentration of chlorine in commercial bleach is <u>1.16M</u>

Question. Six.

(a) (i) The **conductance** of an **aqueous solution** containing **one mole** of an electrolyte in a given volume of a solution placed between two electrodes of unit cross-sectional area and unit distance apart

or; The ratio of conductivity to concentration

or; The product of conductivity and dilution

(ii) The **conductance** of an **aqueous solution** of an electrolyte held between two electrodes of unit distance a part and each with a unit cross-sectional area

or; The reciprocal of resistivity

(b) (i) See graph next page

(ii) Potassium chloride

Shape –**straight line** with **negative gradient**

Explanation; -potassium chloride is a **strong electrolyte.** At a low concentration, the molar conductivity is **high** because; the ions are **far apart** and as a result, the **inter ionic attractions** are **reduced** and this **increases the mobility of the ions**

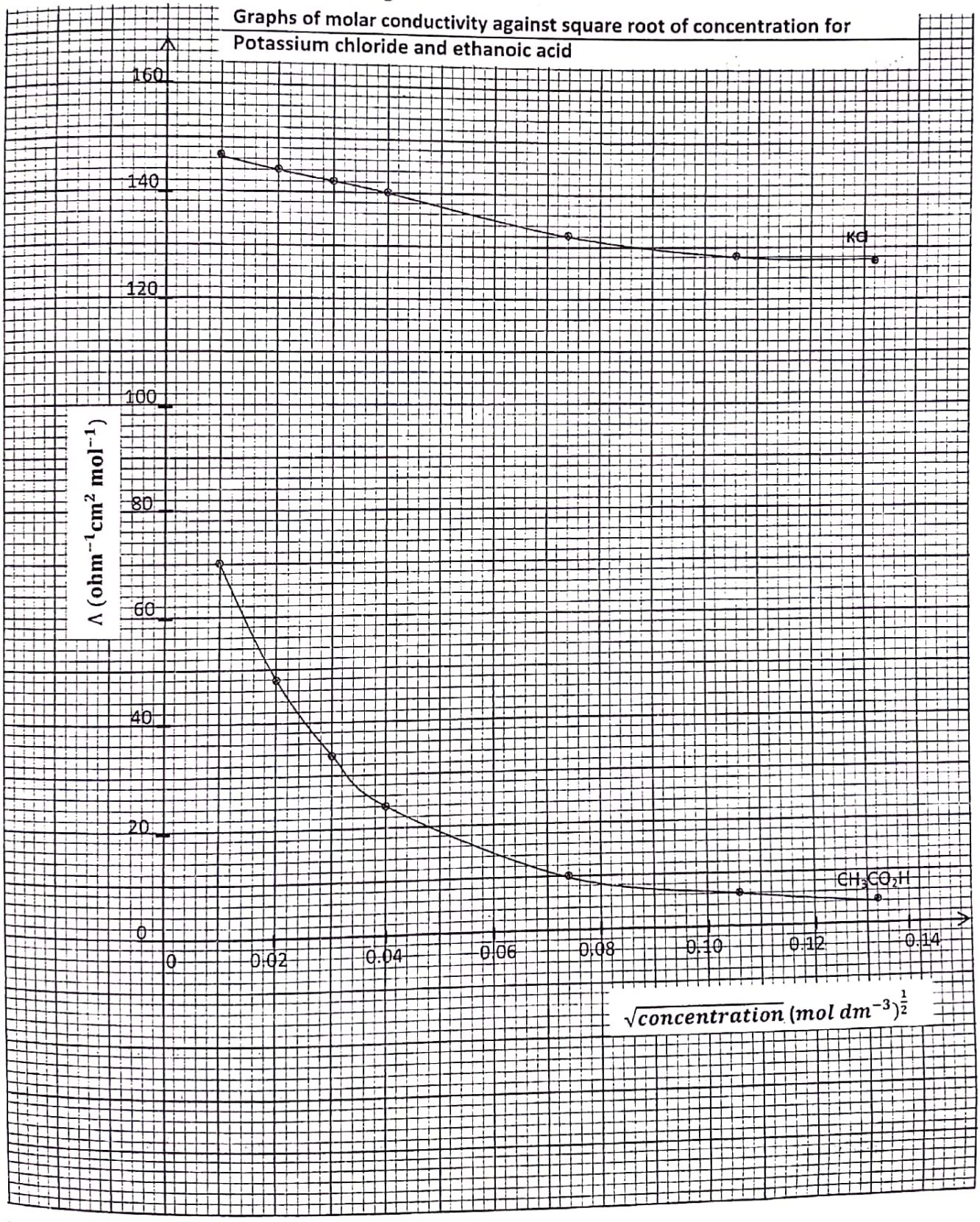
As the concentration increases, the ions **get closer to each other, inter ionic attractions increase** and **ionic mobility reduces.**

Ethanoic acid;

Shape – The graph is a **curve** with a **negative gradient.**

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Explanation;
Ethanoic acid is a **weak electrolyte.** At a low concentration, the **degree of ionization** of the acid is **high** and this **increases the number of conducting ions.**
Conductivity reduces as the concentration increases due to **decrease in the degree of ionization** which **reduces the number of conducting ions**



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(c) Molecular mass of Ethanoic acid $CH_3COOH = (2 \times 12) + (4 \times 1) + (2 \times 16) = 60$

Molar concentration of Ethanoic acid $= \frac{6.66}{60} = 0.111M$

Molar conductivity of Ethanoic acid at infinite dilution is given by;

$\Lambda_o\ (CH_3COOH) = \Lambda_o\ (CH_3COONa) + \Lambda_o\ (HCl) - \Lambda_o\ (NaCl)$

$= (91 + 426) \times 10^{-4} - 126 \times 10^{-4}$

$= 391 \times 10^{-4}\Omega^{-1}m^2mol^{-1}$

Molar conductivity of Ethanoic acid at a concentration of 0.111M;

$\Lambda_c\ (CH_3COOH) = \frac{k}{1000c}$ (where c= molar concentration)

$= \frac{5.21\times10^{-2}}{1000\times0.111}$

$= 4.69 \times 10^{-4}\Omega^{-1}m^2mol^{-1}$

Degree of ionisation; $\propto$ for ethanoic acid;

$\propto = \frac{\Lambda_c}{\Lambda_o}; \frac{(molar\ conductivity\ at\ a\ given\ concentration)}{molar\ conductivity\ at\ inifinite\ dilution}$

$= \frac{4.69\times10^{-4}}{391\times10^{-4}} = 0.012$

Equation of ionization of Ethanoic acid;

$CH_3COOH(aq) \rightleftharpoons CH_3CO\bar{O}(aq) + H^+(aq)$

Initially;	C moles	0	0
at Equilibrium;	$c-\propto c$	$\propto c$	$\propto c$

$$Ka = \frac{[CH_3CO\bar{O}][H^+]}{[CH_3COOH]}$$

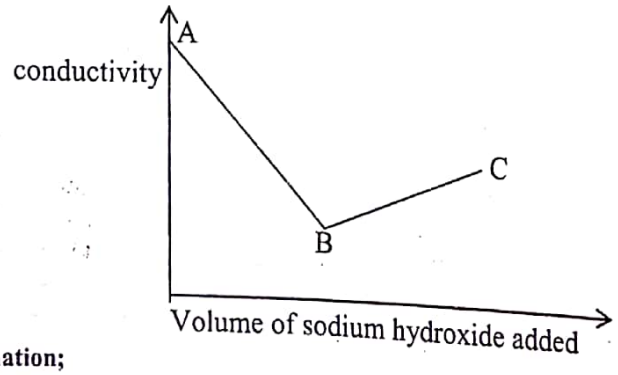
$$Ka = \frac{\propto c \times \propto c}{c-\propto c} = \frac{\propto^2 c^2}{c(1-\propto)}$$

$$Ka = \frac{\propto^2 c}{1-\propto}$$

$$= \frac{(0.012)^2\times0.111}{(1-0.111)} = 1.79 \times 10^{-5} moldm^{-3}$$

(d) The conductivity of acid **decreases** to aminimum value as sodium hydroxide is added and then **increases** as excess sodium hydroxide is added

ie



Explanation;

Initially at point A, conductivity is **high** due to the **highly conducting hydrogen ions** from the hydrochloric acid which is a **strong electrolyte.**

As the sodium hydroxide solution is added, the hydrogen ions are **neutralized** and replaced by the less conducting sodium ions and hence conductivity decreases along AB

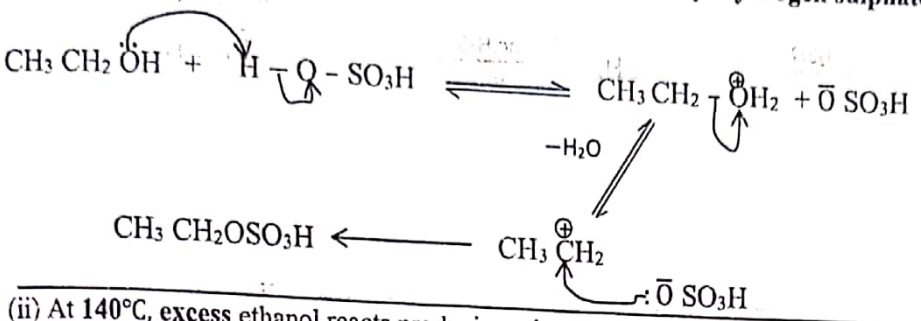
At end point (B) **conductivity is minimum** and this due to sodium ions and chloride ions only from the sodium chloride salt formed.

After the end point (along BC), conductivity increases due to addition of the **excess highly conducting hydroxide ions** from the **strong base** soium hydroxide solution added.

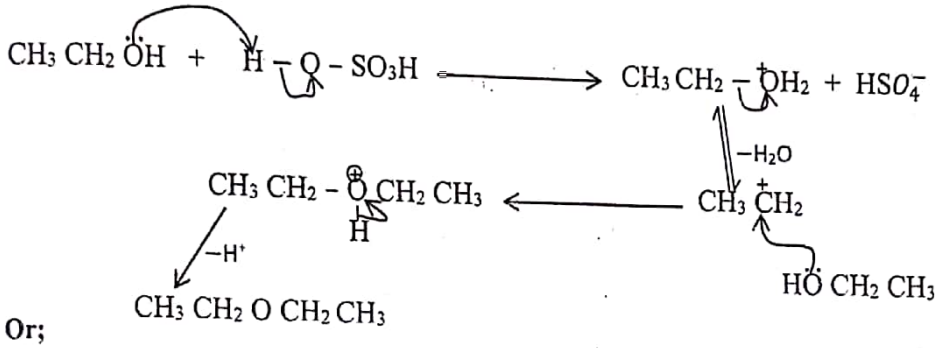
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Question. Seven.

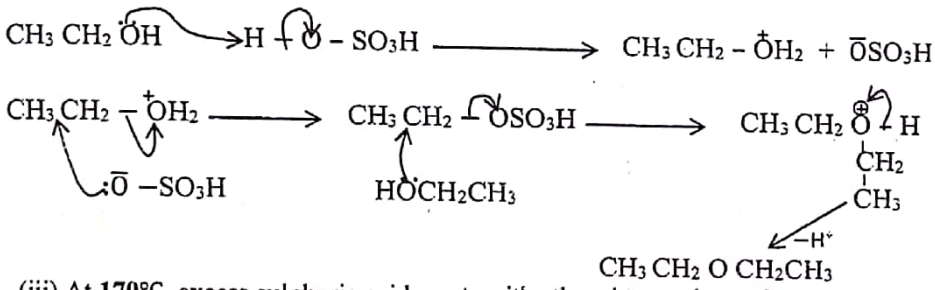
(a) (i) Ethanol reacts with **concentrated** sulphuric acid as follows;
At **low temperature** (0 – 130°C), ethanol reacts to form **ethyl hydrogen sulphate**
Mechanism;



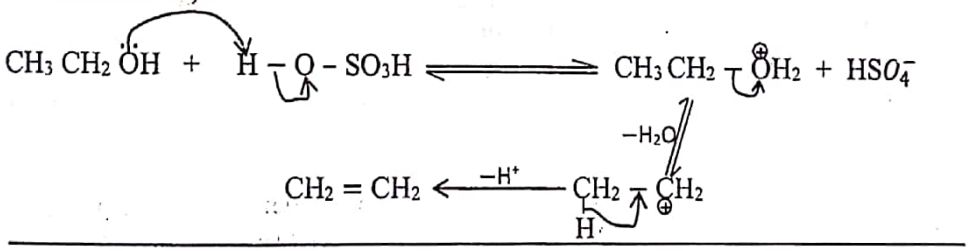
(ii) At **140°C**, **excess** ethanol reacts producing ethoxyethane
Mechanism;



Or;



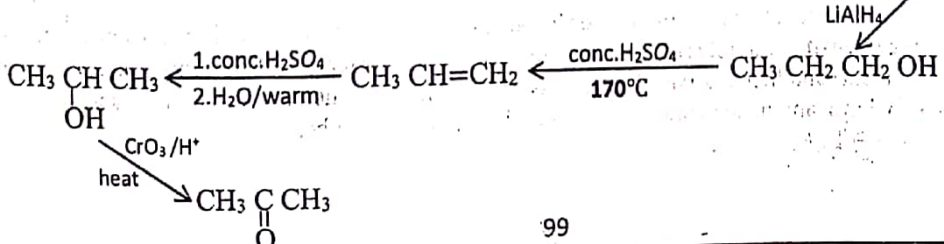
(iii) At **170°C**, **excess** sulphuric acid reacts with ethanol to produce **ethene** and **water**
Mechanism;



(b) (i) $CH_3CH_2OH \xrightarrow[heat]{Cr_2O_7^{2-}/H^+} CH_3COOH \xrightarrow{CaCO_3} (CH_3CO_2)_2Ca \xrightarrow{heat} CH_3COCH_3 + CaCO_3$

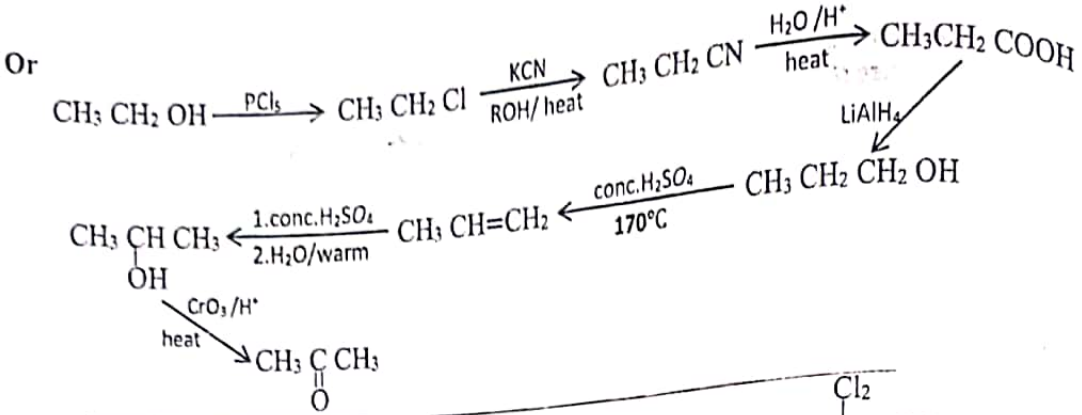
$CH_3CH_2OH \xrightarrow{PCl_5} CH_3CH_2Cl \xrightarrow[ROH/\ heat]{KCN} CH_3CH_2CN \xrightarrow[heat]{H_2O/H^+} CH_3CH_2COOH$

Or

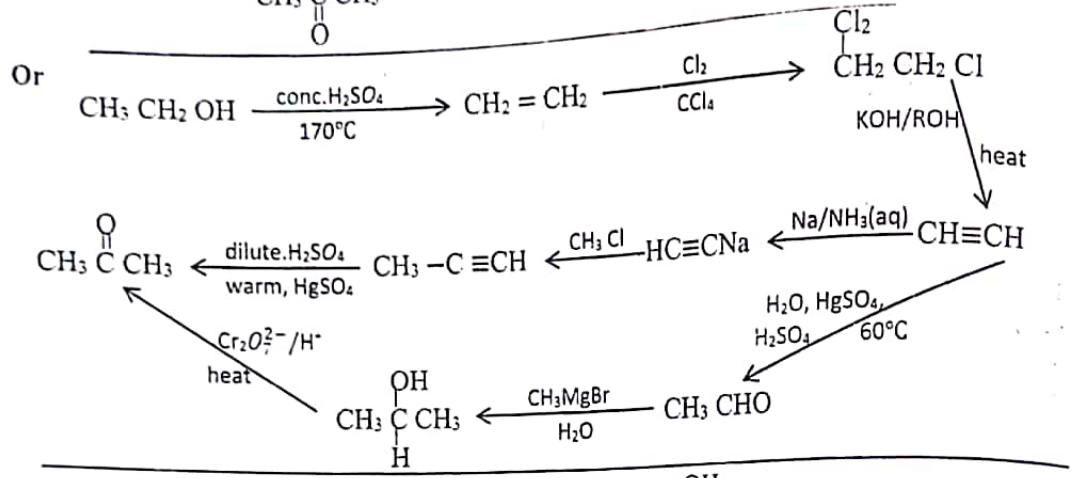


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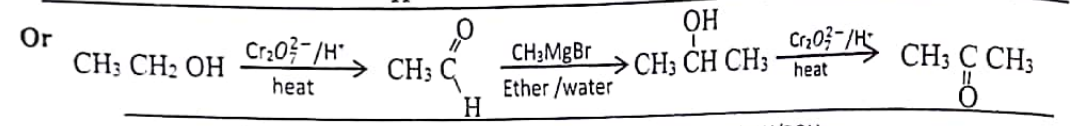
Or

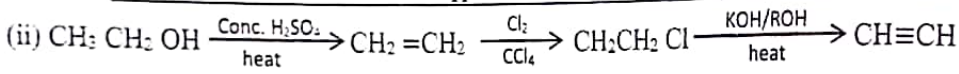


Or



Or



(ii) 

Question. Eight.

(a) The methanoate ion in sodium methanoate solution has an **alkanal group** which is a **reducing agent.** It reduces **silver ions** to **silver atoms**

$HCO\bar{O} \xrightarrow{Ag^+} Ag(s) + CO_2(g)$

The ethanoate ion in sodium ethanoate has **no alkanal group** and thus it is not a **reducing agent**

(b) The green precipitate is **insoluble chromium (III) hydroxide**

$Cr^{3+}(aq) + 3OH^-(aq) \longrightarrow Cr(OH)_3(s)$

This **amphoteric** chromium (III) hydroxide reacts with excess sodium hydroxide solution to form a **soluble** complex of tetra hydroxo chromate (III) ions

$Cr(OH)_3(s) + OH^-(aq) \longrightarrow Cr(OH)_4^-(aq)$

(c) The sodium ion is formed by **loss** of an electron and hence the **nuclear attraction** for the remaining fewer electrons **increases.** There is also **reduction in the number of energy levels,** making the sodium ion to be smaller than the sodium atom. However; The chloride ion is formed by **gaining** of an electron The nuclear attraction for the greater number of electrons **reduces.** Hence making the ion to be larger than the atom

(d) The white precipitates are **calcium sulphate** and **barium sulphate**
Barium sulphate is **less soluble** than calcium sulphate
The solubility product of barium sulphate is easily exceeded by adding fewer drops of ammonium sulphate unlike calcium sulphate

$Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s)$

(e) Lithium ion in lithium carbonate has a **smaller ionic radius** than sodium ion in sodium carbonate, hence has a **higher charge density** and **polarizing power** than sodium ion. Hence, lithium carbonate is **less ionic** (or its partially covalent) and hence **unstable** and thus can decompose when heated whereas sodium carbonate is **mainly ionic** and hence **stable** and cannot decompose when heated

$Li_2CO_3(s) \longrightarrow Li_2O(s) + CO_2(g)$

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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2014

1. State the application of the following reagents in organic chemistry analysis.
   (a) Iron (III) chloride (1 mark)
   (b) Iodine in the pressure of hydroxide ions (1 mark)
   (c) Anhydrous zinc chloride in the presence of concentrated hydrochloric acid. (1 mark)
   (d) Sodium nitrite in the presence of concentrated hydrochloric acid. (1 mark)
2. (a) State three factors that can favour formation of complexes. (1½ marks)
   (b) State the oxidation state and determine the coordination number of the central atom in the following complexes. (3 marks)

Formula of complex	Oxidation state	Co-ordination number
$[CrCl_2(H_2O)_4]^+$		
$[Ag(NH_3)_2]^+$		
$[Fe(SCN)(H_2O)_5]^{2+}$		

3. (a) Define the term electrolytic conductivity. (1 mark)
   (b) Calculate the molar conductivity of a solution containing 0.095g of anhydrous magnesium chloride in a litre of solution at 25°C. (The electrolytic conductivity of magnesium chloride is $2.58 \times 10^{-4}\Omega^{-1}cm^{-1}$ at 25°C. (2½ marks)
   (c) State two applications of conductivity measurements. (1½ marks)
4. (a) Write equation for the reaction between water and
   (i) aluminium chloride. (1½ marks) (ii) silicon tetrachloride. (1½ marks)
   (b) A few drops of aqueous sodium carbonate was added to a solution in (a) (i). State what was observed and write equation for the reaction that took place. (2 marks)
5. Sate what would be observed and write equation for the reaction that would take place if dilute sulphuric acid is reacted with.
   (a) a solution containing iodate and iodide ions
   (b) aqueous sodium chromate.
6. (a) Synthetic rubber, neoprene, is made by polymerization of 2-chlorobuta-1-3-diene, $H_2C{=}\underset{\underset{Cl}{|}}{C}{-}CH{=}CH_2$ according to the following equation.

$$n\,CH_2{=}\underset{\underset{Cl}{|}}{C}{-}CH{=}CH_2 \longrightarrow \left\{CH_2{-}\overset{\overset{Cl}{|}}{C}{=}CH{-}CH_2\right\}_n$$

   (i) State the conditions for the reaction. (1 marks)
   (ii) Name the type of polymerization leading to the formation of polyneoprene. (½ mark)
   (b) The osmotic pressure of a solution containing polyneoprene in $200cm^3$ of benzene is 34kPa at 17°C. Calculate the:
   (i) Molar mass of polyneoprene. (2½ marks)
   (ii) Value, *n*. (1½ marks)
7. The table below shows the standard electrode potentials of some elements in group (II) of the Periodic Table.

Element	Mg	Ca	Sr	Ba
standard electrode potential E^{θ}(V)	−2.37	−2.87	−2.89	−2.91

   (a) (i) Identify the element which is the most powerful reducing agent. (1 mark)
   (ii) Give a reason for your answer in (a) (i) (1½ marks)
   (b) (i) State the trend in standard electrode potential of the elements. (1 mark)
   (ii) Explain your answer in (b) (i) (2 marks)
8. (a) Write equation to show how but-2-ene can be prepared from an alcohol. (1 mark)
   (b) When but-2-ene was reacted with hydrogen bromide in the presence of chloride ions, a mixture of bromo- and chloro- compounds was formed. Outline a mechanism for the reaction leading to the formation of the two products. (3 marks)
   (c) Name;
   (i) the type of mechanism for the reaction in (b). (1 mark)
   (ii) a compound with a different functional group but same type of reaction as in (a) which can be used to prepare but-2-ene. (1 mark)

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9. (a) Thermo energy changes for some processes are shown in the table below.

Process	Energy ($kJmol^{-1}$)
Atomization of calcium	+178
First ionization energy of calcium	+590
Second ionization energy of calcium	+1146
Formation of calcium fluoride	−1220
Electron affinity of fluorine	−328
Bond dissociation energy of fluorine	+242.7

(i) Calculate the lattice energy of calcium fluoride crystal. (2 marks)

(ii) Determine the enthalpy of solution of calcium fluoride.
[Enthalpies of hydration of Ca^{2+} and F^- ions are -1587 and -515 $kJmol^{-1}$ respectively.] (2½ marks)

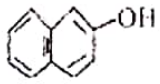
(b) (i) State the effect of temperature on the solubility of calcium fluoride. (1 mark)

(ii) Give a reason for your answer in (b) (i) (½ mark)

10. (a) A compound *M*, relative molecular mass 93, burns with a sooty flame and contains 77.42% carbon, 7.53 hydrogen and rest being nitrogen. Determine the molecular formular of *M*. (3 marks)

(b) *M* is soluble in hydrochloric acid. Write the structural formula of *M*. (1 mark)

(c) M was reacted with nitrous acid and to the product was added 2-naphthol;



(i) State what was observed. (1 mark)

(ii) Write equation for the reaction that took place (2 marks)

(d) M can be prepared from nitrobenzene. Write equation to show how nitro-benzene can be prepared from benzene. (2 marks)

11. State the condition under which beryllium and magnesium react with the following substances and, where applicable, write equation for the reaction. (4 marks)

(a) Water (2½ marks)

(b) Concentrated sodium hydroxide solution. (2½ marks)

(c) Concentrated nitric acid

12. The solubility of lead (II) fluoride in water is 1.9×10^{-3} $moll^{-1}$ at 20°C.

(a) Write:

(i) Equation for the solubility of lead (II) fluoride in water. (1½ marks)

(ii) The expression for the solubility product, K_{sp}, of lead (II) fluoride. (1 mark)

(iii) Calculate the K_{sp}, of the lead (II) fluoride at 20°C. (1½ marks)

(b) When 0.02M lead (II) nitrate was added to a saturated lead (II) fluoride solution, some lead (II) fluoride was precipitated.

(i) Explain why lead (II) was precipitated. (2½ marks)

(ii) Calculate the amount of lead (II) fluoride that was precipitated. (2½ marks)

13. Write equations to show how the following conversions can be effected.

(a) CH_3CH_2Br to CH_3COCH_3 (4 marks)

(b)  to  (2½ marks)

(c) $CH_3\overset{O}{\overset{\|}{C}}-H$ to $HC\equiv CH$ (2½ marks)

14. (a) Chlorine can be prepared by reacting hydrochloric acid with manganese (IV) oxide.

(i) State conditions for the reaction. (1 mark)

(ii) Write equation for the reaction leading to the formation of chlorine. (1½ marks)

(b) Write equation for the reaction that would take place when chlorine is bubbled through:

(i) hot concentrated sodium hydroxide solution. (1½ marks)

(ii) cold dilute potassium hydroxide solution. (1½ marks)

(iii) Potassium bromide solution. (1½ marks)

(c) (i) Name a reagent, other than manganese (IV) oxide, which can be used to prepare chlorine using hydrochloric acid (½ mark)

(ii) Write equation to show how chlorine can be prepared using the reagent you have named in (c) (i) (1½ mark)

15. (a) Carbon monoxide reacts with steam according to the following equation:

$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$, $\Delta H = -40kJ\ mol^{-1}$

(i) Write the expression for the equilibrium constant, Kc. (1 mark)

(ii) Equal moles of carbon monoxide and steam were reacted in a one-litre vessel. When equilibrium was established at 750°C, the vessel contained 26.7% carbon dioxide. Calculate the value of the equilibrium constant, Kc for the reaction at 750°C. (3½ marks)

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(b) State, giving reasons, how the concentration of carbon dioxide would be affected if at equilibrium
(i) the temperature was increased (1½ marks)
(ii) the pressure was increased. (1½ marks)
(iii) an inert gas was added at constant temperature. (1½ marks)

16. (a) Compare the thermal stabilities of silicon (IV) chloride and tin (IV) chloride. (*Include equations of reactions if any*) (2½ marks)
(b) (i) Write equation for the reaction between tin and chlorine. (1½ marks)
(ii) State the condition for the reaction. (1 mark)
(c) State what would be observed and write equation for the reaction that would take place if the product in (b) (i) was exposed to moist air.
(d) State why silicon (IV) chloride readily undergoes hydrolysis whereas carbon-tetrachloride does not. (2 mrks)

17. (a) State three reasons why azeotropes are considered to be mixtures and not compounds.
(b) The total vapour pressure of a mixture of propanone and trichloromethane and the mole fraction of trichloromethane at constant temperature are given in the table below.

Mole fraction of trichloromethane	0.0	0.2	0.4	0.6	0.8	1.0
Total vapour pressure of mixture (mmHg)	347	305	267	244	256	293

(i) Plot a graph of total vapour pressure of mixture against the mole fraction of trichloromethane. (3 marks)
(ii) Using the graph deduce how the mixture deviates from Raoults law. Give a reason for your answer. (2 mrks)
(iii) Explain the causes of the deviation you have stated in (b) (ii) (1½ marks)
(iv) Determine the composition of the azeotrope. (1 mark)

END

SOLUTIONS TO 'A' LEVEL CHEMISTRY;PAPER 1 (P525/1), 2014

1. (a) To distinguish between Phenol and alcohols
Or,Testing for ethanoate ions and benzoate ions
(b) To test for the presence of carbonyl compounds with the structure $-\overset{O}{\overset{\|}{C}}-CH_3$,
Or;To test for the alcohols with the structure $-\overset{OH}{\overset{|}{C}}-CH_3$
(c) To distinguish between different classes of alcohols (primary, secondary and tertiary alcohols)
(d) To distinguish between different classes of amines

2. (a) - availability of accessible empty orbitals
- ionic radius of the cation
- charge of the cation
- charge density of the cation

(b)

Formula of complex	Oxidation state	Co-ordination number
$[CrCl_2(H_2O)_4]^+$	+3	6
$[Ag(NH_3)_2]^+$	+1	2
$[Fe(SCN)(H_2O)_5]^{2+}$	+3	6

3. (a) The conductance or conductivity of an **aqueous** solution of an electrolyte placed between two electrodes each of **unit cross- sectional area** and a **unit distance a part.**
Or;The reciprocal of resistivity.
(b) $RFM\ of\ MgCl_2 = (1 \times 24) + (2 \times 35.5) = 95$
Molar concentration of $MgCl_2 = \frac{0.095}{95} = 1.0 \times 10^{-3} M$
Molar conductivity $= \frac{1000K}{C}$
$= \frac{1000 \times 2.58 \times 10^{-4}}{1.0 \times 10^{-3}} = 2.58 \times 10^2 cm^2 mol^{-1} \Omega^{-1}$

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(c) Determination of ionic product of water
Determination of the solubility product of sparingly soluble salts
Determination of dissociation constants of weak acids and wear bases.
Conductrimetric titrations

4. (a) (i) $Al(H_2O)_6^{3+}(aq) + 3H_2O(l) \rightleftharpoons Al(H_2O)_3(OH)_3(s) + 3H_3O^+(g)$
or; $Al(H_2O)_6^{3+}(aq) + H_2O(l) \rightleftharpoons [Al(H_2O)_5(OH)]^{2+}(aq) + H_3O^+(aq)$
or; $AlCl_3(s) + 3H_2O(l) \longrightarrow Al(OH)_3(s) + 3HCl(aq)$
or; $Al^{3+}(s) + 3H_2O(l) \longrightarrow Al(OH)_3(s) + 3H^+(aq)$
(ii) $SiCl_4(l) + 2H_2O(l) \longrightarrow SiO_2(s) + 4HCl(aq)$ or (g)
or; $SiCl_4(l) + 4H_2O(l) \longrightarrow SiO_2.2H_2O(s) + 4HCl(aq)$ or (g)
or; $SiCl_4(l) + 3H_2O(l) \longrightarrow H_2SiO_3(aq) + 4HCl(aq)$ or (g)

(b) **Effervescence** (Bubbles), **colourless gas** and a **white precipitate.**
$2Al^{3+}(aq) + 3H_2O(l) + 3CO_3^{2-}(aq) \longrightarrow 2Al(OH)_3(s) + 3CO_2(g)$

5. (a) Observation: **Colourless solution** turns **brown**
Equation: $IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \longrightarrow 3I_2(aq) + 3H_2O(l)$

(b) Observation: **Yellow solution** turned **Orange.**
Equation: $2CrO_4^{2-}(aq) + 2H^+(aq) \longrightarrow Cr_2O_7^{2-}(aq) + H_2O(l)$
or $2Na_2CrO_4(aq) + H_2SO_4(aq) \longrightarrow Na_2Cr_2O_7(aq) + Na_2SO_4 + H_2O(l)$

6. (a) (i) Use of potassium peroxodisulphate catalyst
High temperature
High pressure
(ii) Addition Polymerization

(b) (i) $\pi v = \frac{mRT}{Mr}$
$Mr = \frac{m \times 8.31 \times 290}{34 \times 10^3 \times 200 \times 10^{-6}}$

(ii) Value of $n = \frac{molar\ mass\ of\ polyneoprene}{molar\ mass\ of\ the\ monomer}$
$molar\ mass\ of\ monomer = (4 \times 12) + (5 \times 1) + (1 \times 35.5) = 88.5$
$Hence;\ n = \frac{m \times 8.31 \times 290}{(34 \times 10^3 \times 200 \times 10^{-6}) \times 88.5}$

Note: The above question in (b) had an error, because the mass of polyneoprene in $200cm^3$ of benzene is not given, hence the molar mass of the polyneoprene cannot be calculated.

7. (a) (i) Ba or barium
(ii) Barium has the **highest negative** electrode potential

(b) (i) The electrode potential of the elements becomes **more negative from magnesium to barium.**
or Electrode potential **increases from magnesium to barium**
(ii) From magnesium to Barium, **atomization energy**, **ionization energy** and **hydration energy** **decrease**. However, both atomization energy and ionization energy **decrease more rapidly than** **hydration energy** thus making the electrode potential more negative.

8. (a) $CH_3\underset{\underset{OH}{|}}{C}HCH_2CH_3 \xrightarrow[heat]{Conc.H_2SO_4} CH_3\underset{\underset{H}{|}}{C}{=}CHCH_3$

or, $CH_3CH_2CH_2CH_2OH \xrightarrow[170-180°C]{Conc.H_2SO_4} CH_3\underset{\underset{H}{|}}{C}{=}CHCH_3$

Note: (Concentrated H_3PO_4/heat) or (Al_2O_3/heat) can be used as conditions instead of (concentrated sulphuric acid / heat)

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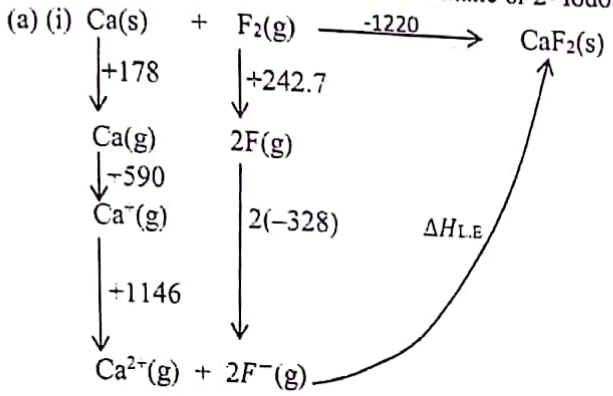
(b) $CH_3C(H)=CHCH_3 \longrightarrow CH_3CH_2\overset{+}{C}HCH_3 \longrightarrow CH_3CH_2CH(Br)CH_3$ (with H^+ and $:Br^-$)

or; $CH_3CH_2\overset{+}{C}HCH_3 \longrightarrow CH_3CH_2CH(Cl)CH_3$ (with $:Cl^-$)

(c) (i) Electrophilic addition reaction

(ii) 2- Bromobutane or 2 -chlorobutane or 2- Iodobutane

(a) (i)



From Hess's law;

$-1220 = 178 + 590 + 1146 + 242.7 + 2(-328) + \Delta HL.E$

$\Delta HL.E = -2720.7 Kjmol^{-1}$

Note: The energy diagram should be complete/ closed
Physical states should be correct and well indicated
Enthalpy changes must be indicated

(ii) ΔHhydration (CaF_2) = ΔHhydration (Ca^{2+}) + $2\Delta H$hydration (F^-)

$= -1587 + 2(-515) = -2617\ Kjmol^{-1}$

Hence; ΔHhydration (CaF_2) = $\Delta HL.E$ + ΔHhydration

$= +2720.7 + (-2617) = +\mathbf{103.7\ Kjmol^{-1}}$

Note; the positive sign **must not** be missing.

(b) (i) The solubility of calcium fluoride increases with increase in temperature.

(ii) The enthalpy of solution of calcium fluoride has a **positive sign** (is endothermic)

0. (a) Percentage of nitrogen in compound M = $100 - (77.42 + 7.53) = 15.5$

Composition;	C	H	N
moles;	$\frac{77.42}{12}$	$\frac{7.53}{1}$	$\frac{15.05}{14}$
	6.45	7.53	1.08
mole ratio;	$\frac{6.45}{1.08}$	$\frac{7.53}{1.08}$	$\frac{1.08}{1.08}$
	6 :	7 :	1

Empercial formula of M is C_6H_7N

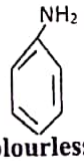
Hence; $(C_6H_7N)_n = 93$

$(6 \times 12)n + (7 \times 1)n + (1 \times 14)n = 93$

$\therefore n = \frac{93}{93} = 1$

Therefore; molecular formula of M is C_6H_7N

(b)

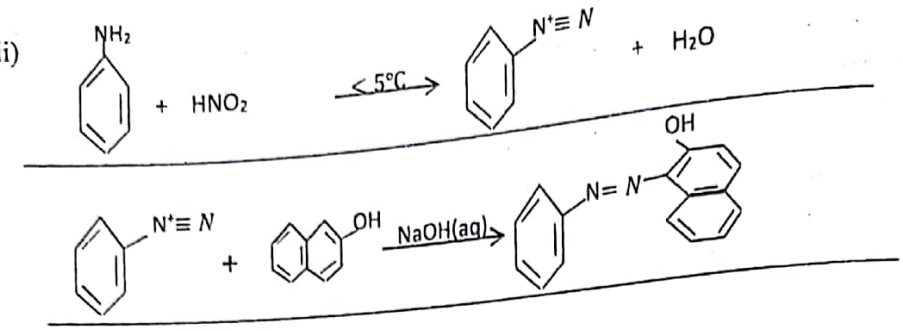


or $C_6H_5NH_2$

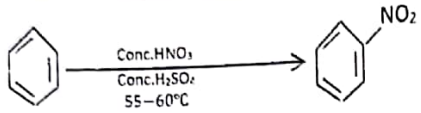
(c) (i) **Colourless solution** formed a **red precipitate**

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(ii)



(iii)



11. (a) - **Cold water**

$Mg(s) + 2H_2O(l) \longrightarrow Mg(OH)_2(s) + H_2(g)$

- **Heated** magnesium and **steam**
- $Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$.

Beryllium **does not** react with either cold water or steam.

(b) Hot and concentrated sodium hydroxide solution

$Be(s) + 2\bar{O}H(aq) + 2H_2O(l) \longrightarrow Be(OH)_4^{2-}(aq) + H_2(g)$

or; $Be(s) + 2\bar{O}H(aq) \longrightarrow BeO_2^{2-}(aq) + H_2(g)$

or; $Be(s) + 2NaOH(aq) + 2H_2O(l) \longrightarrow Na_2Be(OH)_4(aq) + H_2(g)$

or; $Be(s) + 2NaOH(aq) \longrightarrow Na_2BeO_2(aq) + H_2(g)$

Note: Magnesium **does not** react with sodium hydroxide solution.

(c) **Cold** concentrated nitric acid

$Mg(s) + 4HNO_3(aq) \longrightarrow Mg(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$

Note: Beryllium **does not react** with concentrated nitric acid.

12. (a) (i) $PbF_2(s) + aq \rightleftharpoons Pb^{2+}(aq) + 2F^-(aq)$

or; $PbF_2(s) \rightleftharpoons Pb^{2+}(aq) + 2F^-(aq)$

(ii) $Ksp = [Pb^{2+}][F^-]^2$

(iii) $Ksp = (1.9 \times 10^{-3})(2 \times 1.9 \times 10^{-3})^2$

$= 2.7436 \times 10^{-8} mol^3 l^{-3}$

(b) (i) The Lead (II) nitrate solution added is a **strong electrolyte** which **completely dissociates** and therefore **increases** the **concentration of Lead (II) ions** in solution which **reacts with the fluoride ions** to precipitate Lead (II) fluoride . i.e

$Pb^{2+}(aq) + 2F^-(aq) \longrightarrow PbF_2(s)$

(ii) Let the solubility of $PbF_2 = x\, moldm^{-3}$

Hence; $[Pb^{2+}] = (x + 0.02) \simeq 0.02M (since\ x\ is\ negligible)$

$[F^-] = 2x$

$Ksp = [Pb^{2+}][F^-]^2$

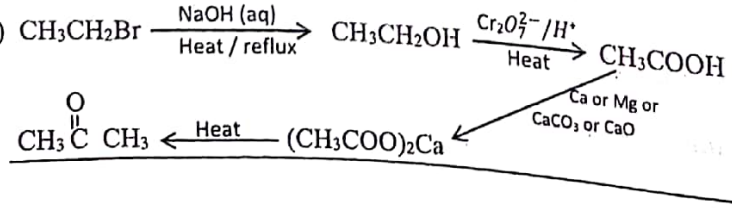
$2.7436 \times 10^{-8} = 0.02 \times (2x)^2$

$\therefore x = \sqrt{\left(\frac{2.7436 \times 10^{-8}}{0.08}\right)} = 5.856 \times 10^{-4} M$

Amount of PbF_2 precipitated $= 1.9 \times 10^{-3} - 5.856 \times 10^{-4}$

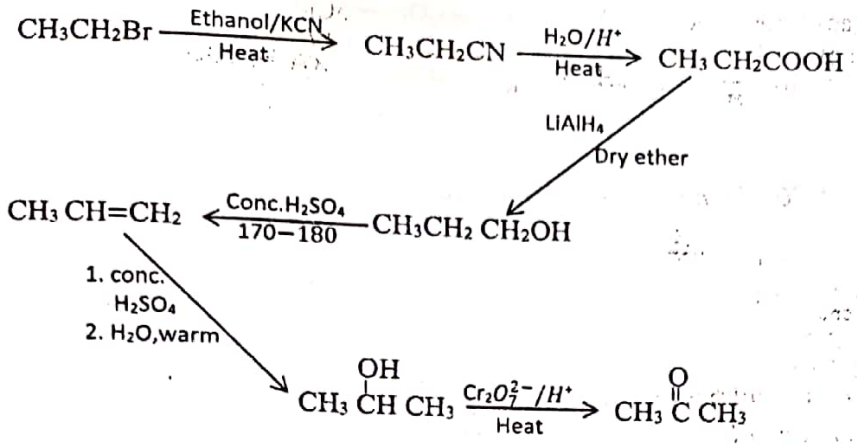
$= 1.3144 \times 10^{-3} moles$

13. (a)

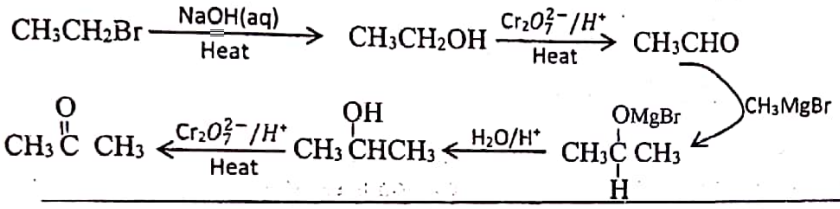


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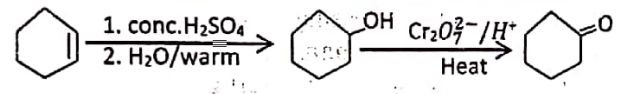
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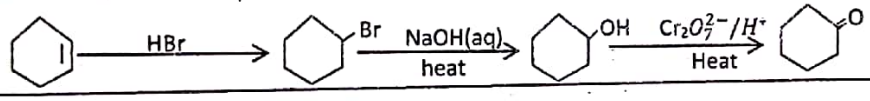
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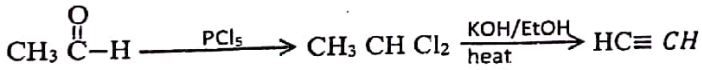
(b)



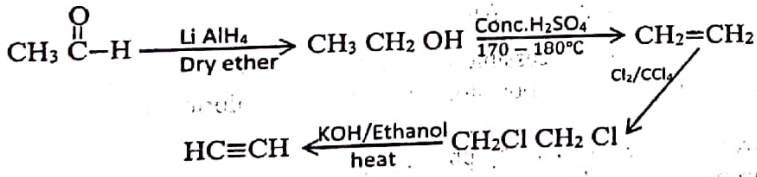
Alternatively



(c)



Alternatively



Recall; Instead of ($Cr_2O_7^{2-}/H^+$ and heat); (MnO_4^-/conc. H_2SO_4 and heat) or (CrO_3/H^+ and heat) can be used.

14. (a) (i) **Concentrated** acid and **Heat**

(ii) $MnO_2(s) + 4HCl(aq) \longrightarrow MnCl_2(aq) + 2H_2O(l) + Cl_2(g)$

or; $MnO_2(s) + 2Cl^-(aq) + 4H^+(aq) \longrightarrow Mn^{2+}(aq) + 2H_2O(l) + Cl_2(g)$

(b) (i) $6NaOH(aq) + 3Cl_2(g) \longrightarrow 5NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$

or; $6\overline{O}H(aq) + 3Cl_2(g) \longrightarrow 5Cl^-(aq) + Cl\overline{O}_3(aq) + 3H_2O(l)$

(ii) $2KOH(aq) + Cl_2(g) \longrightarrow KCl(aq) + KOCl(aq) + H_2O(l)$

or; $2\overline{O}H(aq) + Cl_2(g) \longrightarrow Cl^-(aq) + \overline{O}Cl(aq) + H_2O(l)$

(iii) $2KBr(aq) + Cl_2(g) \longrightarrow 2KCl(aq) + Br_2(aq)$

or; $2Br^-(aq) + Cl_2(g) \longrightarrow 2Cl^-(aq) + Br_2(aq)$

(c) (i) Potassium manganate (VII) or Lead (IV) oxide or calcium hypochlorite (calcium Chlorate(I))

(ii) $2KMnO_4(s) + 16HCl(aq) \longrightarrow 2KCl(aq) + 2MnCl_2(aq) + 8H_2O(l) + 5Cl_2(g)$

$PbO_2(s) + 4HCl(aq) \longrightarrow PbCl_2(s)$ or $(aq) + 2H_2O(l) + Cl_2(g)$

$Ca(OCl)_2(s) + 4HCl(aq) \longrightarrow CaCl_2(aq) + 2H_2O(l) + 2Cl_2(g)$

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or, $2MnO_4^-(aq) + 16H^+(aq) + 10Cl^-(aq) \longrightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 5Cl_2(g)$

$PbO_2(s) + 4Cl^-(aq) + 4H^+(aq) \longrightarrow PbCl_2(s) + 2H_2O(l) + Cl_2(g)$

$Ca(OCl)_2(s) + 2Cl^-(aq) + 4H^+(aq) \longrightarrow Ca^{2+}(aq) + 2H_2O(l) + 2Cl_2(g)$

15. (a) (i) $Kc = \frac{[CO_2][H_2]}{[CO][H_2O]}$

(ii) Let: $x = moles\ of\ CO\ which\ reacted\ at\ equlibrium$

At equilibrium;

$moles\ of\ CO = 1 - x$

$moles\ of\ H_2O = 1 - x$

$moles\ of\ CO_2 = x$

$moles\ of\ H_2 = x$

$total\ moles\ at\ equlibrium = 1 - x + 1 - x + x + x = 2$

$\%\ of\ CO_2\ at\ equilibrium = \frac{x}{2} \times 100 = 26.7$

$\therefore x = 0.534\ moles$

Number of moles $CO_2 = moles\ of\ H_2 = 0.534 moles$

And; Number of moles of $H_2O = moles\ of\ CO = 1 - x$

$= 1 - 0.534 = 0.466 moles$

$Hence;\ Kc = \frac{(0.534)^2}{(0.466)^2} = 1.313$

(b) (i) The concentration of carbon dioxide would **decrease**. This is because increase in temperature **shifts the equilibrium position** to the left since the forward reaction is **exothermic**

(ii) The concentration of carbon dioxide **remains the same**, increasing pressure has **no effect on equilibrium position**, since the reaction takes place with **no change in volume.**

(iii) The concentration of carbon dioxide **remains the same,** adding an insert gas **increases the total pressure** of the system which **does not effect the equilibrium position** as the reaction proceeds with no change in volume.

16. (a) Silicon (IV) chloride is **more stable** than tin (IV) chloride for example tin (IV) chloride decomposes when heated to form tin (II) chloride and chlorine

$SnCl_4(s) \longrightarrow SnCl_2(s) + Cl_2(g)$

(b) (i) $Sn(s) + 2Cl_2(g) \longrightarrow SnCl_4(l)$

(ii) **Heat** and **dry** chlorine

(c) **Observation**: White fumes or misty fumes

Equation: $SnCl_4(l) + 2H_2O(l) \longrightarrow S_nO_2(s) + 4HCl(g)$ or (aq)

(d) The silicon atom in silicon (IV) chloride has accessible **vacant 3d orbitals** which **accept lone pairs** of electrons from water molecules where as the carbon atom in carbon tetrachloride **lacks the 2d orbitals.**

17. (a) The components of the azeotrope can be separated by physical means

The composition of the azeotrope varies with pressure

The azeotrope cannot be represented by a simple molecular formula.

(b)(i) See graph next page

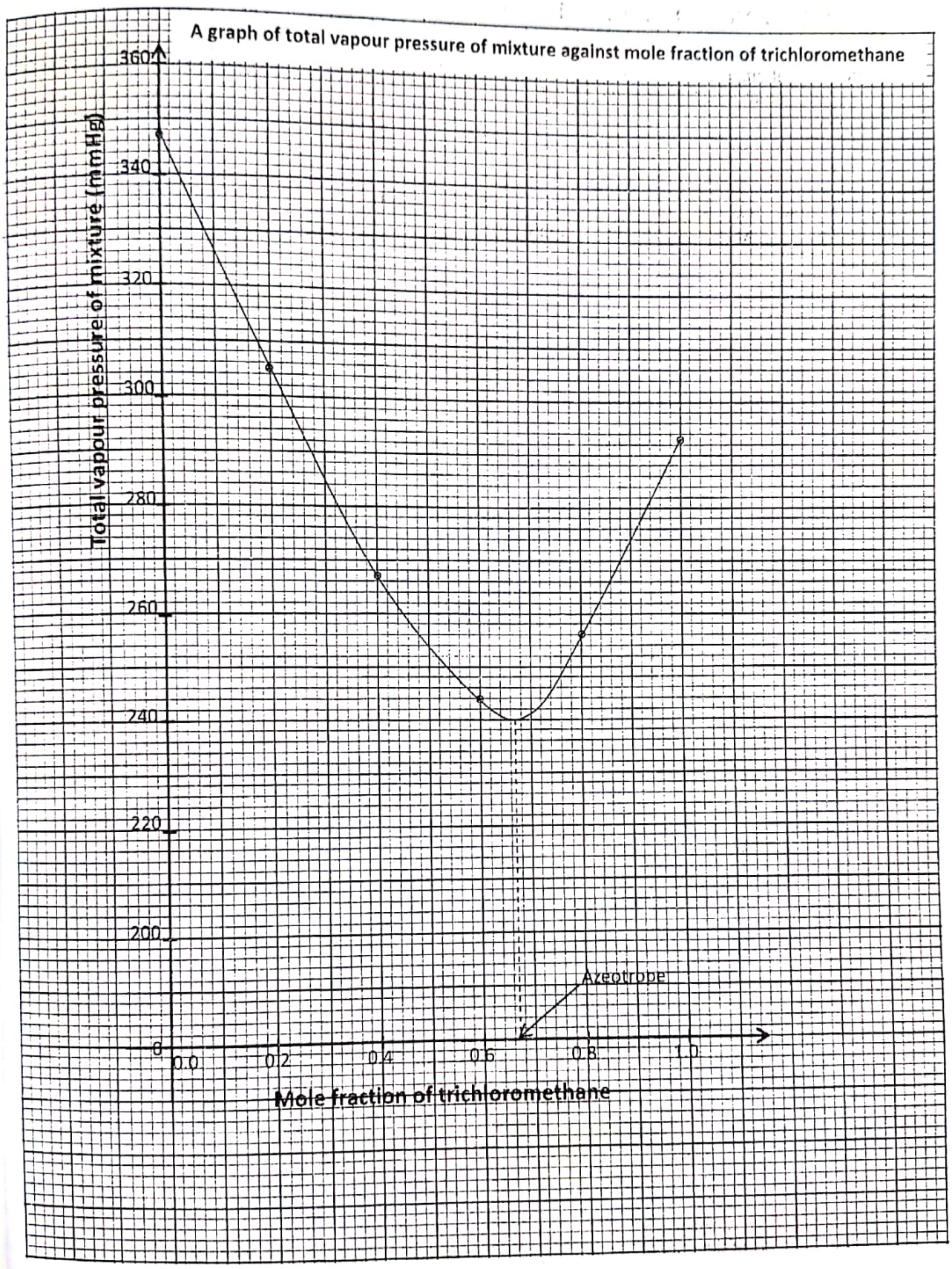
(ii) The mixture **deviates negatively** from Raoult's law

This is because the graph of total vapour pressure against mole fraction **gives a minimum vapour pressure**

(iii) The **intermolecular forces** between the molecules of trichloromethane and propanone are **stronger in strength** than the **intermolecular** forces between the **molecules of the pure components**. This results into **reduction in the escaping tendency** of the molecules from solution into vapour hence low vapour pressure of solution.

(iv) 0.67 mole fraction of trichloro methane and 0.33 mole fraction of propanone.

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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2014

1. The elements beryllium, magnesium, calcium, strontium and barium belong to group (II) of the Periodic Table.
   (a) Write equations and state the conditions under which group (II) eleemnts react with: (4 marks)
   (i) air (4 marks)
   (ii) water (4 marks)
   (iii) dilute sulphuric acid

   (b) The atomic radii and melting points of group (I) elements in the Periodic Table are given the table below.

Element	Atomic radius (nm)	Melting point (°C)
Beryllium	0.112	1283
Magnesium	0.160	650
Calcium	0.197	848
Strontium	0.215	770
Barium	0.222	710

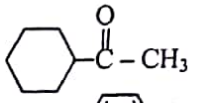
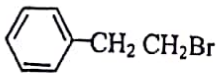
   Explain the trend in :
   (i) atomic radius (3 marks)
   (ii) melting points of group (II) elements (3 marks)
   (c) Although beryllium is in group (II) of the Periodic Table, in some of its properties it resembles aluminium which is in group (III). State the reasons why beryllium differs in some of its properties from the rest of the elements in group (II). (2 marks)

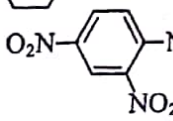
2. (a) Define the term Standard enthalpy of formation (1 mark)
   (b) Some thermochemical data for calcium, calciumchloride and chlorine are given below:

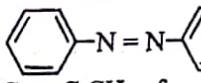
Enthalpy of formation of calcium chloride	-763 KJ mol^{-1}
Enthalpy of atomization of chlorine	$+121$ KJ mol^{-1}
Enthalpy of atomization of calcium	$+193$ KJ mol^{-1}
First ionization energy of calcium	$+590$ KJ mol^{-1}
Second ionization energyof calcium	$+1145$ KJ mol^{-1}
Electron affinity for chlorine	-348 KJ mol^{-1}

   (i) Draw an energy diagram for the formation of solid calcium chloride. (4 marks)
   (ii) Calculate the lattice energy of calcium chloride (2 ½ marks)
   (c) If calcium formed a chloride in which calcium was in the oxidation state of +1, would it be more or less stable than calcium chloride? Explain your answer (3 marks)
   (d) (i) Calculate the enthalpy of solution of calcium chloride. (*The enthalpy of hydration of Ca^{2+} and Cl^- are -1689 KJ mol^{-1} and -383.7KJ mol^{-1} respectively*). ((2 ½ marks)
   (ii) Comment on the solubility of calcium chloride. (1 mark)
   (e) (i) State two factors that can affect magnitude of hydration energy. (2 marks)
   (ii) Explain how the factors you have stated in (e)(i) affect hydration energy. (4 marks)

3. Write equations to show how the following compounds cane synthesised.

   (a)  from  (5 marks)

   (b)  from $CH_3\ CH_2\ CH_2Br$ (4 marks)

   (c)  from  (6½marks)

   (d) $CH_3\ CH_2\ C \equiv C\ CH_3$ from CaC_2 (4½ marks)

4. (a) (i) What is meant by steam distillation? (1 mark)
   (ii) Draw a diagram of the set up of the apparatus that can be used to purify a substance by steam distillation
   (b) (i) State three properties of a substamce that enable it to be purified by steam distillation. (3 marks)
   (ii) Explain how the properties you have stated in (b)(i) enable the substance to be purified by steam ditillation (3 marks)
   (iii) State the advantages of isolating substances by steam distillation. (4 marks)
   (2 marks)

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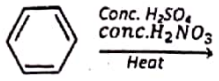
(c) The vapour pressure of water ($V.P_{H_2O}$) and that of substance A, ($V.P_A$) at different temperatures are given in the table below.

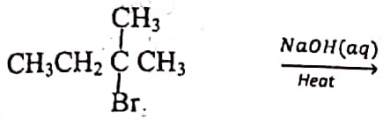
Temperature(°C)	20	40	60	80	100
($V.P_{H_2O}$) atm	0.22	0.26	0.30	0.35	0.39
($V.P_A$) atm	0.35	0.42	0.49	0.56	0.63

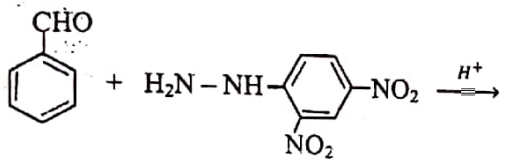
(i) On the same axes, plot graphs of vapour pressure against temperature for water and substance A (4 marks)
(ii) When substance A was distilled in staem at 1atm pressure, the temperature of distillation was 97°C, and the distillate obtained contained 4.29g of substance A and 1.1g of water. Using your graph in (c)(i), calculate the relative molecular mass of substance A. (4 marks)

5. Complete the following equations and in each case outline a mechanism for the reaction.

(a) $CH_3CH_2 - C \equiv CH \xrightarrow{HBr}$ (5 marks)

(b)  (4 marks)

(c)  (4 marks)

(d)  (5 marks)

(e) $CH_3CH{=}CH_2 \xrightarrow{Br_2/H_2O}$ (4 marks)

6. Explain the following ob servations:
(a) Acidified potassium mananganate (VII) solution cforms a brown solid when left to stand for sometime. (2 ½ marks)
(b) The boiling points of ethoxyethane and butan-1-ol are 34.5°C and 117°C respectively, yet the two compounds have the same molecular mass. (4 marks)
(c) When sodium carbonmate solution is added to an aqueous solution of aluminium salt, aluminium hydroxide is precipitated but not aluminium carbonate. (5 ½ marks)
(d) The bond angle in water is 104° whereas the bond angle in hydrogen sulphide is 92° (3 marks)
(e) Ethylmethylamine is a stronger base than trimethylamine. (5 marks)

7. (a) Dedfine the following terms:
(i) Solubility product. (1 mark)
(ii) Common ion effect. (1 mark)
(b) The solubility product of silver oxalate, $Ag_2C_2O_2$, is given by the expression: $K_{sp}[Ag^+]^2[C_2O_4^{2-}]$
Describe an experiment that can be carried out to determine the solubility product of silver oxalate. (6 ½ marks)
(c) A saturated solution of silver oxalate contains 1.1×10^{-4}moles of silver oxalate per litre at 25°C. calculate the solubility product of silver oxalate at 25°C and indicate its units. (3 ½ marks)
(d) Determine the solubility of silver oxalate in a 0.01M silver nitrate solution. State any assumptions you have made. (4 marks)
(e) Explain how the solubility of sikver oxalate, would be affected if few drops of;
(i) concentrated ammonia solution were added (2 marks)
(ii) sodium oxalate solution were added. (2 marks)

8. (a) Describe how chlorine is prepared on industrial scale. Illustrate your answer with a diagram. (5 marks)
(b) Write equations for the reactions between chlorine and:
(i) sodium hydroxide (4 marks)
(ii) water (1 mark)
(iii) hydrogen sulphide (1 mark)
(c) In the manufacture of hydrochloric acid, a mixture of chlorine and hydrogen is exploded tomproduce hydrogen chloride. (1 mark)
(i) State how hydrogen chloride is converted to hydrochloric acid
(ii) Concentrated hydrochloric acid was added to lead(II) nitrate solution dropwise until in excess. State what was observed and write equation for the reaction that took place. (4 ½ marks)
(iii) Explain why hydrochloric acid is not used to acidify potassium manganate(VII) solution. (2 ½ marks)

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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2014

Question. One.

(a) (i) Condition: **Heated element**

$M(s) + O_2(g) \longrightarrow 2MO(s)$

$3M(s) + N_2(g) \longrightarrow M_3N_2(s)$ (Where M = Be, Mg, Ca, Sr, Ba)

(ii) Beryllium **does not** react with water **under any condition**

Heated magnesium reacts with **steam.**

$Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$

Calcium, strontium and Barium react with **Cold water**

$M(s) + 2H_2O(l) \longrightarrow M(OH)_2(aq) + H_2(g)$, (Where M = Ca, Sr, Ba)

(iii) Condition: **Cold** dilute sulphuric acid

$M(s) + H_2SO_4(aq) \longrightarrow MSO_4(aq)$ or $(s) + H_2(g)$; (Where M = Be, Mg, Ca, Sr, Ba)

(b) (i) The atomic radii of the elements **increase from Beryllium to Barium,** because from Beryllium to Barium, from one element to next, the **number of protons** in the nucleus of an atom of an element **increases** which **increases the nuclear charge.**

The **number of electrons** on the outer energy level **remains constant** but there **is increase in the number of full inner energy levels of electrons** which **increases the screening effect.**

The increase in screening effect however **outweighs** the increase in nuclear charge and thus the **effective nuclear charge decreases** and the outer energy level electrons are **less strongly attracted** towards the nucleus hence the **increase in the atomic radius.**

(ii) The melting points of group (II) elements generally **decreases from beryllium to barium** except magnesium which **has un expectedly lower** melting point than calcium.

From beryllium to barium, **atomic radius increases** which results into **decrease in the strength of the metallic bond.**

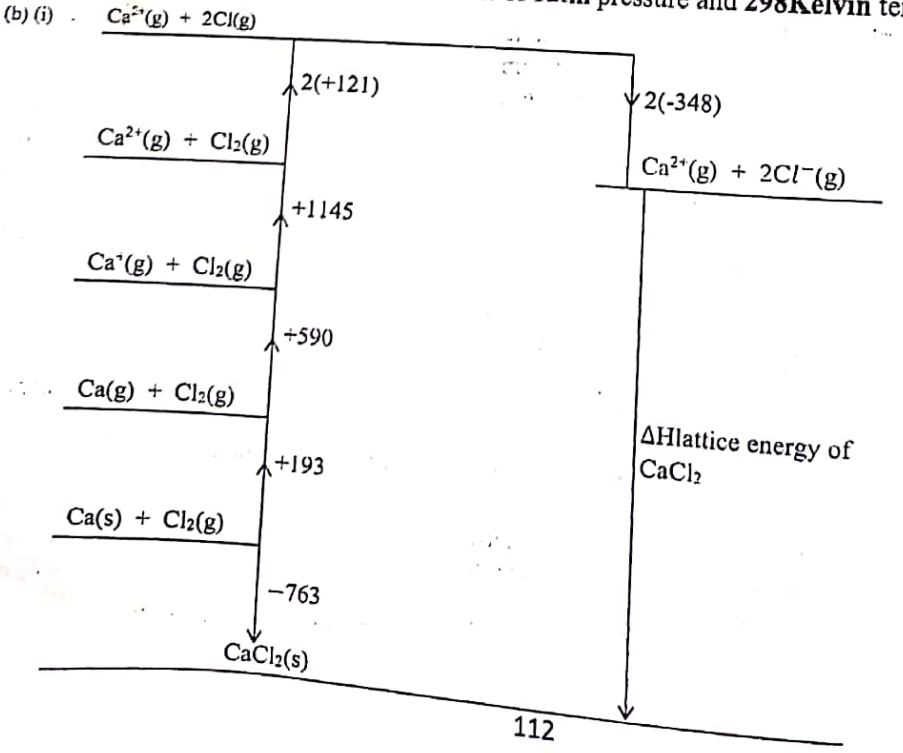
However, magnesium has a lower melting point than calcium because magnesium has a **hexagonal close packed structure** while calcium has **cubic close packed structure.**

(c) - Beryllium has the **smallest atomic radius** of all the group (II) elements
- Beryllium forms an ion with the **highest charge density** or polarizing power
- Beryllium has the **lowest electrode potential**
- Beryllium has the highest electronegativity or lowest electropositivity among the group (II) elements.

Question. Two.

(a) The **heat change** when **one mole** of a compound is formed its constituent elements in their **standard physical states** under standard conditions of **1atm** pressure and **298Kelvin** temperature.

(b) (i)



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(ii) From Hess's law;

$$-763 = 193 + 590 + 1145 + 2(121) + 2(-348) + \Delta HL.E$$

$$\therefore \Delta H\text{Lattice energy of } CaCl_2 = \mathbf{-2237KJmol^{-1}}$$

(c) Calcium (I) chloride is **less stable** than calcium chloride because calcium (I) ion has a **larger ionic radius** and hence **higher charge density** than calcium (II) ion.
Calcium (I) chloride is therefore **less ionic** with **lower lattice energy** than calcium chloride.
Also, the calcium (II) ion in calcium chloride has a **more stable** electronic structure (of $1s^2\,2s^2\,2p^6 3s^2\,3p^6$) than calcium(I) ion in calcium(I) chlorie whose electronic structure is $1s^2\,2s^2\,2p^6 3s^2\,3p^6\,4s^1$.

(d) (i) ΔHhydration $(CaCl_2) = \Delta H$hydration $(Ca^{2+}) + 2\Delta H$hydration (Cl^-)

$$= -1689.6 + 2(-383.7) = -2457KJmol^{-1}$$

ΔHsolution $(CaCl_2) = \Delta H$lattice energy of $CaCl_2$ + hydration energy of $CaCl_2$

$$= +2237 + -2457 = -220KJmol^{-1}$$

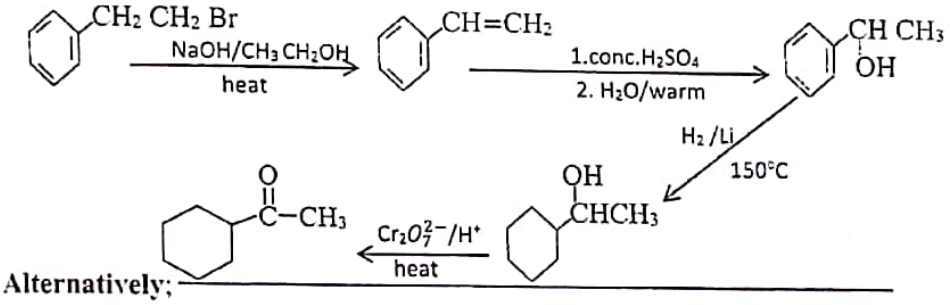
(ii) Calcium chloride is **soluble in water** because its enthalpy of solution is **negative**

(e) (i) Ionic charge and ionic radius

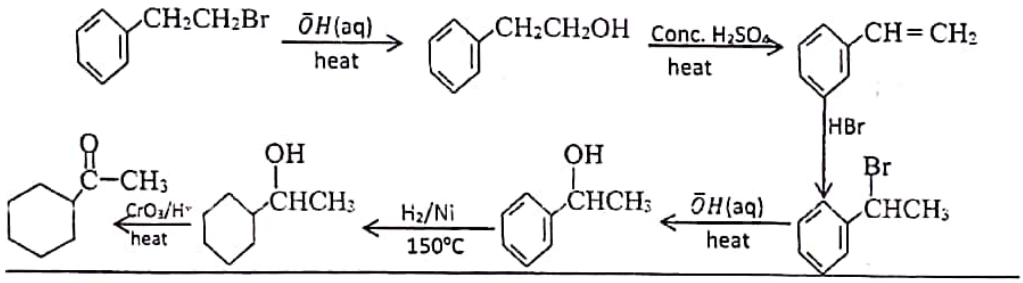
(ii) The **smaller the ionic radius**, the **stronger the attraction of water molecules** by the ion and hence the **higher the hydration energy**
The **greater** the ionic charge, the **stronger** the **attraction of water molecules** by the ion and the **higher the hydration energy**.

Question. Three.

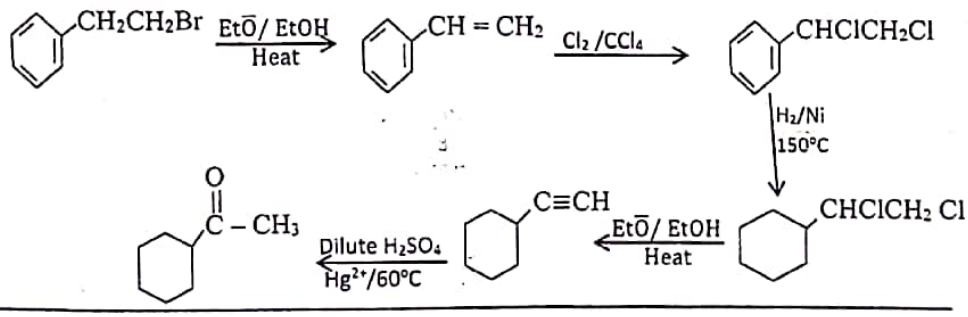
(a)



Alternatively;

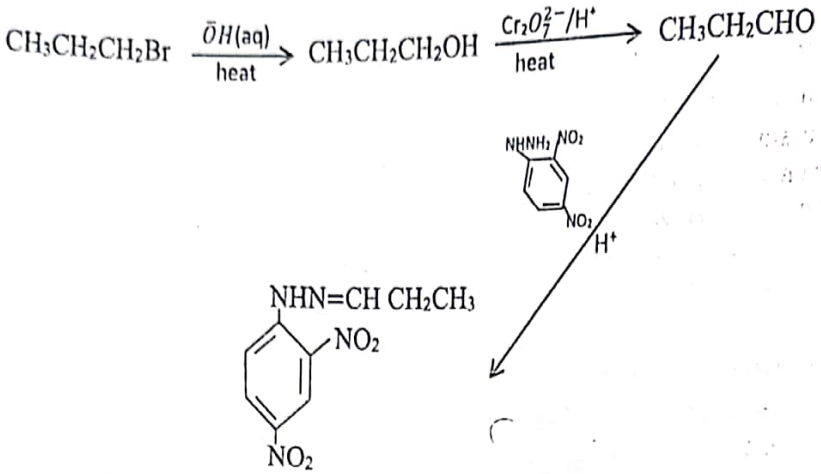


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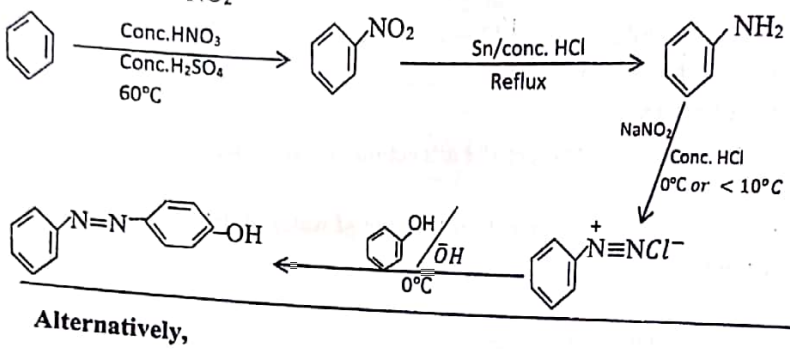


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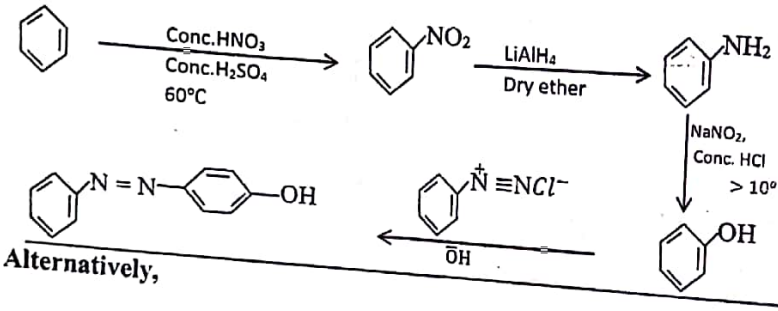
(b)



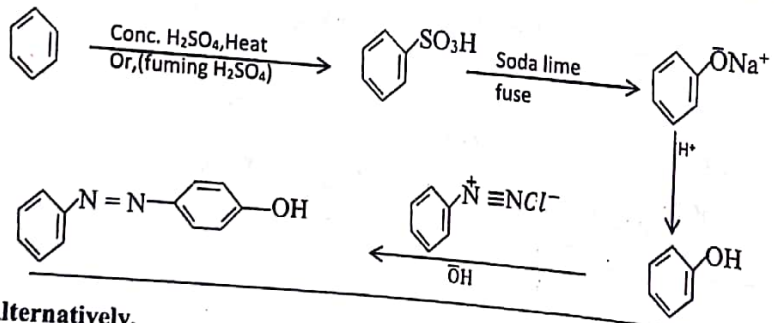
(c)



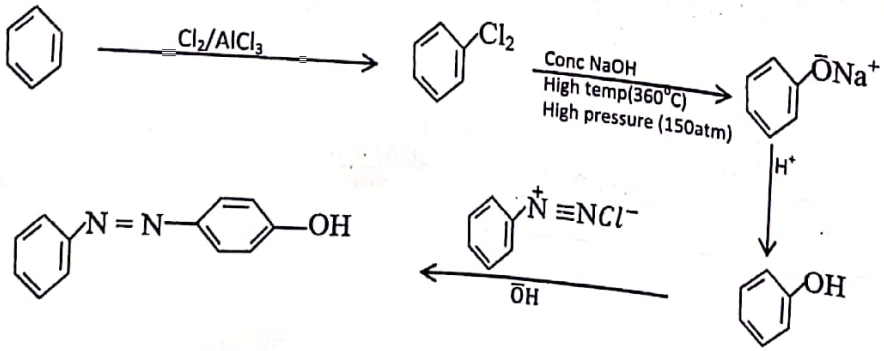
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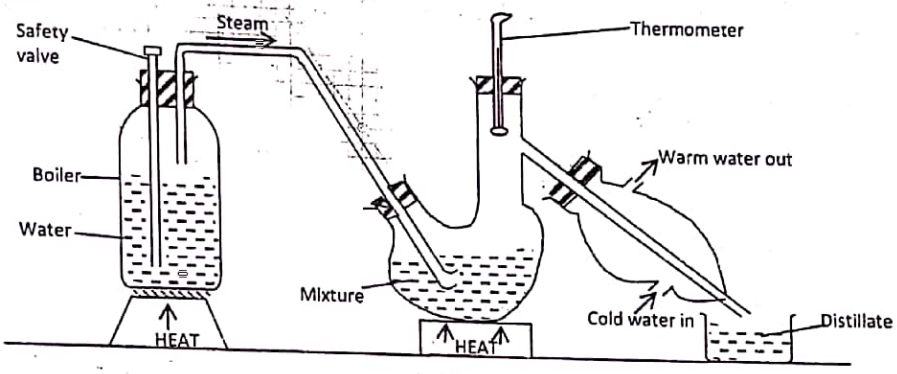
(d) $CaC_2 \xrightarrow{H_2O} HC{\equiv}CH \xrightarrow[\text{Liquid } NH_3 \text{ Or}(NaNH_2)]{Na} HC{\equiv}\bar{C}Na^+ \xrightarrow{CH_3CH_2Br} CH_3CH_2C{\equiv}CCH_3$

$CH_3CH_2C{\equiv}CCH_3 \xleftarrow{CH_3Br} CH_3CH_2C{\equiv}\bar{C}\overset{+}{N}a \xleftarrow[\text{Liquid } NH_3]{Na} CH_3CH_2C{\equiv}CH$

Question. Four.

(a) (i) This is a techinic of removing a **volatile** component which is **immiscible** with water from a mixture containing **non volatile components** or **impurities** by **passing steam** through the mixture at a **temperature below the boiling point of water.**

(ii)



(b)(i) The substance must be **immiscible with water**
The substance must have a **high relative formula mass**
The substance should exert a **higher vapour pressure at 100°C**, hence must be **more volatile** than the impurities

(ii) The substance must be **immiscible with water** so that at a given temperature, each one of them would escape into vapour **independent of their proportions** in the mixture and as a result the mixture **boils at a much lower temperature** than that of the volatile component
The substance must have a **high relative formula mass** in order to obtain **much of it in the distillate.**
The substance should be **more volatile** than the impurities so that it **exerts a higher vapour pressure** near the boiling point of water so that the mixture boils at a temperature below 100°C and also so that **much of it is obtained in the distillate**

(iii) Used to **purify organic** compounds such as drugs
Saves heat energy because the mixture boils at a temperature less than 100°C.
Enables purification of compounds which decompose at temperatures close to their boiling points

(c) (i) see graph next page

(ii) From the graph,
At 97°C,and 1 atm the V.P $H_2O = 0.385\ atm$ and the V.PA $= 0.62atm$
Molecular mass of $H_2O = (2 \times 1) + (1 \times 16) = 18$
Molecular mass of $A = mrA$

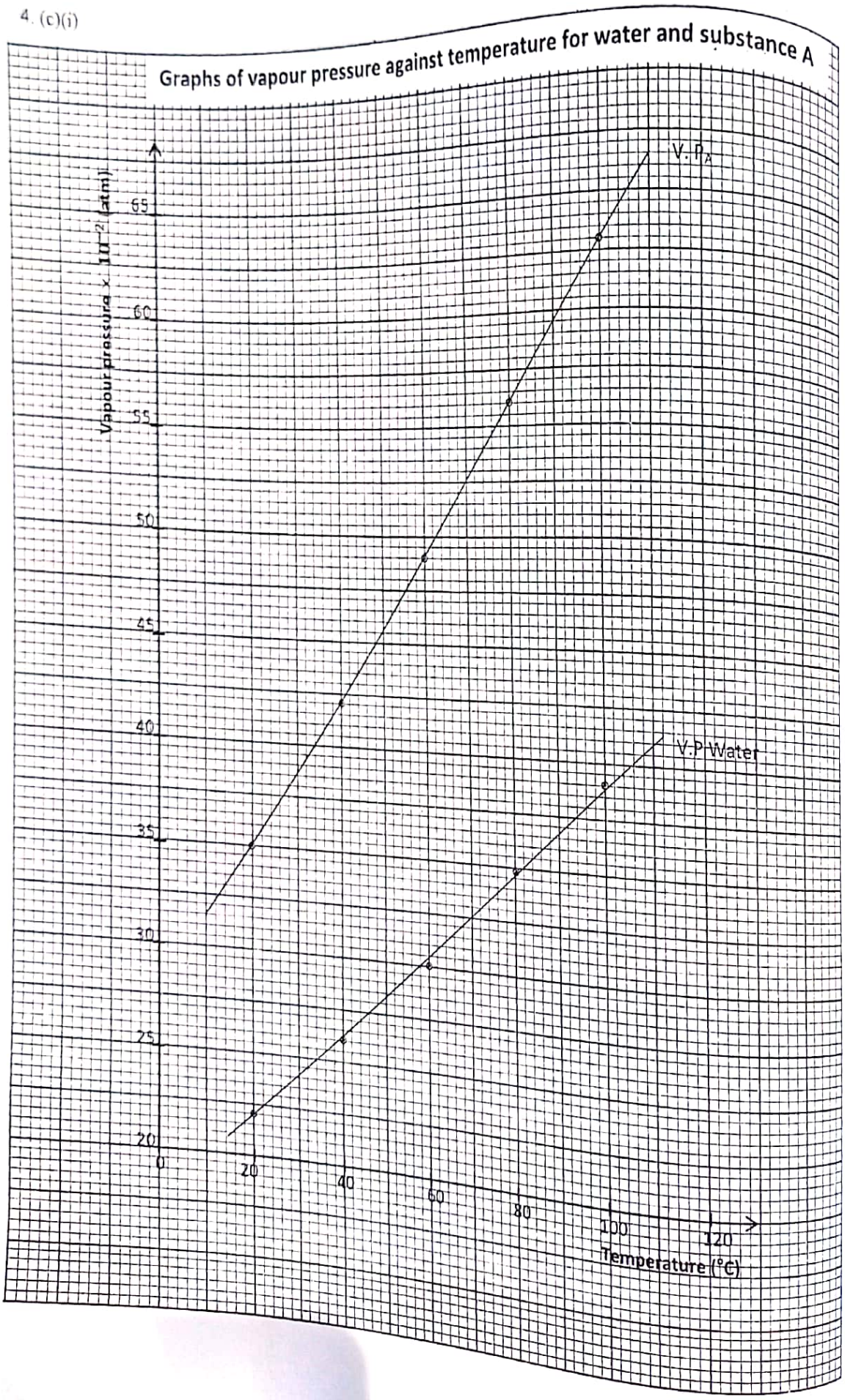
Hence; $\frac{mass\ of\ A\ in\ distillate}{mass\ of\ H_2O\ in\ distillate} = \frac{V.P_A \times mrA}{V.P_{H_2O} \times mrH_2O}$

$$\frac{4.29}{1.1} = \frac{0.62 \times mrA}{0.385 \times 18}$$

$$mrA = \frac{4.29 \times 0.385 \times 18}{1.1 \times 0.62} = 43.59$$

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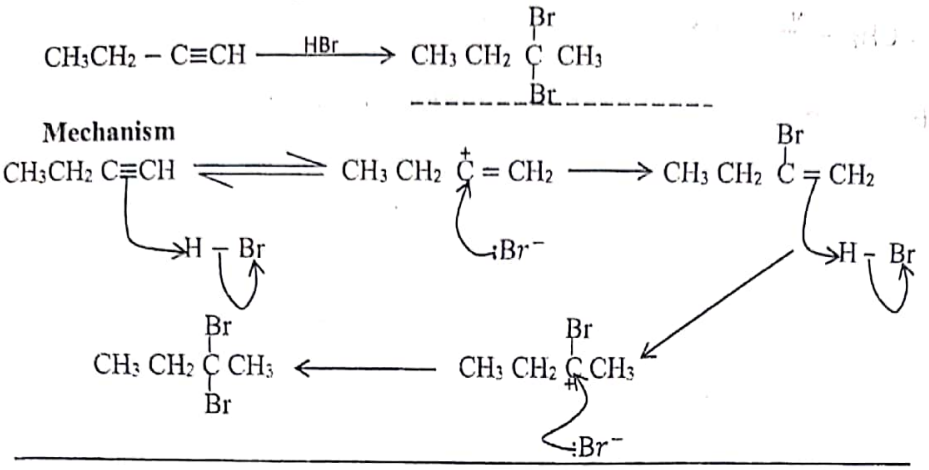
4. (c)(i)



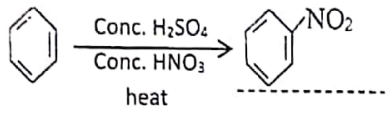
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Question. Five.

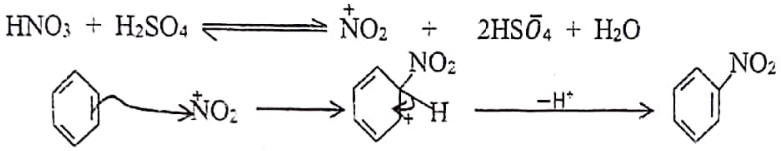
(a)



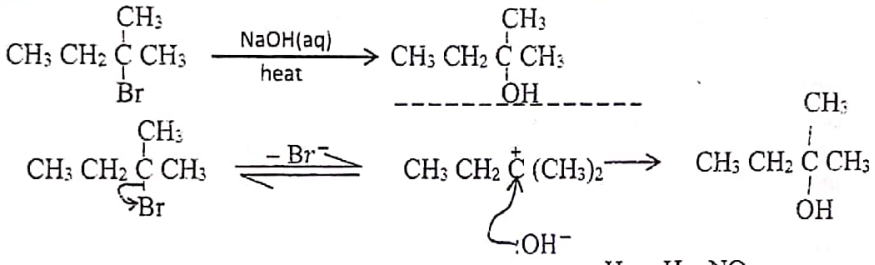
(b)



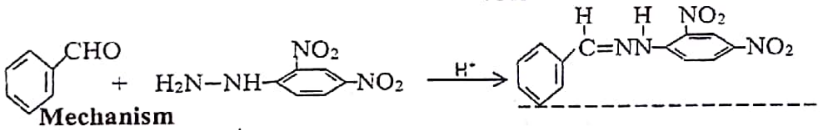
Mechanism



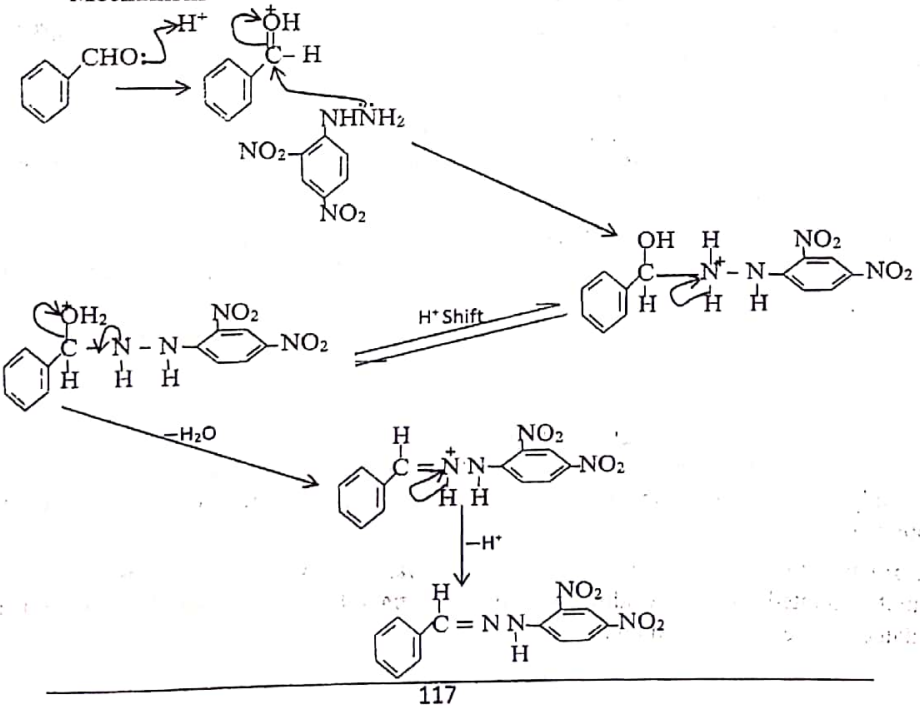
(c)



(d)

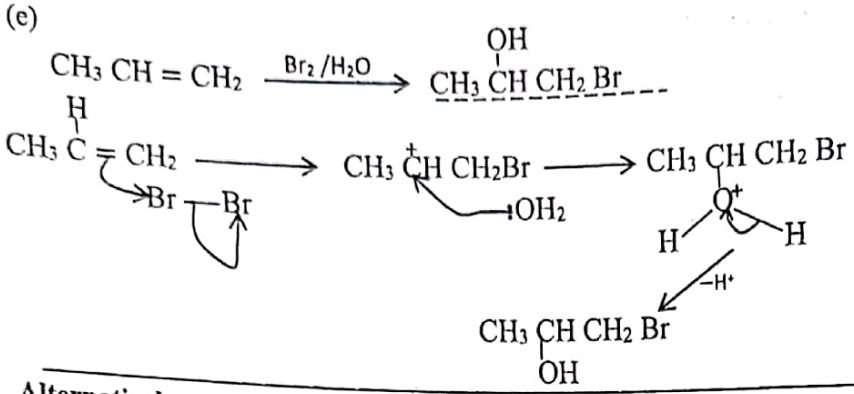


Mechanism



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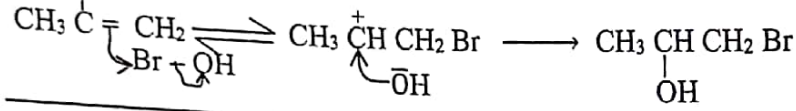
(e)



Alternatively;

$Br_2 + H_2O \rightleftharpoons HOBr + HBr$

Then;



Question. Six.

(a) In acidic medium, manganate (VII) ion **decomposes** into **manganese (IV) oxide**

$$4MnO_4^-(aq) + 4H^+(aq) \longrightarrow 4MnO_2(s) + 2H_2O(l) + 3O_2(g)$$

(b) In butan-1-ol, the **electronegative** oxygen atom makes the **oxygen – hydrogen bond** to be **polar**, and hence molecules of butan-1-ol associate through **strong intermolecular hydrogen bonds** which **require a lot of heat energy** to be broken. But in ethoxyethane the electronegative oxygen atom is not bonded to the hydrogen and hence ethoxyethane molecule are **non polar** and thus held together by **weak vander waal's forces** which require **less heat energy** to break.

(c) Aluminium ion in the aluminium salt has a **small ionic radius** and **high charge of +3** and hence with a **high charge density** and therefore in aqueous solution **undergoes hydrolysis** to form an **acidic solution** (or hydrogen ions) which reacts with sodium carbonate to form aluminium hydroxide and carbon dioxide, i.e;

$$\left.\begin{aligned} &Al^{3+}(aq) + 3H_2O(l) \rightleftharpoons Al(OH)_3(s) + 3H^+(aq)\ ;\ \text{then,} \\ &H^+(aq) + CO_3^{2-}(aq) \longrightarrow H_2O(l) + CO_2(g) \end{aligned}\right]$$

or, $2Al^{3+}(aq) + 3H_2O(l) + 3CO_3^{2-}(aq) \longrightarrow Al(OH)_3(s) + 3CO_2(g)$

(d) The oxygen atom in water is **more electronegative** than the sulphur atom in hydrogen sulphide and thus with draws bonding electrons toward its self **more** than sulphur. This results into **greater repulsions between the bond pairs of electrons** in water than in hydrogen sulphide there by making the bond angle in water to be greater than that in hydrogen sulphide.

(e) The basic strength of amines depends on the **availability** of the **lone pairs of electrons** on the nitrogen atom. Alkyl groups have **a positive inductive effect** and therefore **increase the availability of the lone pairs of electrons** on the nitrogen atom.

However, trimethylamine has **no nitrogen - hydrogen** bonds and hence is **less solvated** which makes it a weaker base while ethyl methyl amine has a nitrogen – hydrogen bond, hence **more solvated** thus making it a stronger base.

Note: Solvation is a process in which there is some chemical association between the molecules of a solute and those of a solvent

Question. Seven.

(a) (i) The product of the **molar** concentrations of the ions contained in a **saturated solution** of a **sparingly soluble ionic** compound, each concentration **raised to the appropriate power at** a given **temperature.**

(ii) The **precipitation** (or reduction in solubility) of a **sparingly soluble ionic** compound from its saturated solution by **adding a soluble compound** containing a **similar ion** to the ions contained in the sparingly soluble compound.

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(b) **Excess** silver oxalate is added to a fixed amount of distilled water and the **mixture shaken** until equilibrium is attained at a **given temperature**.
The mixture is filtered to obtain a **saturated solution** of silver oxalate as the filtrate.
A known volume of the filtrate is pipetted, dilute sulphuric acid added and the mixture warmed.
The warmed mixture is then titrated with a standard solution of potassium manganate (VII)
Manganate (VII) ion reacts with the oxalate ion according to the equation
$2MnO_4^-(aq) + 16H^+(aq) + 5C_2O_7^{2-}(aq) \longrightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$
Using the equation, the concentration of oxalate ions in the saturated solution (filtrate) is determined ie ($x\ moldm^{-3}$) and hence the solubility product of silver oxalate is calculated using the expression;
$Ksp = [Ag^+]^2[C_2O_4^{2-}]$ where the $[Ag^+] = 2x$
Hence, $Ksp = (2x)^2(x) = 4x^3$

Alternatively,

- A **saturated solution** of silver oxalate is prepared by adding an **excess** of silver oxalate in water and **left to stand** at a **constant temperature**.
- The resultant mixture is **filtered** and the conductivity; K, of the saturated solution (filtrate) is measured using a **conductivity meter**.
- The molar conductivity of the solution at infinite dilution; (Λ_∞) is calculated from the molar ionic conductivities of silver ions and oxalate ions at infinite dilution which are obtained from table.
  i.e $\Lambda_\infty(Ag_2C_2O_4) = 2\Lambda_\infty(Ag^+) + \Lambda_\infty(C_2O_4^{2-})$
- The solubility of silver oxalate (x) is calculated using the equation
  $x = \frac{k}{\Lambda_\infty}$; hence, $concentration\ of\ C_2O_4^{2-} = x$ and
  $concentration\ of\ Ag^+ = 2x$

Therefore; solubility product; $Ksp = [Ag^+][C_2O_4^{2-}]$
$= (2x^2).x = \underline{4x^3}$

(c) Let the concentration (solubility) of silver oxalate $= x\ moldm^{-3}$
Hence; according to the equation of solubility;
$Ag_2C_2O_4(s) \rightleftharpoons 2Ag^{2+}(aq) + C_2O_4^{2-}(aq)$

$[C_2O_4^{2-}] = x = 1.1 \times 10^{-4} moldm^{-3}$
$[Ag^+] = 2x$
Thus; $Ksp = [Ag^+]^2[C_2O_4^{2-}]$
$= (2x)^2 \times (x)$
$= 4x^3 = 4 \times (1.1 \times 10^{-4})^3 = \mathbf{5.3 \times 10^{-12} mol^3 dm^{-9}}$

(d) Let the solubility of silver oxalate in 0.01M silver nitrate solution $= y$
Assumption; $[C_2O_4^{2-}] = [Ag_2C_2O_4^{2-}] = y\ moldm^{-3}$
And $[Ag^+] = 2y + 0.01 \simeq 0.01M\ (since\ y\ is\ very\ small)$
Therefore; $Ksp = [Ag^+]^2[C_2O_4^{2-}]$
$5.3 \times 10^{-12} = (0.01)^2 \times y$
$y = \frac{5.3 \times 10^{-12}}{(0.01)^2} = 5.3 \times 10^{-8} moldm^{-3}$

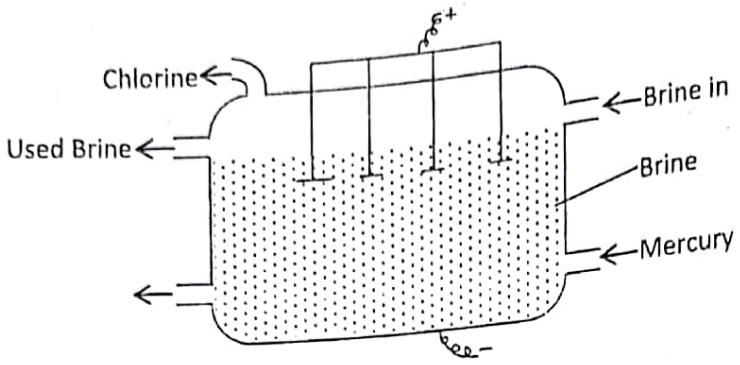
(e) (i) The solubility of silver oxalate **would increase** because the silver ions in the saturated solution react with the ammonia added to form a soluble complex of **diammine silver(I) ion**. This **reduces the concentration of silver ions** in solution and as an attempt to restore their concentration, **more silver oxalate dissolves**, and hence the solubility increases.
$Ag^+(aq) + 2NH_3(aq) \longrightarrow Ag(NH_3)_2^+(aq)$, then
$Ag_2C_2O_4^{2-}(s) \rightleftharpoons 2Ag^+(aq) + C_2O_4^{2-}(aq)$

(ii) The solubility of silver oxalate **would decrease** because the silver ions in the saturated solution **react** with the **excess oxalate ions** from sodium oxalate solution added hence forming a **precipitate** of silver oxalate and thus reducing the solubility of silver oxalate.
$2Ag^+(aq) + C_2O_4^{2-}(aq) \longrightarrow Ag_2C_2O_4(s)$

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Question. Eight.

(a) **Diagram**



-Chlorine is manufactured by **electrolysis of brine** (concentrated sodium chloride solution) using a **titanium or carbon anode** and a **mercury cathode**

-The chloride ions and hydroxide ions migrate to the anode where the chloride ions are discharged to form chlorine gas according to the equation;

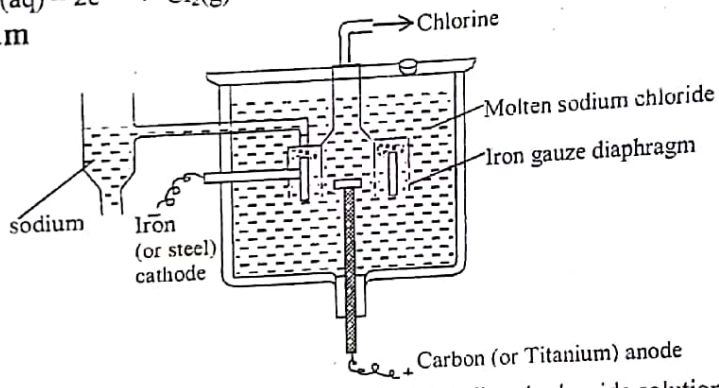
$2Cl^-(aq) \longrightarrow Cl_2(g) + 2e$ **Or;** $2Cl^-(aq) - 2e \longrightarrow Cl_2(g)$

Alternatively;

- Chlorine is obtained by **electrolysis of molten sodium chloride**
- The electrolysis is carried out using a carbon (or Titnium) anode and an iron cathode or steel cathode.
- Chlorine is liberated by discharge of molten chloride ions through oxidation.

$2Cl^-(aq) - 2e \longrightarrow Cl_2(g)$

Diagram



(b) (i) Reaction of chlorine and hot concentrated sodium hydroxide solution

$6NaOH(aq) + 3Cl_2(g) \longrightarrow NaClO_3(aq) + 5NaCl(aq) + H_2O(l)$

or; $6\bar{O}H(aq) + 3Cl_2(g) \longrightarrow ClO_3^-(aq) + 5Cl^-(aq) + H_2O(l)$

Reaction of chlorine and cold dilute sodium hydroxide

$2NaOH(aq) + Cl_2(g) \longrightarrow NaClO(aq) + NaCl(aq) + H_2O(l)$

or $2\bar{O}H(aq) + Cl_2(g) \longrightarrow \bar{O}Cl(aq) + Cl^-(aq) + H_2O(l)$

(ii) $Cl_2(g) + H_2O(l) \rightleftharpoons HCl(aq) + HClO(aq)$

or, $Cl_2(g) + H_2O(l) \rightleftharpoons H^+(aq) + Cl^-(aq) + HClO(aq)$

Note: HClO cannot ionise

(iii) $Cl_2(g) + H_2S(g) \longrightarrow 2HCl(g) + S(s)$

or $Cl_2(g) + S^{2-}(aq) \rightleftharpoons S(s) + 2Cl^-(aq)$

(c) (i) By dissolving hydrogen chloride in water

(ii) **White precipitate, soluble** in excess acid forming a **colourless solution**

$Pb^{2+}(aq) + 2Cl^-(aq) \longrightarrow PbCl_2(s)$

$PbCl_2(s) + 2Cl^-(aq) \longrightarrow PbCl_4^{2-}(aq)$

Or; $Pb^{2+}(aq) + 4Cl^-(aq) \longrightarrow PbCl_4^{2-}(aq)$

(iii) Manganate(VII) **ion oxidizes** hydrochloric acid to chlorine gas

$2MnO_4^-(aq) + 16H^+(aq) + 10Cl^-(aq) \longrightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 5Cl_2(g)$

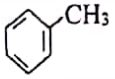
Or; $2KMnO_4(aq) + 16HCl(aq) \longrightarrow 2MnCl_2(aq) + 2KCl(aq) + 8H_2O(l) + 5Cl_2(g)$

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QUESTIONS TO 'A' LEVELCHEMISTRY; PAPER 1(P525/1), 2013

1. Thorium undergoes nuclear decay according to the following equation: $^{232}_{90}Th \xrightarrow{\alpha} X \xrightarrow{\beta} Y \xrightarrow{\beta} Z$.
   (a) Identify the species X, Y and Z. (3 marks)
   (b) 5g of thorium was left to decay. Calculate the mass of thorium that remained after 2.5×10^{10} years. (The half-life of thorium is 1.4×10^{-10} years) (2 marks)
2. When an amine, Z was steam distilled at 98.6°C and 760 mmHg pressure, the distillate contained 25.5g of water and 7.4g of Z.
   (a) Calculate the relative formula mass of Z. (The vapour pressure of water at 98.6°C is 720mmHg) (1½ marks)
   (b) Z burns with a sooty flame and forms a red solid when reacted with benzene diazonium salt at low temperature. Identify Z. (½ mark)
   (c) Z was reacted with bromine water.
      (i) State what was observed. (½ mark)
      (ii) Write equation for the reaction that took place. (1 mark)
   (d) Write equations to show how Z can be synthesized from benzene. (2½ marks)
3. $Cu(NH_3)_4^{2+}(aq)$ and $Fe(CN)_6^{3-}(aq)$ are complexes formed when $Cu^{2+}(aq)$ and Fe^{3+} ions are respectively treated with excess aqueous ammonia and potassium cyanide.
   (a) Name the complexes. (2 marks)
   (b) State what would be observed when
      (i) $Cu^{2+}(aq)$ ions are treated with excess ammonia solution. (1 mark)
      (ii) $Fe(CN)_6^{3-}(aq)$ is treated with a solution containing Fe^{3+} ions. (1 mark)
   (c) State the coordination number of copper and iron in the complexes. (1 mark)
4. (a) State two characteristics of a primary standard. (2 marks)
   (b) State why the following substances are not considered as a primary standard.
      (i) Concentrated sulphuric acid. (1 mark)
      (ii) Sodium thiosulphate-5-water. (1 mark)
5. (a) 2-bromobutane was treated with sodium ethoxide in ethanol to form compound T. Write the equation and a mechanism for the reaction between 2-bromobutane and ethoxide ion (2 marks)
   (b) The compound, T formed in (a) can be synthesized from an alcohol. Write the equation and include a mechanism for the reaction leading to the formation of T from an alcohol.
6. Write equation and state what would be observed when
   (i) Iodine is reacted with hot aqueous solution of sodium hydroxide. (2½ marks)
   (ii) Manganite (VI), MnO_4^{2-} is hydrolysed by water. (3 marks)
7. The standard electrode potentials of two half cells are given in the table below.

Half cell	E^{θ}cell (V)
$HCl(aq)/H_2$	0.00
$CdSO_4(aq)/Cd(s)$	-0.40

   (a) Write the cell notation for the cell formed by combining the two half cells. (1 mark)
   (b) Write ionic equation for the
      (i) Reaction at the cathode. (1 mark)
      (ii) Reaction at the anode. (1 mark)
      (iii) Overall cell reaction. (1 mark)
   (c) Calculate the e.m.f of the cell. (1½ marks)
8. Write equations to show how the following compounds can be synthesized.
   (a) $(CH_3)_2C = NNH_2$ from propan-2-ol. (2½ marks)
   (b)  from benzene. (1½ marks)
9. (a) Write the electronic configuration of
      (i) Carbon. (1 mark) (ii) Silicon. (1 mark)
   (b) Silicon tetrachloride is hydrolysed by water whereas carbon tetrachloride is not.
      (i) Write the equation for the hydrolysis of silicon tetrachloride. (1½ marks)
      (ii) Give a reason for the difference in the reactivity of the two tetrachlorides. (1½ marks)
10. (a) State two factors that can affect the molar conductivity of an electrolyte.
    (b) The molar conductivity of potassium hydroxide at various concentrations are given in the table below.

Molar conductivity of potassium ($\Omega^{-1}cm^2mol^{-1}$)	238	230	224	217	210
Concentration of potassium hydroxide (mol dm^{-3})	0.01	0.04	0.09	0.16	0.25
Square root of the concentration of potassium hydroxide ($mol^{\frac{1}{2}}dm^{\frac{-3}{2}}$)					

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(i) Complete the table above. (1 mark)

(ii) Draw agraph of molar conductivity against the square root of concentration of Explain the shape of the graph you have drawn in (b) (ii) (3 marks)

(iii) Determine the value of the molar conductivity of potassium hydroxide at infinite dilution. (1 mark)

11. Name a reagent that can be used to differentiate between the following pairs of compounds. State what would be observed if each compound is treated with the reagent you have named.

(a) $CH_3\overset{O}{\overset{\|}{C}} - OH$ and $HO-\overset{O}{\overset{\|}{C}}-\overset{O}{\overset{\|}{C}}-OH$ (3 marks)

(b) $C_6H_5CH_2Cl$ and C_6H_5Cl (3 marks)

(c)  and  (3 marks)

12. Sodium, aluminium, silicon and phosphorous are of the elements in period 3 of the Periodic Table.

(a) For each element, write the formula and name the structure of the oxide. (4½ marks)

Element	Formula of oxide	Structure
Sodium		
Aluminium		
Silicon		
Phosphorous		

(b) Write equation for the reaction between aluminium oxide and

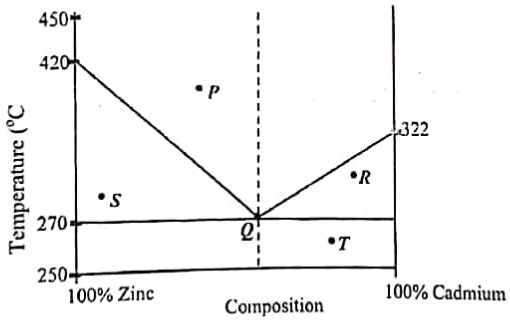
(i) Dilute hydrochloric acid. (1½ mrks)

(ii) Excess sodium hydroxide. (1½ marks)

(c) Write equation for the reaction between the oxide of silicon and sodium hydroxide. (1½ marks)

13. (a) Define the term eutectic mixture.

(b) The phase diagram for Zinc – Cadmium system is shown below.



(i) State the phase present at points, *P*, *Q*, *R*, *S* and *T*. (2½ marks)

(ii) State what would be observed if a solution of composition Y was slowly cooled (2 marks)

(c) Give **three** reasons why eutectic mixtures are **not** compounds. (3 marks)

14. (a) Explain why hydrofluoric acid is a weaker acid than hydrobromic acid. (2 marks)

(b) Write equation for the reaction between

(i) Chlorine and cold sodium hydroxide solution. (1½ marks)

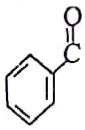
(ii) Bromine and potassium iodide solution. (1½ marks)

(iii) Chlorine and iron (II) chloride solution. (1½ marks)

(c) State what would be observed in reaction (b) (ii) and (b) (iii) (2 marks)

(d) Give a reason for your observation for the reaction in (b) (ii) (½ mark)

15. Write equation and a mechanism for the reaction between

(a) Phenyl ethanone, (Acetophenone)  $-CH_3$ and 2, 4-dinitrophenylhydrazine (Brady's reagent). (4 marks)

(b) But-2-ene and hydrogen chloride gas. (3 marks)

(c) 2-bromo-2-methyl propane and water. (2 marks)

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16. (a) State three properties in which copper differs from calcium. (1½ marks)
(b) Write equation for the reaction between copper and
(i) Moderately concentrated nitric acid. (1½ marks)
(ii) Concentrated nitric acid. (1½ marks)
(c) State what would be observed and write equation for the reaction that would take place if copper(II) sulphate solution was added.
(i) Concentrated hydrochloric acid drop-wise until in excess.
(ii) Excess iron filing.

17. During the manufacture of sulphuric acid by the contact process, sulphur dioxide is oxidized to sulphur(VI) oxide according to the following equation.

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -188kJmol^{-1}$

(a) State the effect on the yield of sulphur (VI) oxide if
(i) temperature was increased. (2 marks)
(ii) pressure was decreased. (2 marks)
(iii) concentration of sulphur dioxide was increased. (2 marks)
(b) Write equations to show how sulphuric acid can be obtained from sulphur (VI) oxide. (3 mrks)

END

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2013

1. (a) X is $^{228}_{88}Ra$ Y is $^{228}_{89}Ac$ Z is $^{228}_{90}Th$

(b) $\lambda t½ = In2 = 0.693$

Hence; $\lambda = \frac{0.693}{t½} = \frac{0.693}{1.4\times10^{10}}$

$$\lambda = 4.95 \times 10^{-11} year^{-1}$$

$$using;\ \lambda t = 2.303 \log_{10}\left(\frac{N_O}{N}\right)$$

$$4.94 \times 10^{-11} \times 2.5 \times 10^{10} = 2.303 \log\left(\frac{5}{N}\right)$$

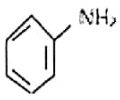
$$\therefore N = 1.45g$$

2. (a) $Vapour\ pressure\ of\ Z = 760 - 720 = 40\ mmHg$

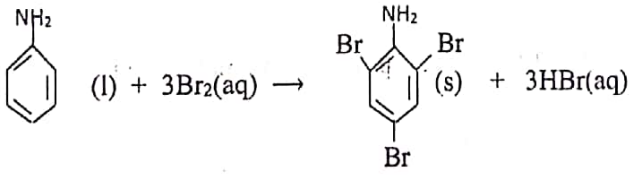
$$\frac{mass\ of Z\ in\ distillate}{mass\ of\ water\ in\ distillate} = \frac{vapour\ pressure\ of\ Z \times relative\ formula\ mass\ of\ Z\ (Mr_Z)}{Vapour\ pressure\ of\ water \times relative\ formula\ mass\ of\ water}$$

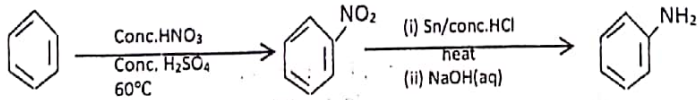
$$\frac{7.4}{25.5} = \frac{40\times Mr(Z)}{720\times18}$$

$$Rmm\ of\ Z(Mr_Z) = \frac{7.4\times720\times18}{40\times25.5} = 94.02$$

(b)  or phenylamine

(c) (i) white precipitate

(ii) 

(d) 

3. (a) $Cu(NH_3)_4^{2+}$ Tetraamminecopper(II) ion
$Fe(CN)_6^{3-}$ Hexacyanoferrate(II) ion

(b) (i) **Blue precipitate, dissolves** to give a **deep blue solution**
(ii) **Yellow** solution turns **brown**

(c) Coordination number of copper is 4
Coordination number of Iron is 6

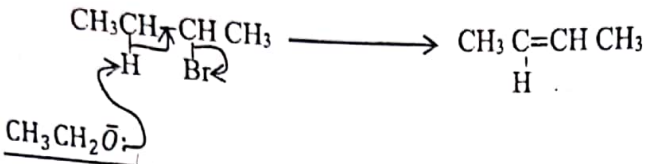
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4. (a) -Should be stable at room temperature
-Has a high degree of purity
-Readily soluble in water
-Has a high relative molecular mass.

(b) (i) Concentrated sulphuric acid is **hygroscopic**
(ii) Sodium thiosulphate -5-water is **efflorescent**

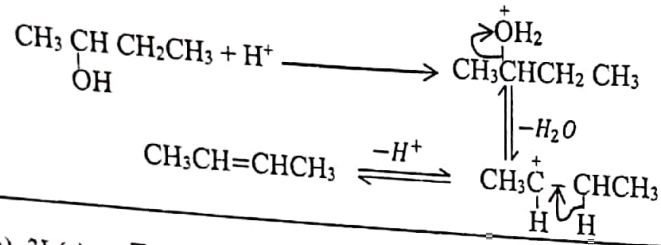
5. (a) $CH_3CH_2\underset{Br}{CH}\,CH_3 \xrightarrow[CH_3CH_2OH]{CH_3CH_2\bar{O},} CH_3\underset{H}{C}{=}CH\,CH_3$

Mechanism



(b) $CH_3\underset{OH}{CH}\,CH_2CH_3 \xrightarrow[heat]{Conc.\ H_2SO_4} CH_3CH{=}CHCH_3$

Mechanism



6. (a) $3I_2(s) + 6\bar{O}H(aq) \longrightarrow 5I^-(aq) + I\bar{O}_3(aq) + 3H_2O(l)$
or $3I_2(s) + 6NaOH(aq) \longrightarrow 5NaI(aq) + NaIO_3(aq) + 3H_2O(l)$
Observation; Black soild dissolves, to give a **coloureless solution**

(b) $3MnO_4^{2-}(aq) + 2H_2O(l) \longrightarrow MnO_2(s) + 2MnO_4^-(aq) + 4\bar{O}H(aq)$
Observation; The **green solution** turned **purple** and a **black solid** also formed.

7. (a) $Cd(s)\,/Cd^{2+}(aq)\,//\,H^+(aq)\,/H_2(g)\,/Pt(s)$
or $Cd(s)\,/\,CdSO_4(aq)\,//\,HCl(aq)\,/\,H_2(g)\,/\,Pt(s)$

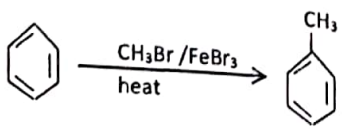
(b) (i) $2H^+(aq) + 2e \longrightarrow H_2(g)$
(ii) $Cd(s) \longrightarrow Cd^{2+}(aq) + H_2(g)$
(iii) $Cd(s) + 2H^+(aq) \longrightarrow Cd^{2+}(aq) + H_2(g)$

(c) $Emf_{cell} = E_R^\theta - E_L^\theta$
$= 0.00 - (-0.40) = \mathbf{+0.40V}$ Note – positive sign **must not** miss.

8. (a) $CH_3\underset{OH}{CH}\,CH_3 \xrightarrow[heat]{Cr_2O_7^{2-}/H^+} CH_3\overset{O}{\overset{\|}{C}}\,CH_3 \xrightarrow{H_2NNH_2/H^+} (CH_3)_2C = NNH_2$

Note In step; (i) Avoid using **warm** instead of **heat.**
Cu /300°C can be used instead of ($Cr_2O_7^{2-}/H^+$ and heat)
In step (ii); with or without a (H^+), the candidate would be correct.

(b)



9. (a) (i) $1s^2\ 2s^2\ 2p^2$
(ii) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

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(b) (i) $SiCl_4(l) + 2H_2O(l) \longrightarrow SiO_2(s) + 4HCl(aq)$ or (g)

(ii) The Silicon atom in silicon tera chloride has **vacant 3d-orbitals** which can accommodate **lone pairs of electrons** from water while the carbon in carbon terachloride **lacks 2d-orbitals.**

10. (a) -Concentration of the solution of electrolyte.
-Magnitude of charge on ions
-Ionic radius
-Temperature
-Viscosity of the solvent

(b) (i)

Molar conductivivity ($\Omega^{-1}cm^2mol^{-1}$	238	230	224	217	2101
Concentration of Potassium hydroxide ($moldm^{-3}$)	0.01	0.04	0.09	0.16	0.25
Square root of the concentration of Potassium hydroxide($mol^{½}dm^{-\frac{3}{2}}$)	0.1	0.2	0.3	0.4	0.5

(ii) See graph next page

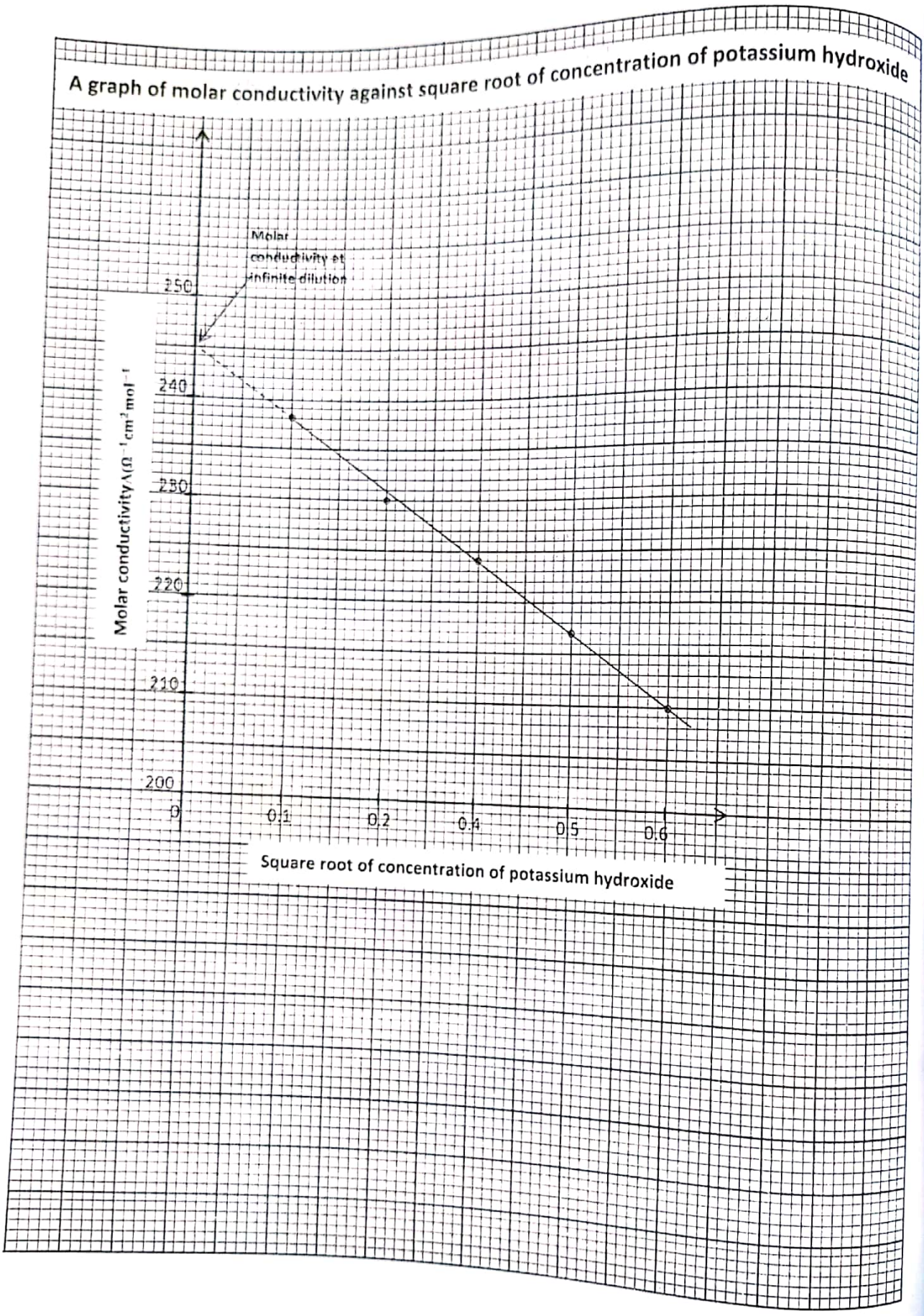
(iii) **Increase in concentration** of potassium hydroxide, **decreases the molar conductivity**. At low concentration, ions are **far apart** and hence their **mobility is high**.
As the concentration increases, the ions get **closer** to each other. Hence resulting into **increase in ionic interference (dragging effect)**. This **decreases the mobility** of the conducting ions hence a decrease in molar conductivity.

(iv) $245\Omega^{-1}cm^2mol^{-1}$

Note - Candidate must show the extrapolation on the graph.
- The horizontal axis must begin from zero because an intercept is required on the vertical axis.

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A graph of molar conductivity against square root of concentration of potassium hydroxide



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11. (a) Reagent: **Acidified** Potassium manganate (VII) **solution** and **heat**
Observation: CH_3COOH - gives **no observable change**

$HO-\overset{O}{\overset{\|}{C}}-\overset{O}{\overset{\|}{C}}-OH$ - **purple** solution turns **colourless** and **bubbles of colourless gas** form

Alternatively;
Reagent; -concentrated sulphuric acid and heat
Observation: CH_3COOH - gives **no observable change**

$HO-\overset{O}{\overset{\|}{C}}-\overset{O}{\overset{\|}{C}}-OH$ - **bubbles of colourless gas** form

(b) Reagent; **Hot** sodium hydroxide **solution** followed by dilute nitric acid and silver nitrate **solution**

Observation $C_6H_5CH_2Cl$ - white precipitate
C_6H_5Cl - No observable change

(c) Reagent; Bromine water
Observation

 - **Brown** solution turns **colourless,**  - No observable change

Alternatively;
Reagent: **Acidified** (or alkaline) Potassium manganate (VII) **solution**
Observation  - **purple** solution turns **colourless,**  - No observable change

12. (a)

Element	Formula of oxide	Structure
Sodium	Na_2O	Giant ionic
Aluminium	Al_2O_3	Giant ionic
Silicon	SiO_2	Giant molecular or Giant covalent
Phosphorus	P_4O_6 or P_2O_3 P_4O_{10} or P_2O_5	Simple molecular Or molecular

(b) (i) $Al_2O_3(s) + 6H^+(aq) \longrightarrow 2Al^{3+}(aq) + 3H_2O(l)$
Or, $Al_2O_3(s) + 6HCl(aq) \longrightarrow 2AlCl(aq) + 3H_2O(l)$
(ii) $Al_2O_3(s) + 2\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_4^-(aq)$
Or, $Al_2O_3(s) + 6\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_6^{3-}(aq)$
Or, $Al_2O_3(s) + 2\bar{O}H(aq) \longrightarrow 2Al\bar{O}_2(aq) + H_2O(l)$
Or, $Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \longrightarrow 2NaAl(OH)_4(aq)$
Or, $Al_2O_3(s) + 6NaOH(aq) + 3H_2O(l) \longrightarrow 2Na_3Al(OH)_6(aq)$
Or, $Al_2O_3(s) + 2NaOH(aq) \longrightarrow 2NaAlO_2(aq) + H_2O(l)$

(c) $SiO_2(s) + 2NaOH(aq) \longrightarrow Na_2SiO_3(aq) + H_2O(l)$
Or, $SiO_2(s) + 2\bar{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + H_2O(l)$

13. (a) A liquid mixture which at **constant pressure** solidifies at **constant temperature** to give a solid mixture of the **same composition** as the liquid mixture
or; Solid mixture which at **constant pressure** melts at a **constant temperature** to give a liquid mixture of the **same composition** as the solid mixture.

(b) (i) P – liquid mixture
Q – Solid zinc, solid cadmium and liquid mixture
R – Solid cadmium and liquid mixture
S – Solid zinc and liquid mixture
T – Solid zinc and solid cadmium

(ii) The liquid mixture **solidifies** or crystallizes and separates into **two solids**

(c) The composition of the eutectic mixture varies with pressure
The eutectic mixture can be separated by physical means
When viewed under a microscope the crystals of the mixture are not homogeneous but heterogeneous

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14. (a) The fluorine atom has **a smaller atomic radius** and **higher eletro negativity** than the bromine atom. The hydrogen – fluorine bond in hydrofluoric acid is therefore **stronger** than the hydrogen - bromine bond and hence the hydrogen – fluoride bond **cannot easily be broken** and the hydrofluoric acid therefore **does not easily release hydrogen ions** in a queous solution compared to hydro bromic acid.

(b) (i) $2NaOH(aq) + Cl_2(g) \longrightarrow NaOCl(aq) + H_2O(l) + NaCl(aq)$
or $2\bar{O}H(aq) + Cl_2(g) \longrightarrow \bar{O}Cl(aq) + Cl^-(aq) + H_2O(l)$

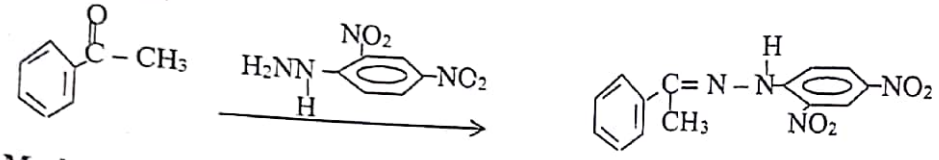
(ii) $2KI(aq) + Br_2(l) \longrightarrow 2KBr(aq) + I_2(aq)$
Or $2I^-(aq) + Br_2(l) \longrightarrow 2Br^-(aq) + I_2(aq)$

(iii) $2FeCl_2(aq) + Cl_2(aq) \longrightarrow 2FeCl_3(aq)$
or $2Fe^{2+}(aq) + Cl_2(aq) \longrightarrow 2Fe^{3+}(aq) + 2Cl^-(aq)$

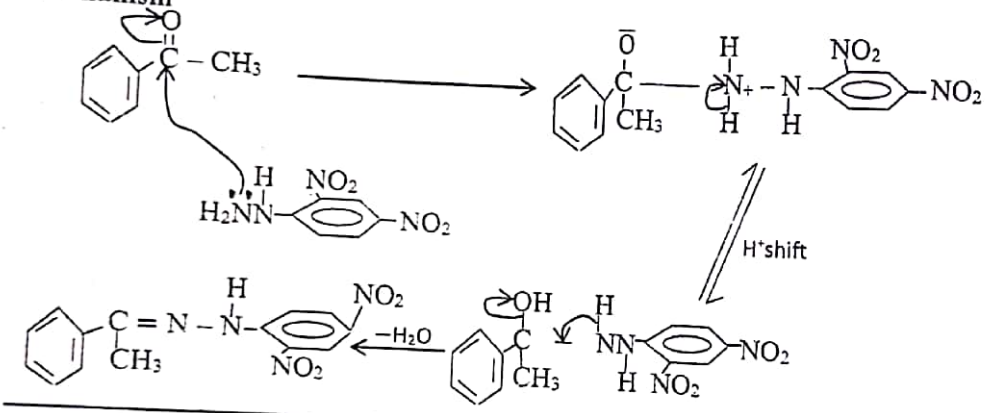
(c) In b(ii) the **clourless solution** turns **brown**
In b(iii) the **green solution** turns **yellow**

(d) Bromine **oxidises** iodide ions to **iodine**

15. (a) **Equation;**

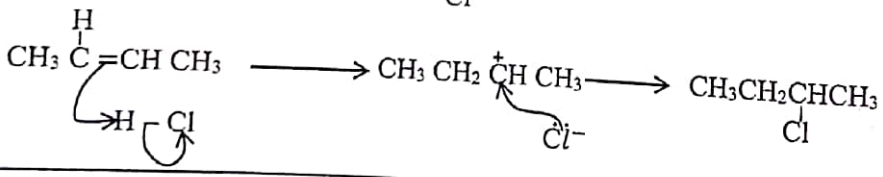


Mechanism



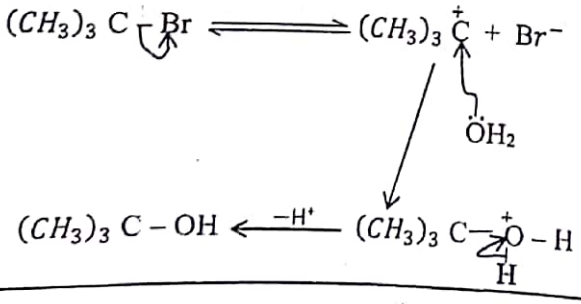
(b) $CH_3\,CH{=}CH\,CH_3 \xrightarrow{HCl(g)} CH_3CH_2\,\underset{Cl}{CH}\,CH_3$

Mechanism;



(c) $(CH_3)_3\,C-Br \longrightarrow (CH_3)_3\,C-OH$

Mechanism



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16. (a) Copper forms complexes unlike calcium
Copper forms coloured compounds unlike calcium
Copper acts as a catalyst unlike calcium
Copper has variable oxidation states unlike calcium

(b) (i) $3Cu(s) + 8HNO_3(aq) \longrightarrow 3Cu(NO_3)_2(aq) + 4H_2O(l) + 2NO(g)$
(ii) $Cu(s) + 4HNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$

(c) (i) Observation
Blue solution turns **yellow**
Equation;
$Cu(H_2O)_4^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons CuCl_4^{2-}(aq) + 4H_2O(l)$
Or, $Cu(H_2O)_6^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons CuCl_4^{2-}(aq) + 6H_2O(l)$

(ii) Observation
Blue solution turns **green** and a **brown solid** is formed as well
Equation.
$Fe(s) + CuSO_4(aq) \longrightarrow FeSO_4(aq) + Cu(s)$
Or, $Fe(s) + Cu^{2+}(aq) \longrightarrow Fe^{2+}(aq) + Cu(s)$

17. (a) (i) The yield of sulphur(VI) oxide **would decrease**
Explanation;
Increase in temperature **favours** the back ward reaction which is **endothermic** and this causes the equilibrium position to shift **from right to left.**

(ii) The yield of sulphur (VI) oxide **would decrease.**
Explanation;
Decrease in pressure **fovours the back ward reaction** which proceeds with an increase in volume, and thus the equilibrium position **shifts from right to left**

(iii) The yield of sulphur(VI) oxide **would increase**
Explanation;
Increase in concentration of sulphur dioxide causes the **equilibrium position to shift from left to right** in order to reduce the concentration of sulphur dioxide.

(b) $SO_3(g) + H_2O(l) \longrightarrow H_2S_2O_7(l)$
$H_2S_2O_7(l) + H_2O(l) \longrightarrow 2H_2SO_4(l)$ or (aq)

QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2013

1. (a) State;
(i) what is meant by the term first ionization energy (1 mark)
(ii) two factors that can determine the value of first ionization energy and explain how the factors affect the value of first ionization energy. (4 marks)

(b) (i) Define the term first electron affinity (1 mark)
(ii) Write equation to show the first electron affinity of oxygen. (1 mark)
(iii) Explain why the first electron affinity of oxygen is an exothermic process while the second electron affinity is an exothermic process. (4 marks)

(c) Aluminium reacts with oxygen to form aluminium oxide according to the following equation.
$2Al(s) + {}^3/_2O_2(g) \longrightarrow Al_2O_3(s) \quad \Delta H^\theta = -1675.7\ KJmol^{-1}$
Some thermo-chemical data of aluminium oxide and oxygen are given below.

Heat of atomization of aluminium	$= +324 KJmol^{-1}$
First ionization energy of aluminium	$= +578.0 KJmol^{-1}$
Second ionization energy of aluminium	$= +1817.0 KJmol^{-1}$
Third ionization energy of aluminium	$= +2745.0 KJmol^{-1}$
Atomization energy of oxygen	$= +249.2 KJmol^{-1}$
First electron affinity of oxygen	$= -141.1 KJmol^{-1}$
Second electron affinity of oxygen	$= +844.0 KJmol^{-1}$

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(i) Draw an energy level diagram for the formation of aluminium(III) oxide. (5 marks)
(ii) Calculate the lattice energy of aluminium(III) oxide (2 ½ marks)
(iii) Comment on the value of lattice energy obtained in (c)(ii) (1 ½ marks)

2. Complete the following equations and in each case outline a mechanism for the reaction.

(a)  $+ Br_2 \xrightarrow[heat]{Fe}$ (4 marks)

(b) $CH_3CHO + NaHSO_3(aq) \longrightarrow$ (2 ½ marks)

(c)  $CH_2I + \bar{O}H(aq) \xrightarrow{heat}$ (2 marks)

(d)  $+$ conc.$HNO_3 \xrightarrow[heat]{Conc.H_2SO_4}$ (4 marks)

(e) $CH_3CH = CH_2 \xrightarrow{H^+/H_2O}$ (4 marks)

(f) $CH_3\overset{OH}{\overset{|}{C}}HCH_3 \xrightarrow[heat]{Conc.H_3PO_4}$ (2 marks)

3. Beryllium, magnesium, calcium, strontium and barium are elements in group II of the Periodic Table.
(a) Describe the reaction of the elements with:
(i) water (3 ½ marks)
(ii) dilute hydrochloric acid (3 ½ marks)
(iii) oxygen (3 marks)
(iv) bromine (2 marks)
(b) State the reasons why beryllium differs from the rest of group II members (3 ½ marks)
(c) (i) Name the reagent that can be used to distinguish between calcium and beryllium ions. (1 mark)
(ii) State what would be observed and write equation(s) for the reaction(s) that would take place if the Reagent you have named in (c)(i) was treated separately with calcium and barium ions. (3 ½ marks)

4. (a) State what is meant by the term:
(i) Radio-activity (1 mark)
(ii) Half-life (1 mark)
(b) The table below shows data for radio-active decay of an element Z.

Time(hours)	0.0	5.0	10.0	15.0	20.0	25.0	30.0
Activity (count per minute)	25.00	23.00	21.25	19.50	18.00	16.50	15.25

(i) Plot a graph of activity against time (3 marks)
(ii) Determine the value of the half-life of element Z (1 ½ marks)
(iii) Determine the decay constant t and state its units (2 marks)
(c) The kinetic data for the reaction between substance X and Y are shown in the table below.

Experiment	Initial [X]	Initial [Y]	Initial rate
I	5.0×10^{-3}	5.0×10^{-3}	3.0×10^{-2}
II	1.0×10^{-2}	1.0×10^{-2}	2.4×10^{-2}
III	5.0×10^{-3}	1.0×10^{-3}	6.0×10^{-3}

Determine the
(i) rate equation for the reaction (2 marks)
(ii) value of the rate constant and state its units (2 marks)
(iii) initial rate of the reaction when the concentration of X and Y are 1.5×10^{-2} and 7.5×10^{-3} mol dm^{-3} respectively
(d) Explain how the following factors affect the rate of a chemical reaction.
(i) Temperature (3½ marks)
(ii) Concentration (1½ marks)
(iii) Surface area (1½ marks)

5. (a) Ammonium chloride solution gives effervescence with magnesium ribbon, whereas sodium ethanoate solution gives a blue precipitate with aqueous copper(II) chloride solution. Explain the observation. (8 marks)

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(b) The hydrolysis constant of sodium methanoate is 6.25×10^{-11} mol dm^{-3} at 25°C
(i) Calculate the pH of a 0.1M aqueous solution of sodium methanoate at 25°C.
(Ionic product of water is 10^{-14} mol dm^{-3} at 25°C) (4 marks)
(ii) To 1dm^3 of 0.1M sodium methanoate solution was added 10cm^3 of 1M hydrochloric acid. Calculate the pH of the resultant solution. *(The acid ionization constant, Ka of methanoic acid is 1.6×10^{-1} mol dm^{-3})* (4 marks)

(c) Explain what would happen to the pH of a solution containing sodium methanoate and methanoic acid, if to it was added a small amount of
(i) hydrochloric acid (2 marks)
(ii) sodium hydroxide (2 marks)

6. Explain the following observations:
(a) Diethylamine is a stronger base than aminobenzene (5 marks)
(b) Bromine water reacts with propene to form 1-bromopropan-2-ol as the major product rather than 1,2-dibromopropane. (5 ½ marks)
(c) Ethanoic acid is a weaker acid than dichloroethanoic acid. (4 ½ marks)
(d) When 2-methylpropene is reacted with hydrogen bromide, the major product is 2-bromo-2-methylpropane rather than 1-bromo-2-methylpropane. (5 marks)

7. Explain the following observations
(a) Lithium carbonate is decomposed by heat, whereas sodium carbonate is not (3 ½ marks)
(b) Lead(IV) chloride exists but lead(IV) bromide does not. (2 ½ marks)
(c) Nitrogen is a gas at room temperature whereas phosphorous is a solid at the same temperature, yet both of them belong to the same group in the Periodic Table. (8 marks)
(d) Iron(II) ions are readily oxidized to iron(III) ions, whereas manganese(II) ions are not oxidized to manganese(III) ions. (*Atomic number of iron and manganese are 26 and 25 respectively*) (6 marks)

8. (a) Describe how sodium hydroxide can be prepared on industrial scale.
(*Your answer should include equations for the relevant reactions*) (6 marks)
(b) Write equations and state conditions under which sodium hydroxide can react with
(i) aluminium (2 ½ marks)
(ii) phosphorous (2 ½ marks)
(iii) chlorine (5 marks)
(c) (i) Describe how soap is manufactured from sodium hydroxide and oil or fat. (3 marks)
(ii) Write equation for the reaction leading to the formation of soap. (1 mark)

END

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2013

Question. One.

(a) (i) Energy required to remove an electron from a **gaseous** atom to form a **unipositively charged gaseous** ion
or Energy required to remove **one mole** of electrons from **one mole** of gaseous atoms to form **one mole** of **unipositively charged gaseous ions**
or Energy required to remove an electron from each mole of atoms in gaseous state to form a mole of cations in gaseous state.

(ii) -Atomic radius
-Effective nuclear charge
-Screening effect
-Electronic configuration or electron structure
-Penetrating power of the valence electrons

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Atomic radius
The smaller the atomic radius, the **closer** are the outer most energy level electrons to the nucleus, the **stronger the attraction** of these electrons by nucleus and the **greater the first ionization energy.**

Effective nuclear charge
The greater the effective nuclear charge, the **more strongly attracted** are the outer most electrons to the nucleus and the **greater the first ionization energy.**

Screening effect;
Increase in screening effect causes a **decrease in the effective nuclear charge** and hence outer electrons become **less strongly attracted** by the nucleus leading to **decrease in the first ionization energy**

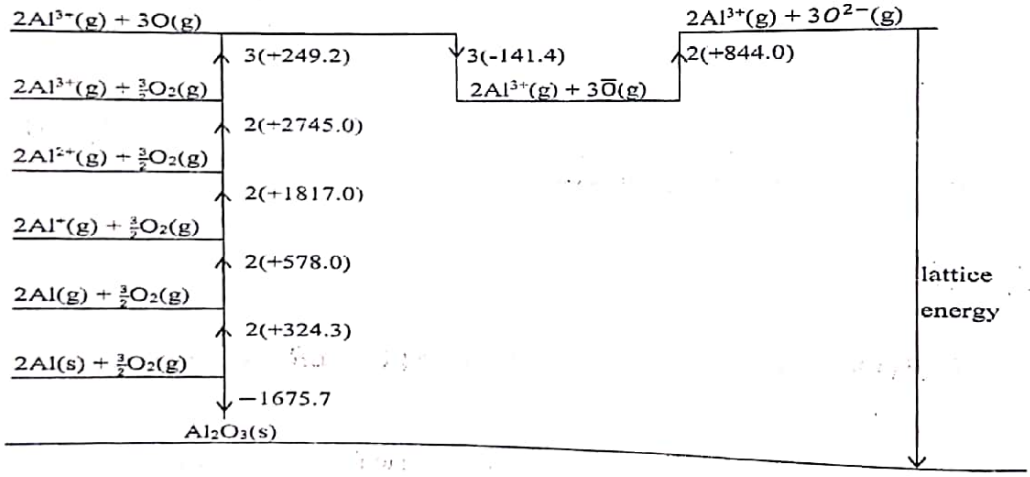
Electronic configuration;
Electronic configuration in which the outer sub-shells are **half filled** or **completely filled** with electrons are **energetically stable** and thus have high first ionization energy values.

Penetrating power of valence electrons
In a given energy level the first ionization energy increases in the order;
$s > p > d > f$, because the penetrating power of valence electrons decreases in the order
$s > p > d > f$ since from the s – sub-shell to the f – sub-shell the electrons become **less strongly attracted** by the nucleus.

(b) (i) Energy liberated when an electron is added to a **gaseous** atom to form a **uninegatively charged gaseous ion**
or, Energy liberated when **one mole** of electrons is added to **one mole** of **gaseous** atoms to form **one mole** of uninegatively charged gaseous ions

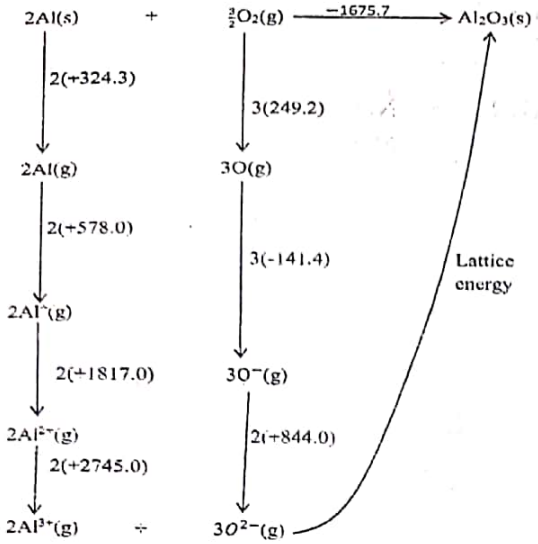
(ii) $O(g) + e \longrightarrow O^-(g)$ **or** $O^-(g) \longrightarrow O(g) + e$

(iii) The first electron affinity of oxygen is an exothermic process because the process involves addition of an electron to a **neutral atom** and so the incoming (added) electron experiences **nuclear attraction** but less repulsion and **energy is released**. But;
The second electron affinity of oxygen is an endothermic process because the process involves addition of an electron to a **negatively charged ion** and so the incoming (added) **electron experiences greater repulsion** from the negative ion thus **energy is absorbed** to effect the process.



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Alternatively



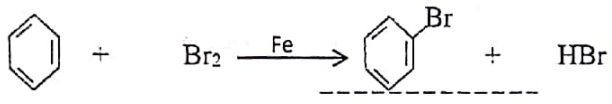
(ii) $-1675.7 = 2(324.3) + 2(578.0) + 2(1817.0) + 2(2745.0) + 3(249.2) + 3(-141.4) + 2(844.0) + lattice\ energy\ of\ Al_2O_3$

$\therefore lattice\ energy\ of\ Al_2O_3 = -15459.7 KJmol^{-1}$

(iii) The value of the lattice energy of aluminium oxide is very **high** because aluminium oxide is **ionic** and hence a very **stable** compound.

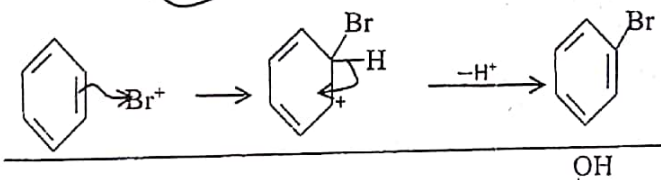
Question. Two.

(a)



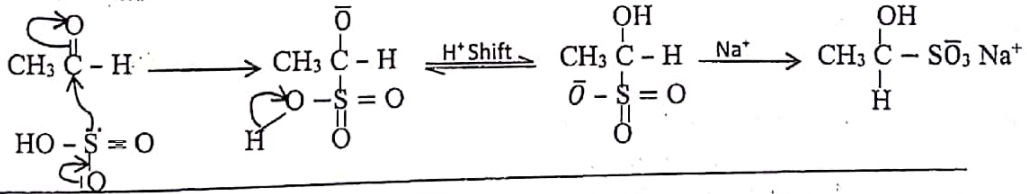
$2Fe + 3Br_2 \longrightarrow 2FeBr_3;$

Then: $Br - Br + FeBr_3 \rightleftharpoons FeBr_4^- + Br^+$

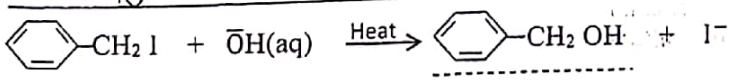


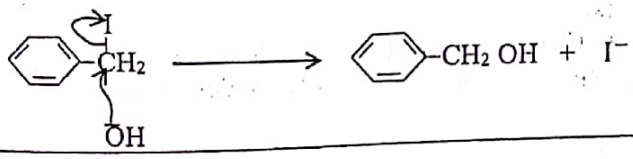
(b)

$CH_3CHO + NaHSO_3(aq) \longrightarrow CH_3C(OH)H - S\bar{O}_3\ Na^+$



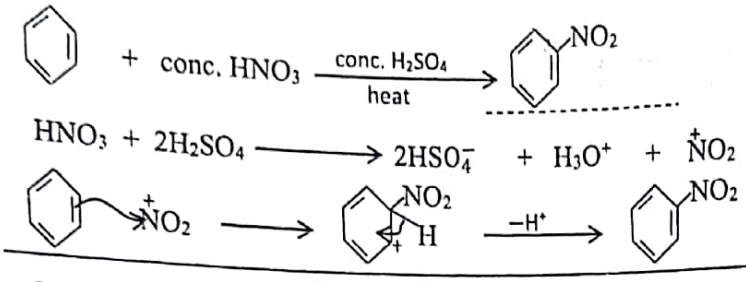
(c)



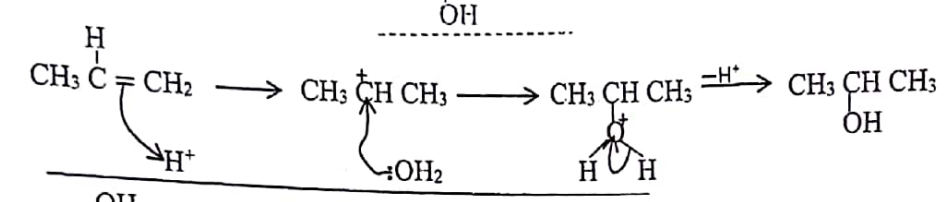


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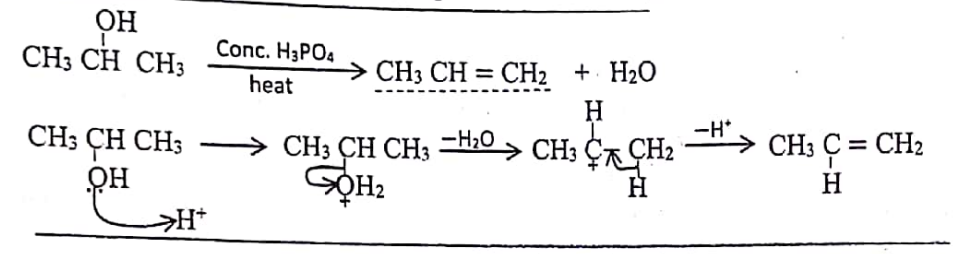
(d)



(e)



(f)



Question. Three.

(a) (i) -Beryllium **does not react** with water under any condition

-**Heated** magnesium reacts with **steam** to form **magnesium oxide** and **hydrogen gas**

$Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$

-Calcium, strontium and barium react with **cold** water to form a metal **hydroxide** and **hydrogen gas**

$M(s) + 2H_2O(l) \longrightarrow M(OH)_2(aq) + H_2(g)$, (M = Ca, Sr, Ba)

-The reactivity of the group (II) elements with water increases from Beryllium to barium

(ii) All the elements react with dilute hydrochloric acid to form a metal **chloride,** and **hydrogen gas.**

$M(s) + 2HCl(aq) \longrightarrow MCl_2(aq) + H_2(g)$; (M = Be, Mg, Ca, Sr, Ba)

or, $M(s) + + 2H^+(aq) \longrightarrow M^{2+}(aq) + H_2(g)$

(iii) All the elements when **heated** react with oxygen to form metal **oxides**

$M(s) + O_2(g) \longrightarrow 2MO(s)$; (M = Be, Mg, Ca, Sr, Ba)

(iv) All the elements react with bromine when **heated** to form metal **bromides**

$M(s) + Br_2(g) \longrightarrow MBr_2(s)$; (M = Be, Mg, Ca, Sr, Ba)

(b) – Beryllium has the **smallest atomic radius** compared to the other group (II) elements

– Beryllium forms an ion with the **highest charge density** or polarizing power compared to other group (II) elements.

– Beryllium has a **lower electrode potential (electropositivity)** value than all other group (II) elements

– Beryllium is **more electronegative** than all other group (II) elements

(c) (i) Potassium chromate(VI) solution and ethanoic acid

or, Ammonium oxalate solution and ethanoic acid

(ii) Calcium ions form **a yellow precipitate** with Potassium chromate(VI) solution which is soluble in ethanoic acid,

$Ca^{2+}(aq) + CrO_4^{2-}(aq) \longrightarrow CaCrO_4(s)$, then;

$CaCrO_4(s) + 2CH_3COOH(aq) \longrightarrow (CH_3COO)_2Ca(aq) + H_2CrO_4(aq)$

Barium ions form a **yellow precipitate** with potassium chromate(VI) solution which is **insoluble** in ethanoic acid eq:

$Ba^{2+}(aq) + CrO_4^{2-}(aq) \longrightarrow BaCrO_4(s)$

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or, Calcium ions form a **white precipitate** with ammonium oxalate solution which is **insoluble** in ethanoic acid. Eq.

$Ca^{2+}(aq) + C_2O_4^{2-}(aq) \longrightarrow CaC_2O_4(s)$

Barium ions form a **white precipitate** with ammonium oxalate solution which is **soluble** in ethanoic acid

$Ba^{2+}(aq) + C_2O_4^{2-}(aq) \longrightarrow BaC_2O_4(s)$, then;

$BaC_2O_4(s) + 2CH_3COOH(aq) \longrightarrow (CH_3COO)_2Ba(aq) + H_2C_2O_4(aq)$

Question. Four.

(a) (i) Radioactivity is the spontaneous disintegration of an **unstable** atom or nucleus or element into a more **stable atom** or nucleus or element **with emission of radiations**

(ii) Time taken for the amount of a reactant to reduce to half its original amount.

(b) (i) See graph next page

(ii) 43 hours (check from graph)

(iii) Using $\lambda t½ = In2$

Decay constant; $\lambda = \frac{In2}{t½} = \frac{0.693}{43} = \mathbf{0.016\ hour^{-1}}$

(c) (i) In experiments (I) and (III) when the concentration of X is **constant**, and the concentration of **Y doubled**, the rate of reaction also **doubled** indicating that the order of reaction with respect to Y is **one** While in experiments (II) and (III) when the concentration of Y is **constant**, the concentration of X **halved** the rate changes by ¼times indicating that the reaction is **second order** with respect to X Thus; the rate equation is; $Rate = k\,[X]^2[Y]$ where k = rate constant

Note; order of reaction can also be deduced or determined by calculation, see solution to question 4. (a) 2019 paper 1

(ii) Rate constant; $k = \frac{Rate}{[X]^2[Y]}$

(substitution using exp 1)

$k = \frac{3.0\times10^{-3}}{(5.0\times10^{-3})^2(5.0\times10^{-3})} = \mathbf{24{,}000 mol^{-2}dm^6s^{-1}}$

(iii) Initial rate of reaction $= k\,[X]^2[Y]$

$= 24{,}000(1.5\times10^{-2})^2 \times (7.5\times10^{-3})$

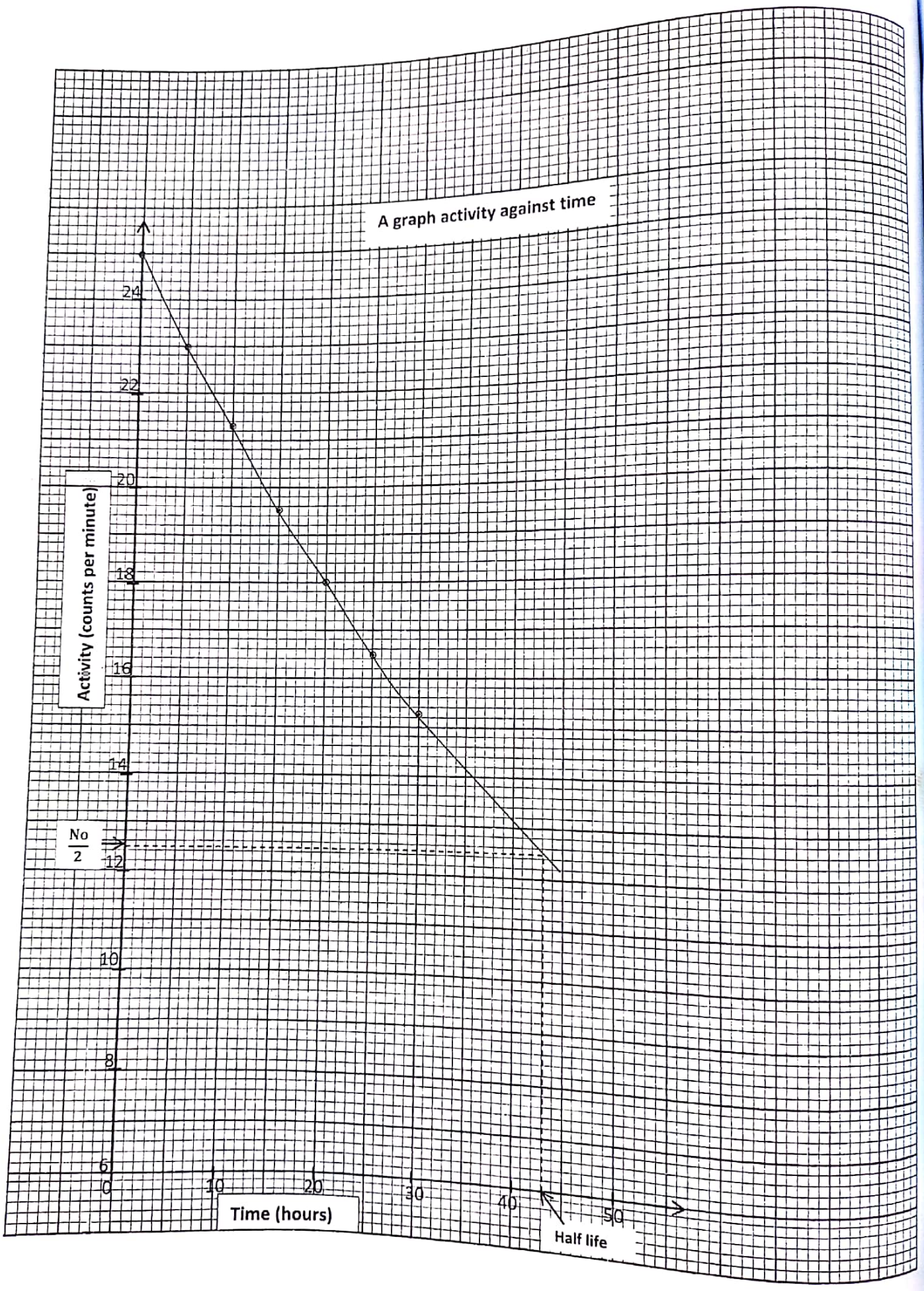
$= \mathbf{4.05\times10^{-2} moldm^{-3}s^{-1}}$

(d) (i) **Increase in temperature increases the rate of reaction,** because at a **higher temperature,** the reaction particles posses **greater kinetic energy** and hence **move faster** and **collide together more frequently,** also for every 10°C rise in temperature, the **number of reactant particles possessing activation energy doubles,** the **value of the rate constant increases** and **rate of reaction increases.**

(ii) **Increase in concentration, increase the number of reactant** particles per unit volume. The reactant particles become **close** to each other and thus **collide together more frequently** leading to **faster rate of reaction.**

(iii) The **higher the surface area,** the **faster** the rate of reaction. When the surface area is **high, more reacting** particles are exposed for the reaction, which **increases their frequency of** collisions hence **faster rate of reaction**

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Question. Five.

(a) The ammonium ion in ammonium chloride solution **hydrolyses** in water to form **hydroxonium ions** which make the solution **acidic**

$$\overset{+}{N}H_4(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$$

These hydroxonium ions **react** with the magnesium ribbon to liberate **hydrogen gas**

$$2H_3O^+(aq) + Mg(s) \longrightarrow Mg^{2+}(aq) + H_2(g) + 2H_2O_{(l)}$$

Sodium ethanoate undergoes **hydrolysis** to form an **alkaline solution;**

$$CH_3\,CO\bar{O}(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + \bar{O}H(aq)$$

These hydroxide ions formed by hydrolysis react with copper(II) ions in copper(II) chloride solution to form **insoluble copper(II) hydroxide**

$$Cu^{2+}(aq) + \bar{O}H(aq) \longrightarrow Cu(OH)_2(s)$$

(b) (i) Equation of hydrolysis of sodium methanoate is;

$$HCO\bar{O}(aq) + H_2O(l) \rightleftharpoons HCOOH(aq) + \bar{O}H(aq)$$

$$Kh = \frac{[HCOOH][\bar{O}H]}{[HCO\bar{O}]}$$

Assumptions: $[\bar{O}H] = [HCOOH]$ and $[HCO\bar{O}] = [HCOONa] = 0.1M$

$$Kh = \frac{[\bar{O}H]^2}{[HCO\bar{O}]}$$

$$6.25 \times 10^{-11} = \frac{[\bar{O}H]^2}{0.1}$$

$$[\bar{O}H] = \sqrt{(6.25 \times 10^{-11}) \times 0.1} \quad = \mathbf{2.5 \times 10^{-6} moldm^{-3}}$$

Using $Kw = [H^+][\bar{O}H]$

$$[H^+] = \frac{Kw}{[\bar{O}H]} = \frac{1\times10^{-14}}{2.5\times10^{-6}} \quad = \mathbf{4.0 \times 10^{-9} moldm^{-3}}$$

$$pH = -\log_{10}[H^+]$$
$$= -\log_{10}(4.0 \times 10^{-9}) \quad = \mathbf{8.4}$$

(ii) Moles of HCl added $= \frac{10}{1000} \times 1 = \mathbf{0.01 moles}$;

Hydrochloric acid reacts with sodium methanate according to the equation;

$$HCOONa(aq) + HCl(aq) \longrightarrow HCOOH(aq) + NaCl(aq) + (\text{un reacted } HCOONa)$$

or; $HCO\bar{O}(aq) + H^+(aq) \longrightarrow HCOOH(aq)$

Since; mole ratio; of HCl : HCOOH = 1:1;

Moles of HCOOH formed = 0.01 moles

Moles of HCOONa which reacted = 0.01 (since mole ratio of HCOONa; HCl = 1:1)

Moles of un reacted HCOONa = 0.1 − 0.01 = 0.09moles

Volume of resultant solution = (100+10) ≃ 1000cm^3(since 10cm^3 is very small compared to 1000cm^3)

Thus; $[HCOONa] = 0.09 moldm^{-3}$

$[HCOOH] = 0.01 moldm^{-3}$

$$pH = PKa + \log_{10}\frac{[salt]}{[acid]}$$

$$= -\log_{10} 1.6 \times 10^{-4} + \log_{10}\left(\frac{0.09}{0.01}\right)$$

$$= 4.75$$

or $[H^+] = \frac{Ka[acid]}{[salt]}$

$$= \frac{1.6\times10^{-4}\times0.01}{0.09} = 1.778 \times 10^{-5}$$

$$pH = -\log_{10}[H^+]$$
$$= -\log_{10} 1.778 \times 10^{-5}$$
$$= 4.75$$

(c)(i) The pH of the solution would **remain constant** because the hydrogen ions from the hydrochloric acid added **react** with the methanoate ions in solution forming **methanoic acid molecules** and hence the **pH remains constant;**

$$H^+(aq) + HCO\bar{O}(aq) \longrightarrow HCOOH(aq)$$

(ii) The pH of the solution would **remain constant,** because the hydroxide ions from the sodium hydroxide solution added would **react** with the hydrogen ions in the solution to form water;

$$H^+(aq) + \bar{O}H(aq) \Longrightarrow H_2O(l)$$

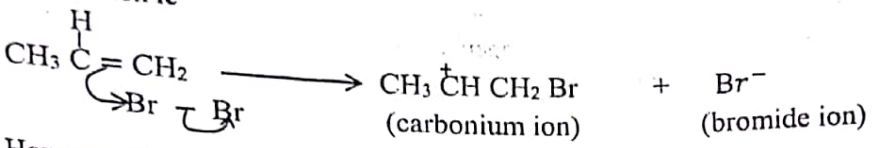
This **reduces the concentration of hydrogen ions** in solution and as an attempt to restore its concentration, **more methanoic acid ionizes** hence **maintaining the pH.**

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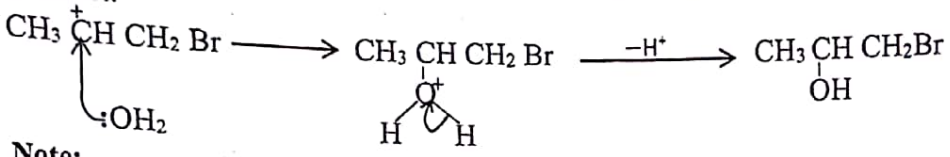
Question. Six.

(a) In diethyl amine, the ethyl groups bonded to the nitrogen atom have a **positive inductive effect** (ie push the bonding electrons towards the nitrogen atom). This **increases the availability** of the lone pair of electrons on the nitrogen atom thus making the amine **easily accept a proton**
However, in amino benzene, the lone pair of electrons on the nitrogen atom **interacts with the delocalized electrons** of the benzene ring and this **reduces the availability** of the lone pair of electrons on the nitrogen atom making amino benzene **not to easily accept a proton**

(b) Propene first reacts with bromine to form a **secondary carbonium ion** and a bromide ion **ie**

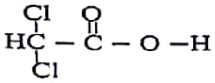


However, due to **higher concentration** of water molecules than bromide ions, **more electrophilic** carbonium ions are **attacked** by the **nucleophilic water molecules** than bromide ions there by forming 1-bromo-propan-2-ol as the major product rather than 1,2-dibromopropane which is formed as **aminor product.**



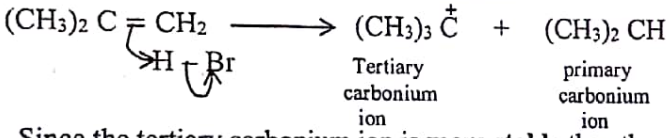
Note;

(c) Structure of ethanoic acid; 

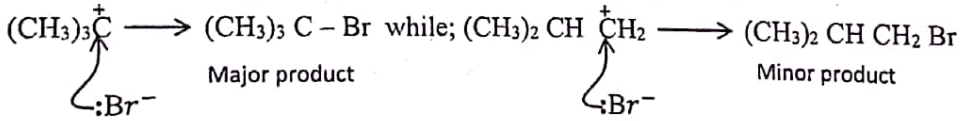
Structure of dichloro ethanoic acid 

In ethanoic acid, the **methyl group** bonded to the carbonyl carbon has a positive inductive effect (ie pushes bonding electrons towards the carbonyl carbon). This makes the oxygen hydrogen bond to be **less polar** and hence **more strengthened** and thus **cannot easily be broken** to release a hydrogen ion Dichloroethanoic acid has **chlorine atoms** which have **a negative inductive effect** (with draw bonding electrons towards them selves). This makes the oxygen-hydrogen bond to be **more polar** and hence **more weakened** and thus can easily be broken making dichloroethanoic acid to easily release a proton

(d) 2-methyl propene first reacts with hydrogen bromide to form a **tertiary carbonium ion,** a **primary carbonium ion** and **bromide ion**



Since the tertiary carbonium ion is **more stable** than the primary carbonium ion, **more** electrophilic tertiary carbonium ions are **attacked** by the nucleophilic bromide ion than the electrophilic primary carbonium ion there by forming **2-bromo-2-methyl propane** as the **major product** rather than **1-bromo-2-methyl propane** which is formed as a **minor product**



Question. Seven.

(a) Both the lithium ion in lithium carbonate and the sodium ion in sodium carbonate have the **same change of +1,** but the lithium ion has a **smaller ionic radius** and hence **higher charge density** than the sodium ion. This makes the carbonate ion to be **more polarized** by lithium ion than sodium ions thus making lithium carbonate **more covalent** in character than ionic and hence **less stable** unlike sodium carbonate which is **more ionic** in character than covalent and hence **more stable** and hence not decomposed by heat

(b) The bromide ion has **a larger ionic radius** than the chloride ion and therefore a stronger reducing agent which **reduces lead (IV) ions to lead (II) ions,** therefore lead (IV) bromide **does not exist.** The chloride ion however **cannot reduce lead (IV) ions to lead (II) ions** and therefore lead (IV) chloride exists.

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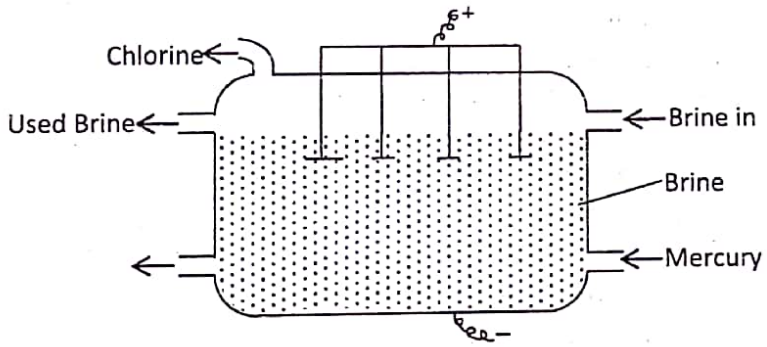
(c) Both nitrogen and phosphorus have **five electrons** in their outer most energy levels, hence belong to the **same group(V)** of the periodic table. Nitrogen atom has a **smaller atomic radius** than phosphorus atom and so nitrogen can form **stable multiple** bonds between its atoms.
Phosphorus atom has a **larger atomic radius** and **can not form multiple bonds** btween its atoms.
Nitrogen exists as discrete **diatomic molecules** (N_2) while phosphorus exists as discerete **tetraatomic molecules** (P_4)
The molecules of each are held together by **vander waal's forces.** The **molecular mass of phosphorus is however higher** than that of nitrogen, hence vander waal's forces in phosphorus are **stronger** and **cannot easily be overcome** unlike nitrogen whose vander waal's forces are **weaker** and hence can **easily be overcome** making nitrogen to exist as a gas at room temperature while phosphorus is a **solid.**

(d) Electronic configurations of iron, iron (II) ion, Iron (III) ion, manganese, manganese (II) ion and manganese (III) ion are;
Fe; $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$, Fe^{2+};$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6$
Fe^{3+}; $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$, Mn; $-1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$
Mn^{2+}; $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$ Mn^{3+}; $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^4$

Iron (II) ion has **six electrons** in the 3d-subenegy level and so has partially filled 3d-orbitals and hence **energetically un stable** while iron (III) has **five electrons** in the 3d-subenergy level hence **half filled** and thus **energetically stable** and so to attain a relatively more stable electron structure, iron(II) ion is **oxidized** to iron (III) ion.
Manganese (II) ions have their 3d-subenergy level with **five electrons** which makes it **half filled** and energetically **stable** hence **cannot be** oxidized to manganese (II) ion whose 3d-subenergy level **has four electrons** hence **energetically unstable.**

Question. Eight.

(a) **Diagram**



Sodium hydroxide is prepared on industrial scale by **electrolysis of concentrated sodium chloride solution** using a **mercury cathode** and **graphite anode** or **titanium anode**
Sodium ions are discharged at the cathode forming sodium

$$Na^+(aq) + e \longrightarrow Na(s)$$

The sodium then mixes wth the mercury acting as cathode to form an alloy called sodium amalgam;

$$Na(s) + Hg(s) \longrightarrow Na\text{-}Hg(s)$$

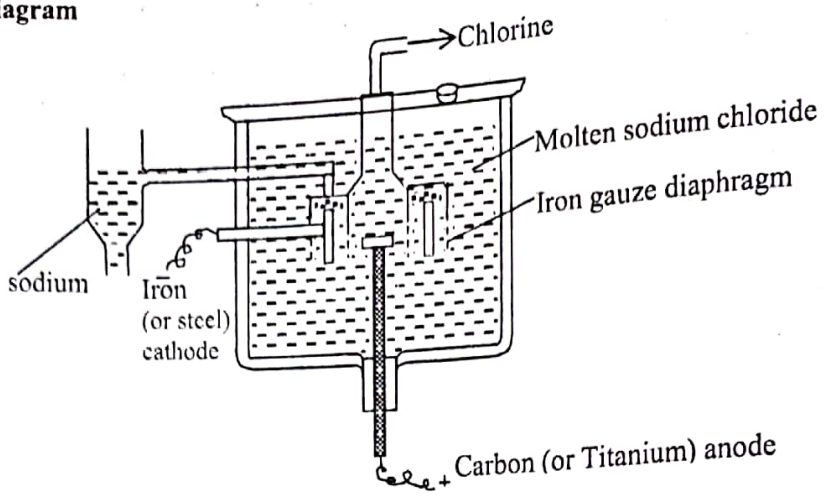
The sodium amalgam then reacts with the water to form sodium hydroxide solution

$$Na\text{-}Hg(s) + H_2O(l) \longrightarrow NaOH(aq) + \tfrac{1}{2}H_2(g) + Hg(l)$$

The sodium hydroxide solution is then **evaporated** and cooled to obtain solid sodium hydroxide.

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Alternatively;
Diagram



Concentrated sodium chloride solution (brine) is **electrolyzed** using titanium or **carbon** anode and iron or **steel** cathode.

Chloride ions are discharged at the anode compartment to form chlorine gas. i.e

$2Cl^-(aq) \longrightarrow Cl_2(g) + 2e$

The resultant solution passes through the diaphragm into the cathode compartments. Hydrogen ions are discharged at the cathode to form hydrogen gas; i.e

$2H^+(aq) + 2e \longrightarrow H_2(g)$

The solution in the cathode compartment contains sodium hydroxide and sodium chloride impurity. This is concentrated by evaporation in which sodium chloride forms crystals and concentrated sodium hydroxide solution remains.

(b) (i) $2Al(s) + 2NaOH(aq) + 6H_2O(l) \longrightarrow 2NaAl(OH)_4(aq) + 3H_2(g)$

or $2Al(s) + 2\bar{O}H(aq) + 6H_2O(l) \longrightarrow 2Al(OH)_4^-(aq) + 3H_2(g)$

(See correct alternative equations in solution to question qn. 17 (c)(i) paper 1; 2016)

Conditions; **hot** and **concentrated** sodium hydroxide solution

(ii) $P_4(s) + 3NaOH(aq) + 3H_2O(l) \longrightarrow 3NaH_2PO_2(aq) + PH_3(g)$

$P_4(s) + 3\bar{O}H(aq) + 3H_2O(l) \longrightarrow 3H_2P\bar{O}_2 + PH_3(g)$

Conditions; – **Hot** and **concentrated** sodium hydroxide solution

(iii) $Cl_2(g) + 2NaOH(aq) \longrightarrow NaCl(aq) + NaClO(aq) + H_2O(l)$

or $Cl_2(g) + 2\bar{O}H(aq) \longrightarrow Cl^-(aq) + Cl\bar{O}(aq) + H_2O(l)$

conditions – **cold** and **dilute** sodium hydroxide solution

$3Cl_2(g) + 6NaOH(aq) \longrightarrow NaClO_3(aq) + 5NaCl(aq) + 3H_2O(l)$

or $3Cl_2(g) + 6\bar{O}H(aq) \longrightarrow Cl\bar{O}_3(aq) + 5Cl^-(aq) + 3H_2O(l)$

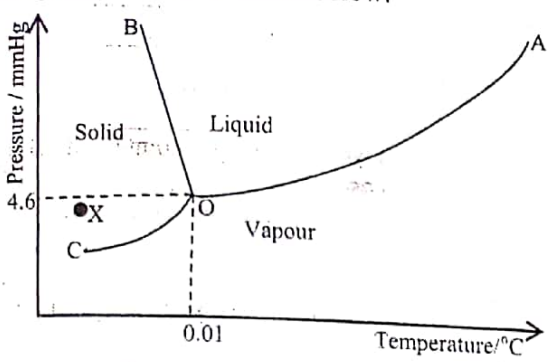
conditions – **Hot** and **concentrated** sodium hydroxide solution

(c) (i) and (II) see solution to question 7, 2018 paper 2

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QUESTIONS TO 'A' LEVEL CHEMISTRY PAPER; PAPER 1(P525/1), 2012

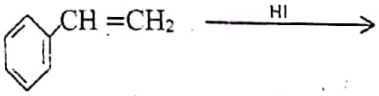
1. The phase diagram of water is shown below.



(a) State what the following points represent.
(i) A (ii) O (2 marks)
(b) State what would happen if ice at point X was heated at constant pressure (1 mark)
(c) From the diagram, state one condition necessary for ice to melt. (1 mark)

2. Complete the following equations and in each case, write the accepted mechanism for the reaction.

(a) $CH_3-\overset{\overset{O}{\|}}{C}-H \xrightarrow{NaHSO_3(aq)}$

(b)  (2 ½ marks)

(3 marks)

3. State what would be observed and write equation for the reaction that would take place when:
(a) A solution of potassium carbonate is added to aqueous aluminium nitrate. (2½ marks)
(b) Solid potassium iodide is heated with concentrated sulphuric acid. (3 marks)

4. The energy changes that take place during the formation of barium chloride are shown in the table below.

Process	ΔH^{θ}/kJ mol^{-1}
$Ba_{(s)} \xrightarrow{A} Ba_{(g)}$	+ 176
$Ba_{(g)} \xrightarrow{B} Ba^{2+}_{(g)} + 2e^-$	+148
$Cl_{2(g)} \xrightarrow{C} 2Cl_{(g)}$	+242
$Cl_{(g)} + e^- \xrightarrow{D} Cl^-_{(g)}$	−364
$Ba^{2+}_{(g)} + 2Cl^-_{(g)} \xrightarrow{E} BaCl_{2(s)}$	−2018

(a) Name the energy changes for the processes. (2½ marks)
A, B, C, D and E
(b) Calculate the standard enthalpy of formation of barium chloride. (3 marks)

5. The following reagents are used to distinguish between different classes of organic compounds. In each case, name the classes of organic compounds and state what would be observed if a member of each class of compounds you have named is separately treated with the reagent.
(a) Reagent: a solution of silver nitrate in ammonia. (3 marks)
(b) Reagent: A solution of bromine in water. (3 marks)

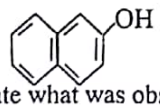
6. Although lithium is in Group I of the Periodic Table, it resembles elements of Group II in some of its properties.
(a) State four properties in which lithium resembles Group II elements. (4 marks)
(b) Give one reason for the anomalous behavior of lithium. (1 mark)

7. Hydrogen reacts with iodine according to the following equation:
$H_2(g) + I_2(g) \longrightarrow 2HI(g); \quad \Delta H = {}^{-}10kJ.$
(a) Draw a labelled diagram for the potential energy versus reaction coordinate. (2 marks)
(b) The rate of the reaction is given by Rate $= K[H_2][I_2]$
Determine the overall order of the reaction. (½ mark)
(c) When 0.1 mole of hydrogen and 0.2 moles of iodine were mixed in a 500 cm^3 vessel at 400°C, the initial rate of formation of hydrogen iodine was $4.6 \times 10^{-5}\ mol\ dm^{-3}s^{-1}$.
Calculate the value of K and give its units. (2 marks)

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8. Determine the oxidation and coordination number of the central atom in the following complexes.

Complex	Coordination number	Oxidation number
$[Pt(NH_3)_4]^{2+}$		
$[PdCl_4]^{2-}$		
$[Fe(CN)_6]^{3-}$		
$[(CrCl(H_2O)_5)]^{+}$		

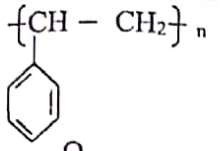
9. The molecular formula of compound A is C_4H_8O. Compound A forms a yellow precipitate with Brady's reagent. (2 marks)
   (a) Write the structural formulae and names of all the possible isomers of A.
   (b) A reated with iodine in aqueous solution of sodium, hydroxide to form a yellow precipitate.
      (i) Identify A (1 mark)
      (ii) Write equation to show how A can be converted to an alkene. (2½ marks)
10. (a) One of the limitations of the method of determining relative molecular mass by freezing point method is that the solute should not associate or dissociate in solution.
      (i) State three other limitations of determining molecular mass by freezing point method. (1½ marks)
      (ii) Explain how association of a solute affects the molecular mass determined by freezing point method. (3½ marks)
   (b) A solution containing 0.142g of naphthalene in 20.25g of benzene caused a lowering of freezing point of 0.284°C. Calculate the molar mass of naphthalene. (cryoscopic constant kf of benzene is 5.12 $mol^{-1}kg^{-1}$) (4 marks)
11. (a) (i) Write the electronic configuration of chromium. (1 mark)
      (ii) State three charateristics of chromium as a transition metal. (1½ marks)
   (b) Chromium (III) chloride was dissolved in water and the solution tested with litmus paper. State what was observed and explain your answer. (4 marks)
   (c) Ammonia solution was added drop-wise to an aqueous solution of a chromium (III) salt untiol in excess.
      (i) State what was observed. (1 mark)
      (ii) Write equation for the reaction that took place. (1½ marks)
12. 1.8g of compound X contains carbon, hydrogen and nitrogen only. X on combustion liberated 5.28g of carbon dioxide gas and 224cm^3 of nitrogen gas at s.t.p
   (a) Determine the empirical formula of X. (3 marks)
   (b) When vapourised, 0.2g of X occupied 81cm^3 at 184.1°C and 101.325kPa. Determine the molecular formula of X. (2½ marks)
   (c) X burns with a sooty flame and the pH of its aqueous solution is greater than 7. Write the molecular structure of X. (1 mark)
   (d) X was reacted with sodium nitrate in the presence of hydrochloric acid at 5°C and the product treated with 2-naphthol, 
      (i) State what was observed. (½ mark)
      (ii) Write equations for the reactions that took place. (2 marks)
13. The equations for redox reactions are shown below.
   $2H^+(aq) + 2Fe^{2+}(aq) \rightleftharpoons H_2(g) + 2Fe^{3+}(aq)$
   $3Zn(s) + 6\bar{O}H(aq) + BrO_3^-(aq) + 3H_2O(l) \rightleftharpoons 3Zn(OH)_4^{2-}(aq) + Br^-(aq)$
   (a) For each reaction, write the half-cell reactions taking place at
      (i) the anode.
      (ii) the cathode. (2½ marks)
   (b) (i) For each reaction, write the cell notation of the cell made by combining the electrodes of each half-cell. (2½ marks)
      (ii) State what each symbol used in (b) (i) stands for. (2marks)
14. (a) Draw the structure and name the shape of the following oxy anions of nitrogen. (2 marks)

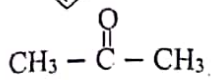
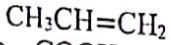
Oxy anion	Structure	Shape
$N\bar{O}_2$		
$N\bar{O}_3$		

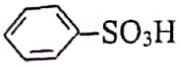
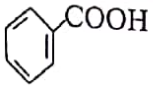
   (b) (i) Name the reagent(s) that can be used to distinguish the oxy anions in (a)
      (ii) State what would be observed, if a solution of each oxy anion is treated separately with the reagent(s) you have named in (b) (i). (4 marks)
      (iii) Write the equation(s) of any reaction(s) that would take place when a solution of each oxy anion is treated separately with the reagent(s) you have named in (b)(i). (2 marks)

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15. Write equations to show how the following compounds can be synthesized and in each case, indicate the conditions for the reaction.

(a)  from $C_6H_5COCH_3$. (3 marks)

(b)  from  (3 marks)

(c)  from  (3 marks)

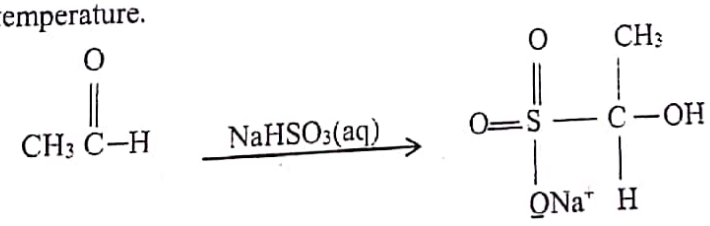
16. (a) A certain volume of a gaseous hydride of silicon of formula Si_nH_{2n+2}, diffused through a barrow hole in 17.08s. The same volume of carbon dioxide diffused through the hole under identical conditions in 20.0s.
(i) Calculate the relative molecular mass of the hydride. (2 marks)
(ii) Determine the molecular formula of the hydride. (1½ marks)
(b) (i) Explain why silicon hydride undergoes hydrolysis in the presence of sodium hydroxide solution whereas carbon hydride does not. (4 marks)
(ii) Write equation for the hydrolysis of a silicon hydride in sodium hydroxide solution. (1½ marks)

17. (a) (i) Write the equation for the ionization of phenol in water. (1 mark)
(ii) If the pH of a 1.0×10^{-2} mol dm^{-3} solution of phenol is 5.95, calculate the dissociation constant, Ka of phenol. (3½ marks)
(b) 10 litres of aqueous solution of trichloroethanoic acid was completely neutralized by $10cm^3$ of a 0.01M sodium hydroxide. Calculate the pH of the solution of trichloroethanoic acid. (2½ marks)
(c) The solution of trichloroethanoate. Calculate the pH of the resultant solution.
(Ka of trichloroethanoic acid is 0.224 mol dm^{-3} at 25°C.) (2 marks)

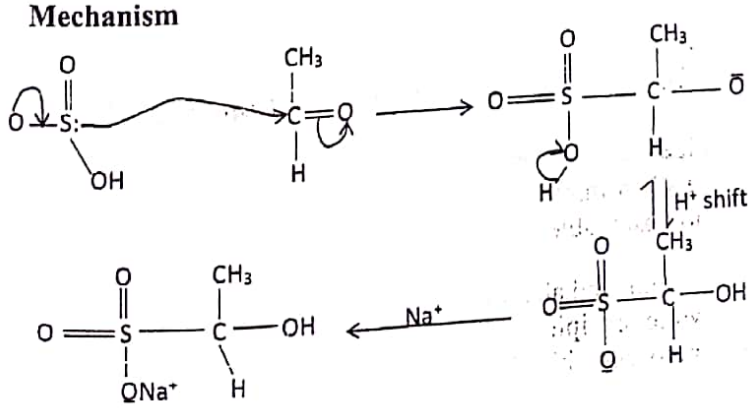
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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2012

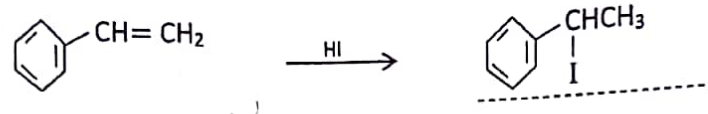
1. (a) (i) Critical point
(ii) Triple point
Note: Point A **is not** representing critical temperature and candidates should avoid writing tripple instead of triple
(b) The ice would **sublime** i.e would change from **solid to vapour**
(c) - Increase in pressure
- Increase in temperature.

2. (a) 

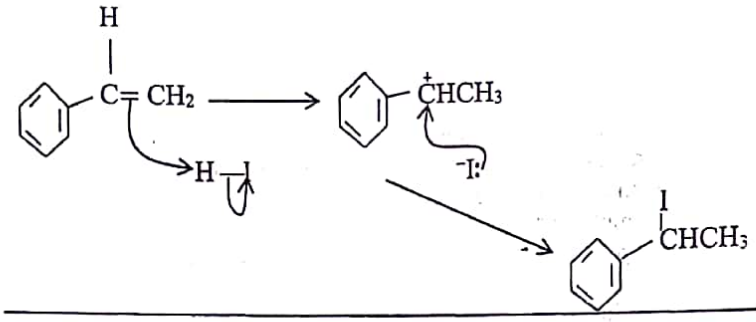
Mechanism



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(b) 

Mechanism;



3. (a) **White precipitate** and **effervescence** of a **colourless gas**

$2Al^{3+}(aq) + 3H_2O(l) + 3CO_3^{2-}(aq) \longrightarrow 2Al(OH)_3(s) + 3CO_2(g)$

or; $2Al(H_2O)_6^{3+}(aq) + 3CO_3^{2-}(aq) \longrightarrow 2Al(H_2O)_3(OH)_3(s) + 3CO_2(g) + 3H_2O(l)$

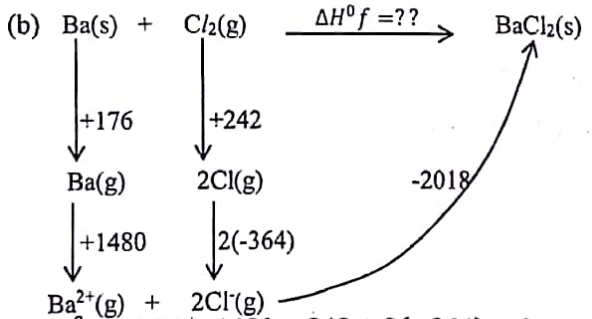
(b) **Violet vapour** or **purple vapour** or **black sublimate**

$2KI(s) + 3H_2SO_4(aq) \longrightarrow 2KHSO_4(aq) + I_2(g)$ or $(s) + SO_2(g) + 2H_2O(l)$

or; $8KI(s) + 9H_2SO_4(aq) \longrightarrow 8KHSO_4(aq) + 4\,I_2(g)$ or $(s) + H_2S(g) + 4H_2O(l)$

4. (a) A Atomisation energy of barium
B Ionisation energy of barium
C Bond dissociation energy of chlorine
D Electron affinity of chlorine
E Lattice energy of barium chloride

Note – The spelling for the enthalpy change must be correct.

(b) 

$\Delta H^{\theta} f = 176 + 1480 + 242 + 2(-364) + (-2018) = \mathbf{-848 KJmol^{-1}}$

Alternatively;

$\Delta H^{\theta} f(BaCl_2) = A + B + C + 2D + E$

$= 176 + 1480 + 242 + 2(-364) + (-2018) = \mathbf{-848 KJmol^{-1}}$

5. (a) **Class;** carbonyl compounds or (aldehydes and ketones)
Observations; Aldehydes form a silver mirror
Ketones give no observable change

(b) **Class;** Hydroxy compounds or (phenol and alcohols)
Observations; Phenol forms a white precipitate
Alcohols give no observable change

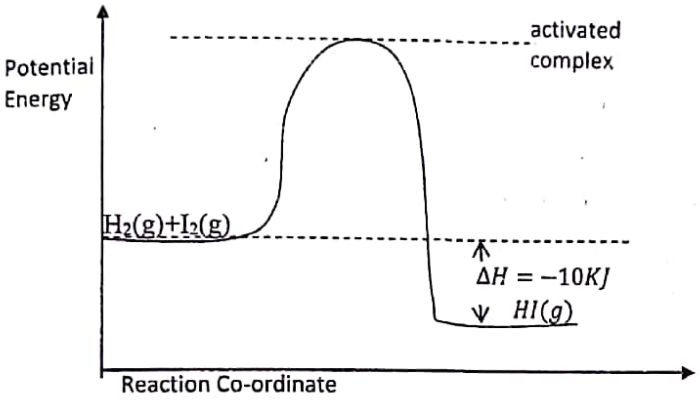
or;
Class; Amines or (phenyl amine and aliphatic amine)
Observations; phenyl amine forms a white precipitate
Aliphatic amine gives no observable change

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6. (a) - Lithium forms normal oxides when heated in oxygen
- Lithium forms a carbonate which decomposes on heating to form an oxide and carbon dioxide.
- Lithium forms a hydroxide which decomposes on heating to give an oxide, and water
- Lithium when heated reacts with nitrogen to form a nitride
- The hydrogen carbonate of lithium is known in solution
- The carbonates and phosphates of lithium are sparingly soluble in water.
- The halides of lithium (except lithium fluoride) are soluble in organic solvents.
- The nitrate of lithium decomposes on heating to give an oxide , nitrogrn dioxide and oxygen

(b) - Lithium has the smallest atomic radius compared to the other elements in the same group
- Lithium ion has the **highest charged density** or polarizing power compared to other ions formed by the elements in the same group.
- Lithium has the **lowest electro positivity** compared to other elements in group I

7. (a)



(b) Overal order of reaction $= 1 + 1 = 2$

(c) Molar concentration of $I_2 = \frac{1000\times0.2}{500} = 0.4M$

Molar concentration of $H_2 = \frac{1000\times0.1}{500} = 0.2M$

Hence; $K = \frac{Rate\ of\ reaction}{[H_2][I_2]}$

$= \frac{4.6\times10^{-5}}{0.2\times0.4} = \mathbf{5.75\times10^{-4}mol^{-1}dm^3s^{-1}}$

8.

Complex	Co-ordination number	Oxidation number
$[Pt(NH_3)]_4^{2+}$	4	+2
$[PbCl_4]^{2-}$	4	+2
$[Fe(CN)_6]^{3-}$	6	+3
$[CrCl(H_2O)_5]^{+}$	6	+2

9. (a) $CH_3CH_2CH_2CHO$ Butanal

$CH_3\overset{O}{\overset{\|}{C}}CH_2CH_3$ Butanone

$CH_3CH(CH_3)CHO$ 2-methylpropanal

(b) (i) $CH_3\overset{O}{\overset{\|}{C}}CH_2CH_3$ or butanone

(ii) $CH_3CH_2\overset{O}{\overset{\|}{C}}CH_3 \xrightarrow{H_2/Ni} CH_3CH_2\overset{OH}{\overset{|}{C}}HCH_3$

$CH_3CH_2\overset{OH}{\overset{|}{C}}HCH_3 \xrightarrow[heat]{Conc.H_2SO_4} CH_3CH=CHCH_3$

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Note; in step (i) ($LiAlH_4$ / dryether) or ($NaBH_4/H_2O$) or ($NaBH_4$/Alcohol) can be used instead of (H_2/Ni)

10. (a) (i) The solution should be **dilute**
Solute should be **non volatite**
Solute should **not react with the solvent**
On freezing, **only the solvent should solidify**

(ii) Association of solute molecules **reduces the number of solute particles in solution.** This results into **decrease in the value of the freezing point depression.** Since freezing point depression is **inversely proportional to the relative molecular mass of the solute, the relative molecular mass** of the solute determined will be **higher** than the theoretical value (expected value)

(b) 20.25g of benzene dissolved 0.142g of naphthalene .

$\therefore$ 1000g of benzene dissolved $\frac{1000\times0.142}{20.25} = 7.0123g$ **of naphthalene**

0.284°C is depression caused by 7.0123g of naphthalene

$\therefore$ 5.12°C is depression caused by $\left(\frac{5.12\times7.0123}{0.284}\right) g$ of naphthalene

Molar mass of naphthalene = 126.42g

11. (a) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$ **or** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$

(ii) Chromium forms coloured compounds
Chromium forms complexes
Chromium is paramagnetic
Chromium forms interstitial alloys
Chromium has catalytic activity

(b) Blue litmus turned red or pink
Explanation;
When dissolved in water, chromium (III) chloride forms hydrated chromium(III) ions which undergo **hydrolysis** to form **hydrogen ions** or **hydroxonium ions** which make the solution **acidic.**

$Cr(H_2O)_6^{3+}(aq) + H_2O(l) \rightleftharpoons [Cr(H_2O)_5OH]^{2+}(aq) + H_2O^+(aq)$

or $Cr(H_2O)_6^{3+}(aq) + 3H_2O(l) \rightleftharpoons Cr(H_2O)_3(OH)_3(s) + 3H_2O^+(aq)$

or $Cr^{3+}(aq) + 3H_2O \rightleftharpoons Cr(OH)_3(s) + 3H^+(aq)$

(c) (i) **Green precipitate, insoluble** in excess ammonia

(ii) $Cr^{3+}(aq) + 3\bar{O}H(aq) \longrightarrow Cr(OH)_3(s)$

12. (a) mass of carbon in × $= \frac{12}{44} \times 5.28 = 1.44g$

mass of Nitrogen in × $= \frac{28}{22400} \times 224 = 0.28g$

mass of Hydrogen in × $= 1.86 - (1.44 + 0.28) = 0.14g$

composition of ×;	C	H	N
moles;	$\frac{1.44}{12}$	$\frac{0.14}{1}$	$\frac{0.28}{14}$
	0.12	0.14	0.02
Mole ratio	$\frac{0.12}{0.02}$	$\frac{0.14}{0.02}$	$\frac{0.02}{0.02}$
	6 :	7 :	1

Emperical formula of X is, C_6H_7N

(b) From; $Pv = \frac{m}{mr}RT$

$$mr = \frac{mRT}{Pv}$$

$$= \frac{0.2 \times 8.31 \times 457.1}{101325 \times 81 \times 10^{-6}} = 92.6g$$

Hence; $(C_6H_7N)_n = 92.6$

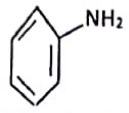
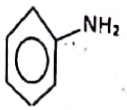
$(6 \times 12)n + (7 \times 1)n + (1 \times 14)n = 92.6$

$93n = 92.6$

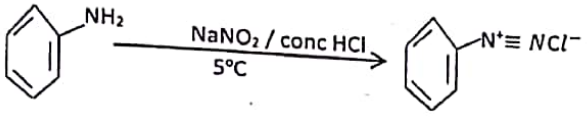
$n = \frac{92.6}{93} = 1$

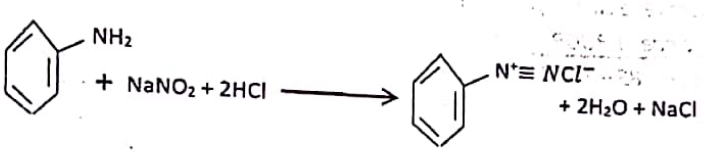
Thus; molecular formula of X is C_6H_7N

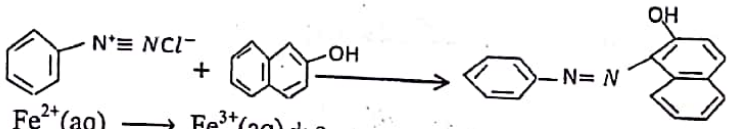
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(c)  alternatively 

(d) (i) Red precipitate

(ii) 

or 

Then; 

13. (a) (i) $Fe^{2+}(aq) \longrightarrow Fe^{3+}(aq) + e$

$Zn(s) + 4\bar{O}H(aq) \longrightarrow Zn(OH)_4^{2-}(aq) + 2e$

(ii) $2H^+(aq) + 2e \longrightarrow H_2(g)$

$BrO_3^-(aq) + 3H_2O(l) + 6e \longrightarrow Br^-(aq) + 6\bar{O}H(aq)$

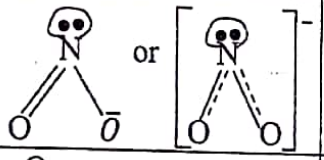
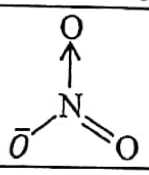
(b) (i) $Pt(s)/Fe^{2+}(aq),\ Fe^{3+}(aq)\ //\ H^+(aq), H_2(g)\ /\ Pt\ (s)$

$Zn(s)\ /\ \bar{O}H(aq),\ Zn(OH)_4^{2-}(aq)\ //\ BrO_3^-(aq), H_2O(l), Br^-(aq), \bar{O}H(aq)/Pt(s)$

(ii) / shows separation of phases // shows a salt bridge

, shows separation of species in the same phase *Pt*- Platinum electrode.

14. (a)

Oxyanion	Structure	Shape
$N\bar{O}_2$		V- Shape or bent shape
$N\bar{O}_3$		Trigonal planar

(b)(i) Acidified potassium manganate (VII) **solution**

(ii) NO_2^- would turn the **purple** solution of potassium manganate (VII) solution to **colourless.**

NO_3^- – gives no observable change

Alternatively;

Reagent; Acidified potassium dichromate (VI) solution

Observation; NO_2^- – **orange** solution turns **green.**

NO_3^- – no observable change.

Reagent; Freshly prepared iron (II) sulphate solution followed by concentrated sulphuric acid.

Observation; NO_2^- – gives no observable change

NO_3^- – Brown ring forms at the liquid junction

(iii) $2Mn\bar{O}_4(aq) + 5N\bar{O}_2(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5N\bar{O}_3(aq) + 4H_2O(l)$

Equation of reaction with acidified potassium dichromate(VI)

$Cr_2O_7^{2-}(aq) + 3N\bar{O}_2(aq) + 8H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3N\bar{O}_3(aq) + 4H_2O(l)$

Equation of reaction with iron (II) sulphate and concentrated sulphuric acid

$$\begin{bmatrix} 6Fe^{2+}(aq) + 8H^+(aq) + 2NO_3^- \rightarrow 6Fe^{3+}(aq) + 4H_2O(l) + 2NO(g) \\ Then;\ Fe(H_2O)_6^{2+}(aq) + NO(g) \rightarrow [Fe(H_2O)_5NO]^{2+}(aq) \end{bmatrix}$$

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15. (a) $C_6H_5COCH_3 \xrightarrow[\text{or } (LiAlH_4/\text{dry ether})]{H_2/Ni} C_6H_5CH(OH)CH_3$

$C_6H_5CH(OH)CH_3 \xrightarrow[\text{heat}]{\text{Conc.}H_2SO_4} C_6H_5CH{=}CH_2$

$C_6H_5CH{=}CH_2 \xrightarrow[\text{heat or (85 – 100°C)}]{\text{di(benzene carbonyl) peroxide or ROOR}} -[CH(C_6H_5)-CH_2]_n-$

(b) $CH_3CH{=}CH_2 \xrightarrow{HCl} CH_3CH(Cl)CH_3 \xrightarrow[\text{Heat}]{NaOH(aq)} CH_3CH(OH)CH_3$

$CH_3CH(OH)CH_3 \xrightarrow[\text{Heat}]{Cr_2O_7^{2-}/H^+} CH_3COCH_3$

(c) $C_6H_5COOH \xrightarrow[\text{Heat}]{\text{Soda lime}} C_6H_6 \xrightarrow[\text{reflux}]{\text{conc. } H_2SO_4} C_6H_5SO_3H$

Note in step (ii) of part (c), **heat** would be used instead of **reflux** and instead of conc. H_2SO_4, (fuming H_2SO_4 and a temperature of 35 - 50°C or room temperature would be used).

16. (a) (i) $\frac{tCO_2}{t\,hydride} = \sqrt{\frac{Rmm\ of\ CO_2}{Rmm\ of\ hydride}}$ (t = time)

$Rmm\ of\ CO_2 = (1 \times 12) + (2 \times 16) = 44$

$Rmm\ of hydride = 44 \times \left(\frac{17.08}{20}\right)^2 = 32.09$

Hence; molecular formula of the hydride is; SiH_4

(ii) $Si_nH_{2n+2} = 32.09$

$28n + 2n + 2 = 32.09$

$\therefore n = \frac{32.09 - 2}{30}$

$n = 1$

(b) (i)Electronic configuration of; Si; $1S^2\,2S^2\,2P^6\,3S^2\,3P^2$ and C; $1S^2\,2S^2\,2P^2$

Silicon in silicon hydride has **vacant 3d-orbitals** that can **accept lone pairs of electrons** from water. On the other hand, carbon in carbon hydride **lacks 2d- orbitals** and therefore cannot **accept lone pairs of electrons** from water and thus carbon hydride cannot undergo hydrolysis

(ii) $SiH_4(g) + H_2O(l) + 2\bar{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + 4H_2(g)$

Or; $SiH_4(g) + H_2O(l) + 2NaOH(aq) \longrightarrow Na_2SiO_3\,(aq) + 4H_2(g)$

17. (a) (i) $C_6H_5OH(aq) + H_2O(l) \rightleftharpoons C_6H_5\bar{O}(aq) + H_3O^+(aq)$

or, $C_6H_5OH(aq) \rightleftharpoons C_6H_5\bar{O}(aq) + H^+(aq)$

(ii) $Ka = \frac{[H_3O^+][C_6H_5\bar{O}]}{[C_6H_5OH]}$

But; $[H_3O^+] = [C_6H_5\bar{O}]$

Hence; $Ka = \frac{[H_3O^+]^2}{[C_6H_5OH]}$

From; $pH = -\log_{10}[H_3O^+]$

$[H_3O^+] = 10^{-5.95} = 1.12 \times 10^{-6} moldm^{-3}$

$Ka = \frac{(1.12 \times 10^{-6})^2}{1.0 \times 10^{-2}} = \mathbf{1.26 \times 10^{-10} moldm^{-3}}$

(b) Number of moles NaOH which reacted $= \frac{10}{1000} \times 0.01 moles = \mathbf{1.0 \times 10^{-4} moles}$

Equation of reaction between trichloro ethanoic acid and sodium hydroxide

$Cl_3CCOOH\,(aq) + NaOH(aq) \longrightarrow Cl_3CCOONa(aq) + H_2O(l)$

1mole of NaOH reacts with 1mole of Cl_3CCOOH

$\therefore 1.0 \times 10^{-4}$ mole of NaOH reacts with $1 \times (1.0 \times 10^{-4}) = \mathbf{1.0 \times 10^{-4}}$ **mole of Cl_3CCOOH**

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10litres of acid contain 1.0×10^{-4}mole of Cl_3CCOOH

$\therefore$ 1litre of acid contain $\frac{1.0\times10^{-4}}{10}$ mole of Cl_3CCOOH

$=1 \times 10^{-5} moldm^{-3}$

Hence molar concentration of $Cl_3CCOOH = 1 \times 10^{-5} moldm^{-3}$

Equation of ionization of Cl_3CCOOH is

$Cl_3CCOOH(aq) \quad Cl_3CCO\bar{O}(aq) + H^+(aq)$

$1 \times 10^{-5} moldm^{-3} \quad 1 \times 10^{-5} moldm^{-3}$

$[H^+] = 1 \times 10^{-5} moldm^{-3}$

$pH = -\log_{10}(1 \times 10^{-5}) = \mathbf{5.0}$

(c) $[H^+] = \frac{Ka[Cl_3CCOOH]}{[Cl_3CCOOH]}$

$= \frac{0.224\times10^{-5}}{0.1}$

$[H^+] = 2.24 \times 10^{-5} moldm^{-3}$

$pH = -\log_{10}[H^+]$

$= -\log_{10}(2.24 \times 10^{-5}) = \mathbf{4.65}$

Alternatively;

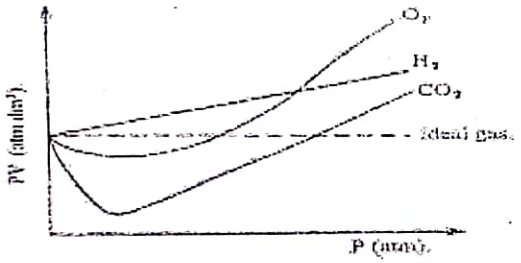
$pH = PKa + \log_{10}\frac{[salt]}{[acid]}$

$pH = -\log_{10} 0.224 + \log_{10}\left(\frac{0.1}{1\times10^{-5}}\right)$

$pH = 4.65$

QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2012

1. (a) State what is meant by the term an ideal gas. (01 mark)
   (b) Explain how liquefication of a gas can be affected by:
   (i) Pressure (2½ marks) (ii) Temperature (2½ marks)
   (c) The curves below show deviations of some gases from ideal behavior.



   (i) State why hydrogen shows a small deviation from ideal behavior compared to other gases. (1½ marks)
   (ii) Compare the deviations of oxygen and carbon dioxide from ideal behavior. (2½ marks)

(d) A gas Q contains 30.43% nitrogen and the rest being oxygen. 0.23g Q occupied 154.11cm^3 at 150°C and 840mm Hg.
Determine the;
(i) empirical formula of Q. (02 marks) (ii) molecular formula of Q. (3½ marks)
[1 mole of a gas occupies 24dm^3 at a temperature of 25°C and pressure of 760 mmHg]

(e) When a mixture of Q and oxygen was bubbled through water, a compound Y was formed.
(i) Identify Y. (½ mark)
(ii) Write equation for the reaction leading to the formation of Y. (1½ marks)
(iii) Briefly describe a test(s) that can be carried out to identify Y. (2½ marks)

2. (a) Chromium and iron are transition elements. State three properties of transition elements. (1½ marks)
   (b) The atomic numbers of chromium and iron are 24 and 26 respectively.
   (i) Write the electronic configuration of chromium and iron atoms. (2 marks)
   (ii) State why iron (III) compounds are more stable than iron (II) compounds. (1 mark)
   (c) Using equations to illustrate your answer, describe how chromium reacts with:
   (i) Water. (2½ marks) (ii) Dilute hydrochloric acid. (2 marks)
   (d) State what would be observed and write equations for the reactions that would take place when sodium hydroxide solution is added drop wise until in excess to an aqueous solution of:
   (i) Chromium (III) sulphate. (4 marks) (ii) Iron (II) sulphate (4 marks)

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(e) Write equation to show how iron (II) chloride can be converted to iron (III) chloride. Write equation for the reaction that took place. (1 mark)

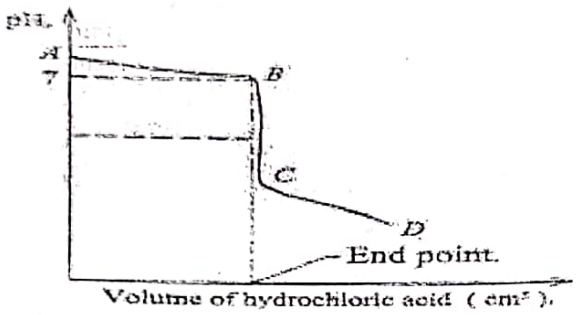
(f) A solution of sodium hydrogen carbonate can be converted to iron (III) chloride. Write equation that took place. (2 marks)

3. (a) Explain why the pH of a solution containing ammonia and ammonium chloride would remain almost constant when mixed with a small quantity of:

(i) Sodium hydroxide solution (3 marks)

(ii) Dilute hydrochloric acid (4 marks)

(b) The graph below shows the variation in pH of ammonia solution when it was titrated with dilute hydrochloric acid.



Explain the shape of the graph (6½ marks)

(c) 1.07g of ammonium chloride was dissolved in 1 dm^3 of 0.01M ammonia solution. Calculate the pH of the solution and state any two assumptions made in the calculation.

[K_b for ammonia is = $1.78\times 10^{-5} moldm^{-3}$ and $K_w = 1\times 10^{-14} mol^2 dm^{-6}$] (6½ marks)

4. (a) Explain why benzene undergoes electrophilic substitution reaction whereas cyclohexene undergoes electrophilic addition reaction. In each cases write equation to illustrate your answer. (4 marks)

(b) Write equation:

(i) to show how methylbenzene can be converted to benzene. (2 marks)

(ii) for the reaction between methylbenzene and chlorine in the presence of sunlight and outline a mechanism for the reaction. (4 marks)

(c) Write the mechanism for the reaction between benzene and:

(i) a mixture of concentrated nitric acid and sulphuric acid (3½ marks)

(ii) propene in the presence of phosphoric acid (3½ marks)

(iii) Ethanoly chloride in the presence of iron (III) chloride. (3 marks)

5. (a) State what is meant by the following terms, **Order of a reaction**' and '**Half-life**' of a reaction. (2 marks)

(b) A compound B decomposes according to the following equation.

$2B \longrightarrow$ products

The table below shows the concentration of B at various times.

Time (minutes)	2.0	4.0	7.0	10.0	14.0	20.0
Concentration of B ($mol l^{-1}$) [B]	0.820	0.670	0.490	0.372	0.240	0.141

Draw a graph of $\log_{10}[B]$ against time. (5 marks)

(c) Using the graph, determine the:

(i) Original concentration of B. (1 mark)

(ii) Order of the reaction. (2 marks)

(iii) Rate constant for the reaction (2 marks)

(iv) Half-life for the reaction. (1½ marks)

(d) (i) Using the same axes, draw a labelled diagram for energy-reaction coordinate for a catalyzed and an un catalyzed reaction. (3½ marks)

(ii) State the difference in your diagrams (1 mark)

(iii) State how a catalyst increases the rate of a reaction. (2 marks)

6. (a) Describe how pure aluminium can be extracted from bauxite. Your answer should include equations for the reactions that take place. (Diagram **not** required) (10 marks)

(b) (i) Briefly describe how hydrated aluminium chloride, $AlCl_3 \cdot 6H_2O$ can be prepared from aluminium. (3 marks)

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(ii) State what would be observed when hydrated aluminium chloride is strongly heated and write equation for the reaction that takes place.

(iii) Explain what would be observed when sodium carbonate solution is added to a concentrated solution of aluminium chloride. (2½ marks)

7. Write equations to show the following conversions can be carried out. In each case, indicate the reagents and conditions for the reactions. (4½ marks)

(a) Benzene to $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-C_6H_4-SO_3^-Na^+$ (4 marks)

(b) Propan-2-ol to $(CH_3)_2C=NNHCONH_2$ (3 marks)

(c) Nitrobenzene to $C_6H_5-N=N-C_6H_4-OH$. (5½ marks)

(d) 2-Chloropropane to $CH_3CH_2CH_2NH_3$ (4½ marks)

(e) Ethane to $CH_3COOCH_2CH_3$ (3 marks)

8. Explain the following observations.
(*Illustrate your answer with equations where applicable.*)

(a) Phosphorus burns spontaneously in air at room temperature whereas nitrogen is inert at the same temperature yet both elements are in the same group in Periodic Table. (5 marks)

(b) The boiling points of tertiary amines are lower than those of primary amines of same molecular mass. (5 marks)

(c) When concentrated hydrochloric acid is added to lead (II) ethanoate solution, a white precipitate is formed which dissolves in excess acid. (5 marks)

(d) The dissociation constant, K_a of methanoic acid is higher than that of ethanoic acid (4 marks)

(e) Beryllium chloride readily dissolves in methylbenzene whereas barium chloride does not. (3 marks)

END

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2012

Question. One.

(a) An ideal gas is a gas with **no intermolecular forces of attraction**. The molecules of the gas occupy a **negligible volume** and the gas **obeys gas laws.**

(b) (i) When the pressure is **high**, the gas molecules get **close together**, thereby **increasing the strength of the intermolecular forces of** attraction hence **leading to liquefaction** However, at low pressure, the gas molecules are **far apart** which **reduces the strength of the intermoleular forces** (vander waal's forces) making **liquefaction difficult**

(ii) At a **lower temperature**, the gas molecules posses **low kinetic energy** hence get **closer to each other**. This **increases the strength of the intermolecular forces** thus causing liquefaction.

(c) (i) Hydrogen gas shows a **small deviation** from the ideal behavior compared to other gases because hydrogen gas molecules have the **least relative molecular mass** and **occupy the smallest volume.** This reduces the strength of the **vander waal's forces** making hydrogen to deviate least from ideal behavior.

(ii) Carbon dioxide **deviates more** than oxygen from ideal behavior because carbon dioxide has a **higher molecular mass** than oxygen. This **increases the strength of the vander waal's forces** hence making carbon dioxide deviate more from ideal behavior than oxygen.

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(d) (i) Percentage of oxygen in Q = 100-30.43 = 69.57%

	N		O
Composition of Q;			
Number of moles;	$\frac{30.43}{14}$		$\frac{69.57}{16}$
	2.174		4.348
Mole ratio;	$\frac{2.174}{2.174}$		$\frac{4.348}{2.174}$
	1	:	2

Empirical formula of Q is NO_2

(ii) Using; $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Volume of gas; $V_2 = \frac{P_1V_1T_2}{T_1P_2}$

$= \frac{840\times154.11\times(25+273)}{(150+273)+760}$

$= 120cm^3$

$120cm^3$ of Q weigh 0.23g

$\therefore 24000cm^3$ of Q weigh $\frac{24000\times0.23}{120}g$

Hence; molecular mass of Q = 46g.

Thus; $(NO_2)n = 46$

$14n + (2 \times 16)n = 46$

$n = \frac{46}{46} = 1$

Therefore: molecular formula of Q is NO_2

(e) (i) Nitric acid or HNO_3

(ii) $4NO_2(g) + O_2(g) + 2H_2O(l) \longrightarrow 4HNO_3(aq)$

(iv) To the solution of Y in a test tube, is added a **blue litmus paper,** and the solution turns it red, indicating that the solution is acidic. Then to same solution is added **freshly prepared iron (II) sulphate solution** followed by **concentrated sulphuric acid.** A **brown ring** forms confirming presence of Y.

or; To Y, is added copper or magnesium metal, **bubbles** of a **brown gas** are evolved.

Question. Two.

(a) Transition elements form coloured compounds
Transition elements have variable oxidation states
Transition elements form many complexes
Transition elements are paramagnetic
Transition elements and their compounds can be used as catalysts
Transition elements form interstitial compounds

(b) (i) Cr; $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$ or $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$
Fe; $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$, or $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$

(ii) Electronic configuration of; Fe^{2+}; $-1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6$
Fe^{3+}; $-1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$

The Iron (III) ions in Iron (III) compounds have five electrons in their 3d-orbitals and thus are **half filled** and therefore **energetically stable** while Iron (II) ions in Iron (II) compounds have **six electrons** in the their outer 3d-orbitals and therefore are **neither filled nor half filled** and so Iron (II) ion compounds are **unstable**

(c) (i) **Heated** chromium reacts with **steam** to form **chromium (III) oxide** and **hydrogen gas**

$2Cr(s) + 3H_2O(g) \longrightarrow Cr_2O_3(s) + 3H_2(g)$

(iii) Chromium reacts with dilute hydrochloric acid to form **chromium (II) chloride solution** and **hydrogen gas.**

$Cr(s) + 2HCl(aq) \longrightarrow CrCl_2(aq) + H_2(g)$

or; $Cr(s) + 2H^+(aq) \longrightarrow Cr^{2+}(aq) + H_2(g)$

(d) (i) A **grey-green precipitate, soluble** in excess sodium hydroxide solution forming a **green solution.**

$Cr_2(SO_4)_3(aq)\ 6NaOH(aq) \longrightarrow 2Cr(OH)_3(s) + 3Na_2SO_4(aq)$

$Cr^{3+}(aq) + 3\bar{O}H(aq) \longrightarrow Cr(OH)_3(s)$

Then; $Cr(OH)_3(s) + \bar{O}H(aq) \longrightarrow Cr(OH)_4^-(aq)$

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Or; $Cr(OH)_3(s) + 3\bar{O}H(aq) \longrightarrow Cr(OH)_6^{3-}(aq)$

Or; $Cr(OH)_3(s) + \bar{O}H(aq) \longrightarrow CrO_2^-(aq) + 2H_2O(l)$

(ii) **Green precipitate, insoluble** in excess sodium hydroxide solution.

$Fe^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Fe(OH)_2(s)$

(e) $2FeCl_2(aq) + Cl_2(g) \longrightarrow 2FeCl_3(aq)$

Or; $2Fe^{2+}(aq) + Cl_2(g) \longrightarrow 2Fe^{3+}(aq) + 2Cl^-(aq)$

Or; $2Fe^{2+}(aq) + H_2O_2(aq) + 2H^+(aq) \longrightarrow 2Fe^{3+}(aq) + 2H_2O(l)$

Or; $MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \longrightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$

Or; $Cr_2O_7^{2-}(aq) + 6Fe^{2+}(aq) + 14H^+(aq) \longrightarrow 2Cr^{3+}(aq) + 6Fe^{3+}(aq) + 7H_2O(l)$

Or; $3Fe^{2+}(aq) + NO_3^-(aq) + 4H^+(aq) \longrightarrow 3Fe^{3+}(aq) + 2H_2O(l) + NO(g)$

(f) $FeCl_3(aq) + 3NaHCO_3(aq) \longrightarrow 3NaCl(aq) + Fe(OH)_3(s) + 3CO_2(g)$

Or; $Fe^{3+}(aq) + 3HC\bar{O}_3(aq) \longrightarrow Fe(OH)_3(s) + 3CO_2(g)$

Question. Three.

(a) (i) The ammonium chloride salt present in the solution is a **strong electrolyte** which **completely dissociates** in solution to produce a **high concentration of ammonium ions** which **react with the hydroxide ions** in solution of the sodium hydroxide with which the solution is mixed to form **ammonia molecules** and **water** (or unionized ammonium hydroxide) thus **maintaining the pH.**

$\dot{N}H_4(aq) + \bar{O}H(aq) \longrightarrow NH_3(aq) + H_2O(l)$

Or; $\dot{N}H_4(aq) + \bar{O}H(aq) \longrightarrow NH_4OH(aq)$

(ii) The ammonia in solution is a **weak base** and its ionization is **suppressed** by the high concentration of ammonium ions from the salt and so these **ammonia molecules react with the hydrochloric acid** with which the solution is mixed to form **ammonium chloride**, hence **maintaining the pH**

$NH_3(aq) + HCl(aq) \longrightarrow NH_4Cl(aq)$

Or; The hydrogen ions from the hydrochloric acid react with hydroxide ions present in the solution to form water.;

$H^+(aq) + \bar{O}H(aq) \longrightarrow H_2O(l)$

Ammonia solution **ionizes** to restore the original concentration of hydroxide ions and hence the pH remains constant

(b) Initially, at point A, the pH is **slightly above seven** because ammonia is a **weak base.**
The **pH decreases gradually** along AB because some ammonia is **being neutralized** by the acid and also the ammonium chloride salt formed and the un neutralized ammonia form a basic **buffer** solution which resists pH change. Neutralisation is complete at point B.
The pH **decreases sharply** along BC with a very small amount of acid added because **all the ammonia has completely been neutralized**, and the hydrochloric acid added is a **strong acid**
The pH at end point it is **less than seven** because the ammonium chloride salt formed **undergoes hydrolysis** producing an **acidic solution**
The pH then **decreases gradually** along CD because of the excess **hydrochloric acid** added which is a **strong acid.**

(c) Molar mass of $NH_4Cl = (1 \times 14) + (4 \times 1) + (1 \times 35.5) = 53.5$

Concentration of $NH_4Cl = \frac{1.07}{53.5} = 0.02 molm^{-3}$

Equations of reactions that take place are;

$NH_4Cl(aq) \longrightarrow \dot{N}H_4(aq) + Cl^-(aq)$

$NH_3(aq) + H_2O(l) \rightleftharpoons \dot{N}H_4(aq) + \bar{O}H(aq)$

Hence; $Kb = \frac{[\dot{N}H_4][\bar{O}H]}{[NH_3]}$

Assumptions; $[\dot{N}H_4] = [NH_4Cl] = 0.02M$

$[NH_3] = 0.01M$

Hence; $[\bar{O}H] = \frac{Kb \times [NH_3]}{[\dot{N}H_4]}$

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$= \frac{1.78\times10^{-5}\times0.01}{0.02} \quad = 8.9\times10^{-6} moldm^{-3}$

But; $[H^+] = \frac{Kw}{[OH]} = \frac{1\times10^{-14}}{8.9\times10^{-6}} = 1.12\times10^{-9} moldm^{-3}$

$pH = -\log_{10}[H^+]$

$= -\log_{10} 1.12\times10^{-9} \quad = 8.95$

Alteranatively;

$[Salt] = \frac{1.07}{53.5}$ 0.02M

[base] = 0.01M

Using; $POH = -\log_{10} Kb + \log_{10}\frac{[Salt]}{[base]}$

$POH = -\log_{10} 1.78\times10^{-5} + \log_{10}\frac{0.02}{0.01}$

$= 5 - \log 1.78 + \log 2$

$= 5 - 0.2504 + 0.3010$

Hence; POH = 5.05

But; PKw = PH + POH

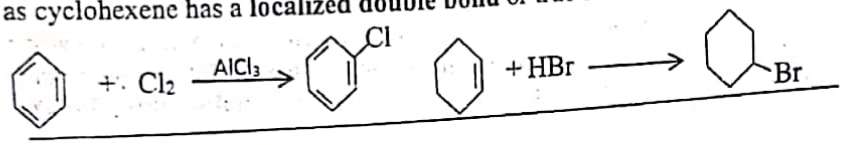
Thus; pH = pKw - POH

= 14 – 5.05

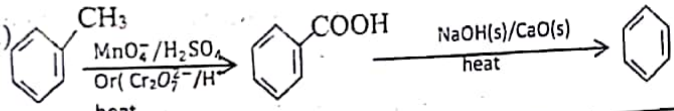
= 8.95

Question. Four.

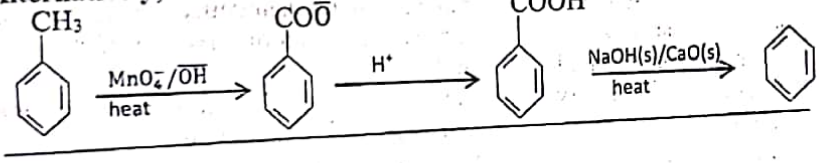
(a) Benzenc has **delocalized double bonds** which are **not true double bonds** between carbon atoms where as cyclohexene has a **localized double bond** or true double bond.



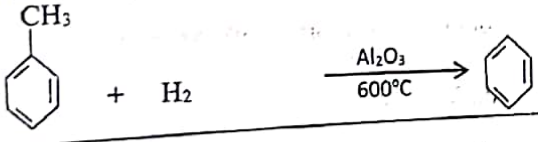
(b) (i)



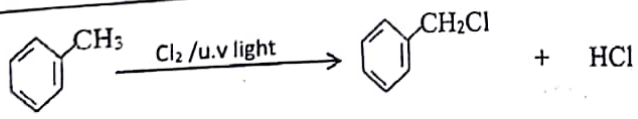
Alternatively;



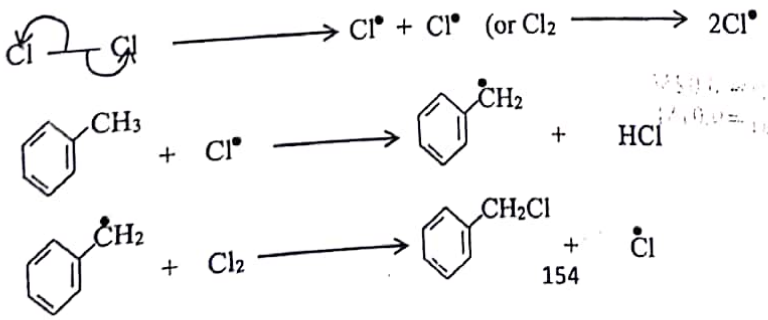
Alternatively;



(ii)



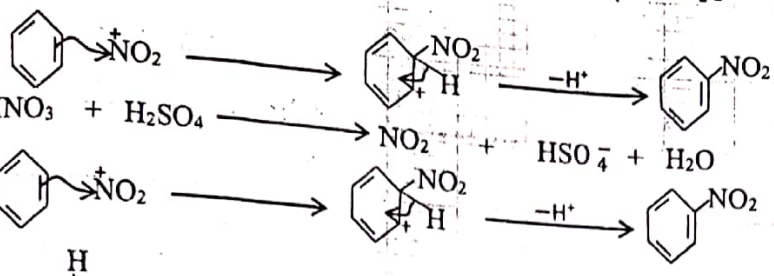
Mechanism;



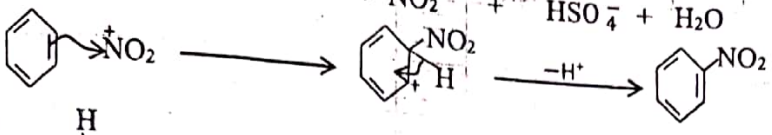
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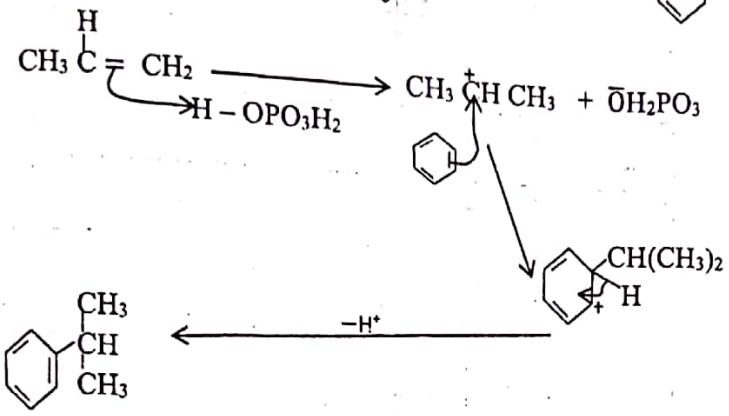
(c) (i) $HNO_3 + H_2SO_4 \longrightarrow NO_2^+ + HSO_4^- + H_2O$



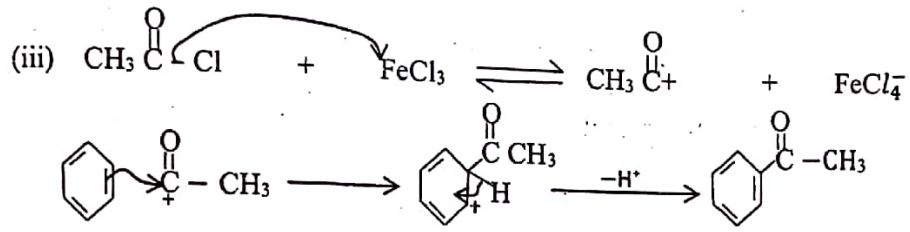
(d) (i) $HNO_3 + H_2SO_4 \longrightarrow NO_2^+ + HSO_4^- + H_2O$



(ii)



(iii)



Question. Five.

(a) Order of reaction is the **power** to which the **molar** concentration of a reactant is raised in the **experimentally** determined rate equation

Or; order of a reaction is the **sum** of the powers to which the **molar** concentrations of reactants are raised in the **experimentally** determined rate equation

Half life is the time taken for half of the original amount of a substance to react

(b)

Time(minutes)	2.0	4.0	7.0	10.0	14.0	20.0
Concentration of B($moll^{-1}$)	0.820	0.670	0.490	0.372	0.240	0.141
$\log_{10}[B]$	-0.086	-0.174	-0.310	-0.430	-0.620	-0.851

See graph next page

(c) (i) From the graph; when time = 0 minutes

$$\log_{10}[B] = 0$$

$$[B] = 10^{\circ} = 1$$

Therefore, the original concentration of B is **1.0M**

(ii) Order of reaction is one since the graph of $\log_{10}[B]$ against time is a **straight line with a negative gradient**

(iii) From the graph;

$$\text{Slope} = \frac{-0.75-(-0.22)}{(17.2-5)} = -0.0434 minute^{-1}$$

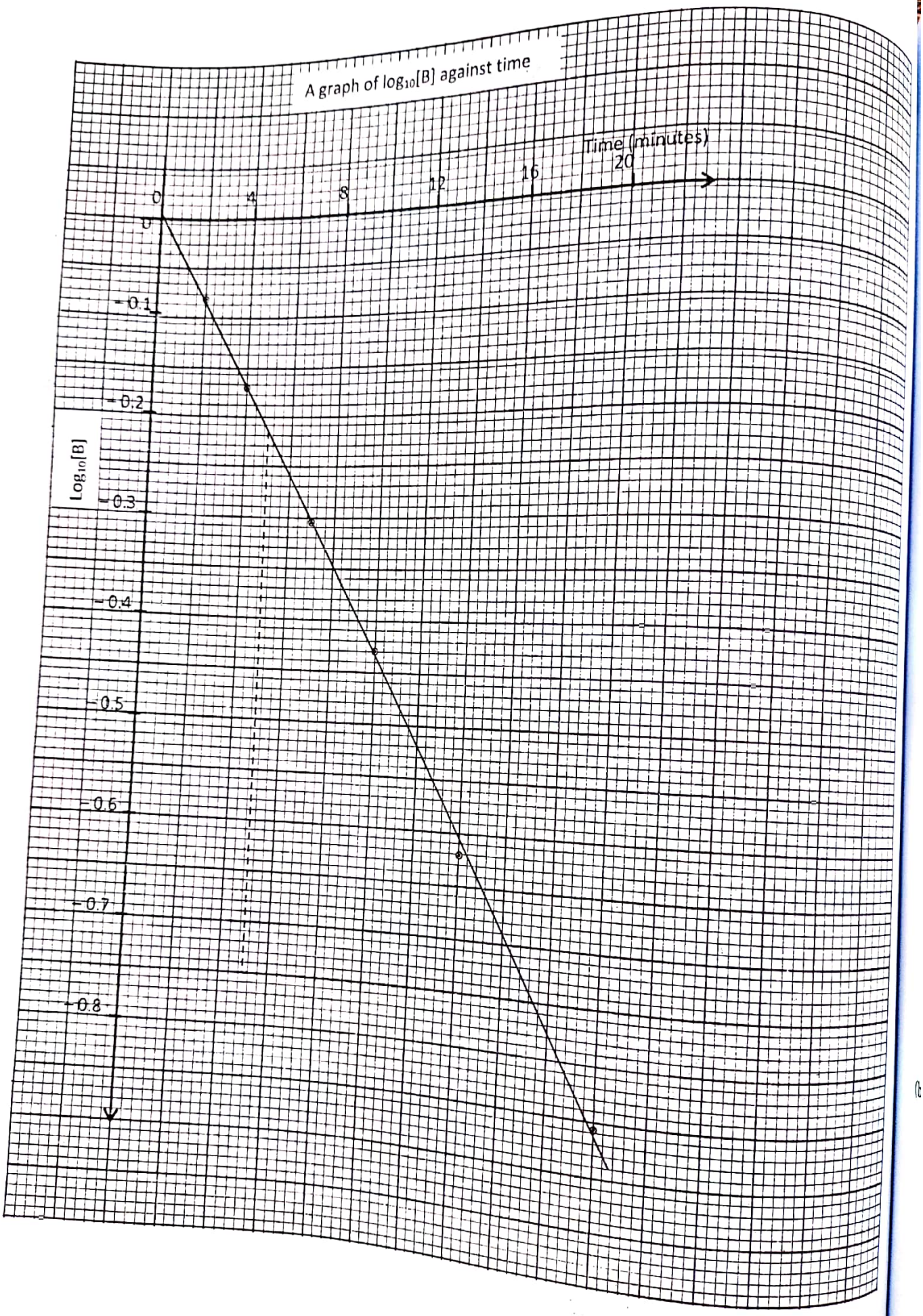
But slope for a first order reaction $= \frac{-K}{2.303}$

Therefore rate constant; $K = 2.303 \times 0.0434$

$$= 9.995 \times 10^{-2}\ minute^{-1}$$

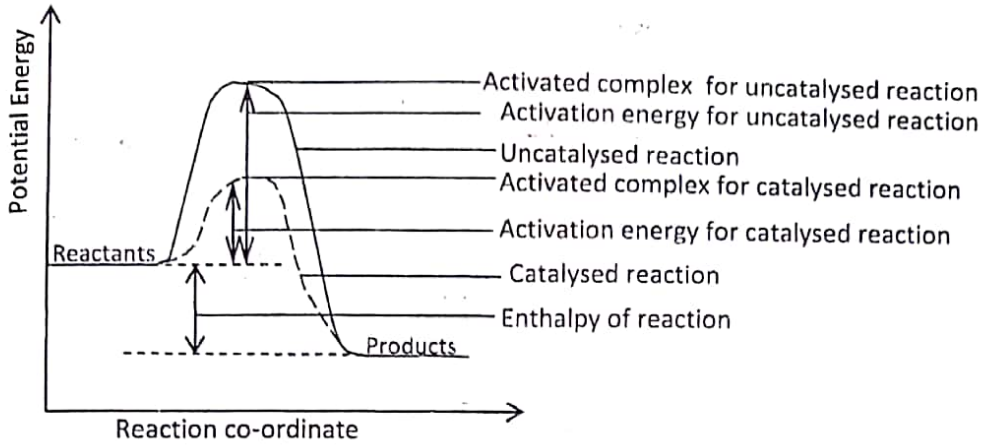
(iv) Half life; $t½ = \frac{In2}{K} = \frac{0.693}{9.995 \times 10^{-2}} = 6.9\ minutes$

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(d) (i)



(ii) The activation energy for the catalyzed reaction is lower than that of the uncatalyzed reaction

(iii) By reducing the activation energy of the reaction

Question. Six.

(a) The ore, Bauxite which contains impurities such as silicon (IV) oxide is first **crushed** into powder and then **heated** with **concentrated sodium hydroxide solution.**

The amphoteric aluminium oxide **dissolves** in sodium hydroxide solution forming **sodium aluminate**

$Al_2O_3(s) + 2\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_4^-(aq)$

or, $Al_2O_3(s) + 2\bar{O}H(aq) \longrightarrow 2AlO_4^-(aq) + H_2O(l)$

or, $Al_2O_3(s) + 6\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_6^{3-}(aq)$

The acidic **silicon(IV) oxide dissolves** in sodium hydroxide solution to form **sodium silicate**

$SiO_2(s) + 2NaOH(aq) \longrightarrow Na_2SiO_3(aq) + H_2O(l)$

or, $SiO_2(s) + 2\bar{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + H_2O(l)$

The basic Iron (III) oxide impurity cannot dissolve in sodium hydroxide and so is **removed** from solution **by filtration**

Aluminium hydroxide is added to the filtrate to **precipitate out the aluminium hydroxide** from the solution

$Al(OH)_4^-(aq) \longrightarrow Al(OH)_3(s) + \bar{O}H(aq)$

The aluminium hydroxide is **filtered off** and **heated** to form **aluminium oxide**

$2Al(OH)_3(s) \longrightarrow Al_2O_3(s) + 3H_2O(l)$

The aluminium oxide is heated with **molten cryolite** and then **electrolyzed** using **graphite** electrodes at 1000°C, at a very **low voltage** and **high current,** Aluminium is then produced at the cathode;

$Al^{3+}(l) + 3e \longrightarrow Al(l)$

Note; Aluminium hydroxide can be precipitated from the filtrate by adding carbon dioxide instead of aluminium hydroxide;

ie $2Al(OH)_4^-(aq) + CO_2(g) \longrightarrow 2Al(OH)_3(s) + CO_3^{2-}(aq) + H_2O(l)$

(b) (i) Aluminium is **reacted** with **excess hydrochloric acid** to form a **saturated solution of aluminium chloride.**

$2Al(s) + 6HCl(aq) \longrightarrow 2AlCl_3(aq) + 3H_2O(l)$

The aluminium chloride solution is **then evaporated** and allowed to cool to obtain crystals which are then **filtered** and **dried**

$AlCl_3(s) + 6H_2O(l) \longrightarrow AlCl_3 \cdot 6H_2O(s)$

(ii) The **white crystals** turn into a **white powder** and **misty fumes** are evolved

$2AlCl_3 \cdot 6H_2O(s) \longrightarrow Al_2O_3(s) + 6HCl(g) + 9H_2O(g)$

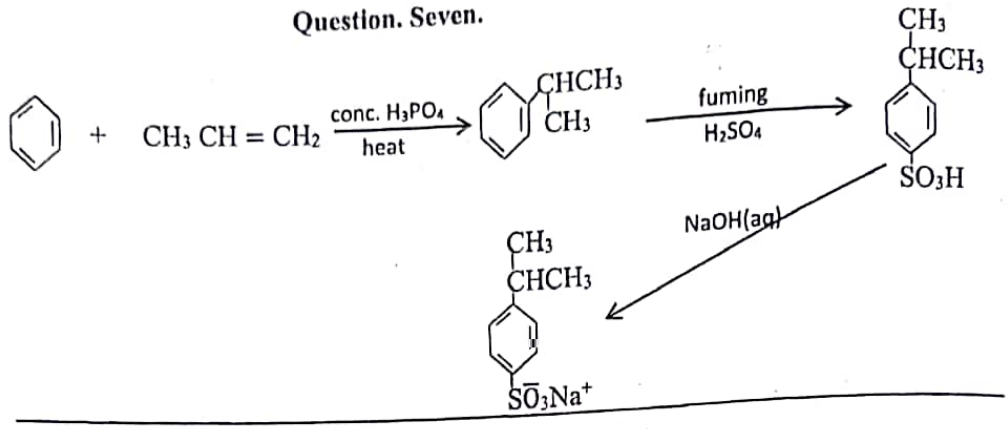
(iii) **White precipitate** and **effervescence** of a **colourless gas** are observed because aluminium cgloride undergoes **hydrolysis** to form **aluminium hydroxide** and **hydrogen ions** which make the solution acidic. This **acidic** solution then reacts with sodium carbonate to form **carbon dioxide**

$2AlCl_3(aq) + 3Na_2CO_3(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_3(s) + 3CO_2(g) + 6NaCl(aq)$

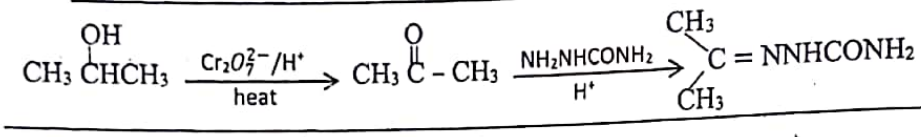
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Question. Seven.

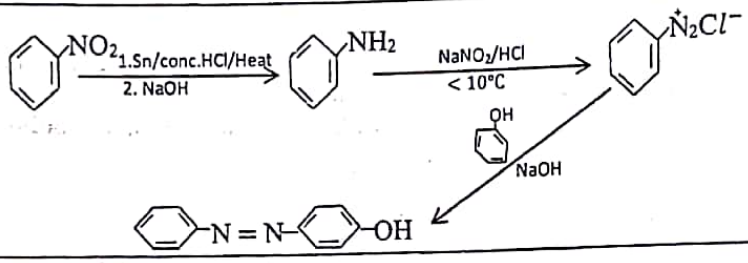
(a)



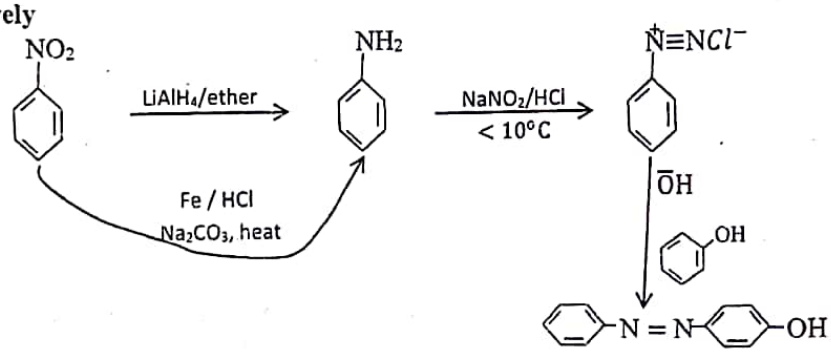
(b)



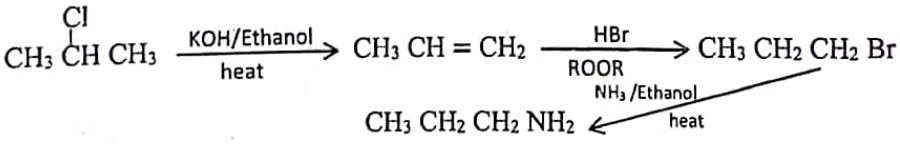
(c)



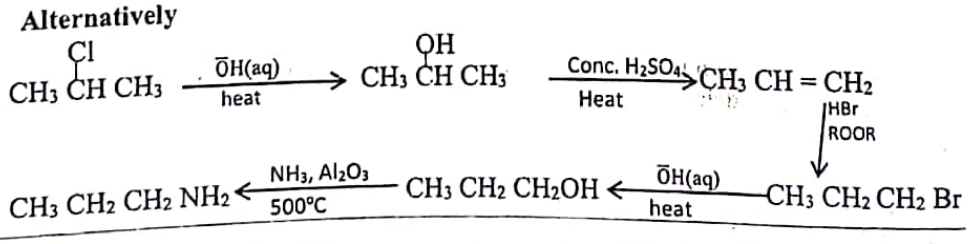
Alternatively



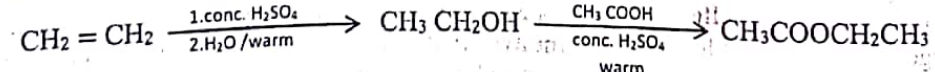
(d)



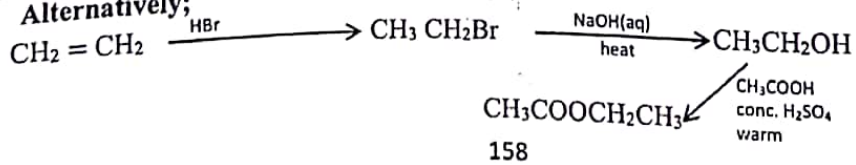
Alternatively



(e)



Alternatively;



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Question. Eight.

(a) Phosphorus exists as a **tetra atomic molecule** (P_4) in which the phosphorus atoms are held together by **single covalent bonds** which a **relatively weaker** and hence **can easily be broken** thus making phosphorus **reactive** and able to burn in air. However, nitrogen exists as a **diatomic molecule** in which the two nitrogen atoms are held together **by triple bonds** which are relatively **strong** and hence cannot easily be broken, thus making nitrogen inert. But; both phosphorus and nitrogen have **five electrons** in their out most energy levels hence belong to the same group (V) in the periodic table.

(b) Tertiary amines have **no hydrogen atoms** bonded to the **electronegative** nitrogen atom and thus **no polar nitrogen - hydrogen bonds** present and therefore tertiary amine molecules are **non polar** and held together by **weak vander waal's forces** which require **less heat energy** to be broken.
In primary amines, the **electronegative** nitrogen atom bonded to hydrogen atoms makes the **nitrogen-hydrogen bonds** to be polar and therefore molecules of primary amines associate through **strong intermolecular hydrogen bonds** which require **greater heat energy** to be broken.

(c) **Chloride ions** in concentrated hydrochloric acid **react with lead (II) ions** in lead (II) ethanoate to form **insoluble lead (II) chloride** which reacts with the excess chloride ions to form a **soluble complex** of **terachloro plumbate (II) ion**

$$Pb^{2+}(aq) + 2Cl^{-}(aq) \longrightarrow PbCl_2(s)$$

Or; $(CH_3COO)_2\,Pb(aq) + 2HCl(aq) \longrightarrow PbCl_2(s) + 2CH_3COOH(aq)$

$$PbCl_2(s) + 2Cl^{-}(aq) \longrightarrow PbCl_4^{2-}(aq)$$

(d) In methanoic acid, the **hydrogen atom** bonded to the carbonyl carbon has **no inductive effect** and so the oxygen-hydrogen bond is relative polar and hence **weak** and can **easily be broken** to cause ionization making methanoic acid to have a higher ka value.
In ethanoic acid, the **methyl group** bonded to the carbonyl carbon has a **positive inductive effect** and this makes the oxygen –hydrogen bond to be **less polar** and hence **more strengthened** and thus cannot easily be broken and therefore ethanoic acid **cannot easily** ionize in solution and thus has a lower ka value.

(e) Beryllium ion in bertllium chloride has a **smaller ionic radius**, and hence **higher charge density** than barium ion and therefore beryllium chloride is **more covalent** in character than ionic and so can dissolve in **non polar** solvents like methyl benzene unlike barium chloride which is **ionic**.

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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2011

1. Electrode potentials for some half–cell are given below.

Half–cell	E^{θ}(V)
$Fe^{2+}(aq)$, $Fe^{3+}(aq)$ /Pt	−0.771
$Cr^{3+}(aq)$, $Cr_2O_7^{2-}(aq)$, $H^+(aq)$ /Pt	−1.33

(a) Write the cell notation for the cell formed when the two half-cells are connected. (1 mark)

(b) Write:
(i) equations for the half reactions. (2 marks)
(ii) equation for the overall cell reaction. (1½ marks)

(c) (i) Calculate the e.m,f of the cell. (1 mark)
(ii) Sate whether the reaction is feasible or not. Give a reason for your answer. (1 mark)

2. Complete the following equations

(a) $CH_3CH_2CH{=}CH_2 \xrightarrow[H_2O]{\text{Conc. } H_2SO_4}$ (1 mark)

(b) $CH_3CH_2CH_2\,COOH + CH_3CH_2OH \xrightarrow[\text{heat}]{\text{Conc. } H_2SO_4}$ (1 mark)

(c) $CH_3CH_2CH\,CH_2CH_3 \xrightarrow[180°C]{\text{Excess conc. } H_2SO_4}$ (1 mark)

(d) $CH_3CH_2CH_2Br \xrightarrow[\text{Heat}]{NaOH(aq)}$ (1 mark)

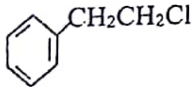
3. (a) Sate what would be observed and write equation for the reaction that would take place if potassium iodide was added to an aqueous solution of copper (II) sulphate.
Observations (2½ marks)
Equation
(b) A few drops of sodium thiosulphate solution was added to the mixture in (a), state what was observed and write equation for the reaction that took place
Observations (2½ marks)
Equation

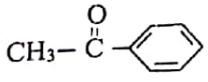
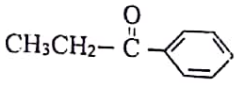
4. When 0.45g of a compound Q made up of carbon, oxygen and hydrogen atoms only was burnt, 0.44g of carbon and 0.09g of water was formed.
(a) (i) Calculate the empirical formula of Q. (2½ marks)
(ii) Determine the molecular formula of Q if its relative molecular mass is 90.
(b) Compound Q reacts with magnesium ribbon liberating hydrogen gas. Write the structural formula of Q. (½ mark)
(c) Acidified manganite (VII) solution was added to aqueous solution of Q
(i) State what was observed. (½ mark)
(ii) Write the equation of the reaction that took place (1½ marks)

5. (a) Write equation for the complete combustion of ethanol, CH_3CHO. (1½ marks)
(b) The enthalpies of combustion of carbon, hydrogen and ethanol are -394, -286 and -1187kJ mol^{-1} respectively. Calculate the enthalpy of formation of ethanal. (3½ marks)

6. (a) Calculate the oxidation state of chlorine in each of the following ions.
(i) ClO_2^- (1 mark)
(ii) ClO_4^- (1 mark)
(b) Write equations to show the reaction between chlorine and
(i) dilute sodium hydroxide solution (1½ marks)
(ii) concentrated sodium hydroxide solution (1½ marks)

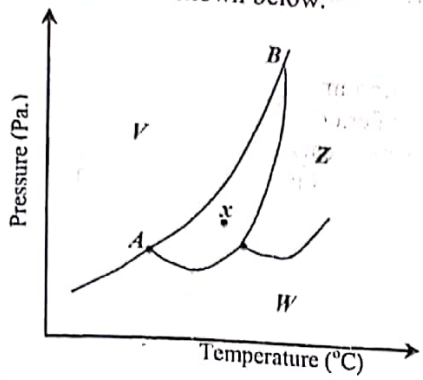
7. Name a reagent that can be used to distinguish between the following pairs of compounds. In each case, state what would be observed if each member of the pair was treated with the reagent you have named.

(a)  and  (3 marks)

(b)  and  (3 marks)

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8. The phase diagram of a substance ***E*** is shown below.



(a) Identify the phase at
(i) *W* (½ mark) (ii) *V* (½ mark) (iii) *Z* (½ mark)
(b) Name curve ***AB*** (½ mark)
(c) State what would happen to the phase of ***E*** at point when pressure is lowered at constant temperature. (1 mark)
(d) State how you would expect the melting point of ***E*** to vary with increase in pressure. (1 mark)

9. Write equation for the reaction between
(a) acidified potassium dichromate and sodium nitrite, (1½ marks)
(b) chromium (III) oxide and sodium hydroxide solution. (1½ marks)

10. (a) State what would be observed and in each case write for the reaction that would take place if a mixture of the following compound were heated.
(i) Benzoic acid and iron (III) chloride solution. (2½ marks)
(ii) Methanoic acid and ammoniacal silver nitrate (2½ marks)
(b) (i) Write equation and outline a mechanism for the reaction between 2-bromo-2-methylpropane and sodium ethoxide (3 marks)
(ii) Write the same given to the type of mechanism you have outlined in (b) (i) above. (1 mark)

11. (a) Silver ethanedioate is sparingly soluble in water. Write:
(i) equation for the solubility of silver ethanedioate in water (1½ marks)
(ii) the expression for the solubility product, Ksp of silver ethanedioate. (½ mark)
(b) The solubility product, Ksp, of silver ethanedioate is $5.3\times 10^{-2} mol^3$ *at* 25°C. Calculate the concentration of the following ions in a saturated solution of silver ethanedioate.
(i) Silver ions (2½ marks) (ii) Ethanedioate ions. (½ mark)
(c) Calculate the mass of silver nitrate that should be added to the saturated solution in (b) in order to reduce the concentration of the ethanedioate ions to a fifth of its original value. (2marks)
(d) Sodium ethanedioate solution was added to the solution in (b). State how the concentration of the silver ions was affected and give a reason for your answer. (2 marks)

12. The molecular formula of a complex of cobalt is $[Co(NH_3)_5(H_2O)]Cl_3$.
(a) (i) Write the name of the complex. (1 mark)
(ii) State the coordination number of cobalt in the complex (1 mark)
(b) Excess dilute ammonia solution was added to the complex.
(i) State what was observed (1 mark)
(ii) Write equation for the reaction that took place (1½ marks)
(c) To $10cm^3$ of a 0.5M solution of the complex, was added excess silver nitrate solution.
(i) State what was observed (1 mark)
(ii) Write equation for the reaction that took place (1½ marks)
(d) The mixture from (c) above was filtered and the residue dried. Calculate the mass of the dried residue. (2 marks)

13. Phosphorus (V) chloride decomposes at high temperature according to the following equation:
$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
When 40.2g of phosphorus (V) chloride was placed in 4.5 litre vessel and heated at a certain pressure, 4.2g of chlorine was formed at equilibrium.
(a) Calculate the:
(i) Amount of phosphorus (V) chloride and phosphorus(III) chloride at equilibrium in moles per litre. (3 marks)
(ii) Equilibrium constant Kc, for the reaction and state its units (2 marks)

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(b) State how the value of the equilibrium constant would be affected and in each case give a reason for your answer if (2½ marks)

(i) The pressure was increased, (1½ marks)

(ii) Some chlorine was removed at equilibrium.

14. (a) Some elements of the third short period in the Periodic Table are listed below. Write the formula and name the structure of the hydrides of each of the elements. (3 marks)

Element	Formula of hydride	Name of the structure of the hydride
Na		
Si		
S		

(b) State how each of the hydrides reacts with water and in each case. Write equation for the reaction for the reaction that took place if any.

(i) Sodium hydride (2½ marks)

(ii) Silicon hydride (1 mark)

(iii) Sulphur hydride (2½ marks)

15. Write equations to show the following conversions can be carried out in each case indicate the reagent and conditions for the reactions.

(a) CH_3CH_2CHO to $CH_3CHBrCH_2Br$ (3 marks)

(b) $CH_3CH{=}CH_2$ to $C_6H_5NH - N = C(CH_3)_2$ (3 marks)

(c) $CH_3CH_2CH_2Br$ to CH_3COCH_3 (3 marks)

16. (a) Name one source of vegetable oil. (½ mark)

(b) Describe briefly how soap can be prepared from one of the sources of vegetable oil you have named in (a) above. (3 marks)

(c) Write the general equation for the

(i) formation of soap, (1 mark)

(ii) reaction between hard water and soap. (1 mark)

(d) A sample of soap was prepared from 9.5g of a vegetable oil containing the ester of hexadecanoic acid ($C_{15}H_{31}COOH$). Calculate the mass of soap formed. (3½ marks)

17. The table below shows the atomic radii of elements of group (II) in the Periodic Table.

Element	*Be*	*Mg*	*Ca*	*Sr*	*Ba*
Atomic radius (nm)	0.112	0.160	0.197	0.215	0.221

(a) (i) State the atomic radii of the elements vary in the group. (1 mark)

(ii) Explain your answer in (a)(i) above. (3 marks)

(b) State three properties in which beryllium is different from the rest of the group (II) elements. (3 marks)

(c) Explain how atomic radius affects reactivity of group (II) elements with water. (2 marks)

END

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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2011

1. (a) $Pt(s) / Fe^{2+}(aq), Fe^{3+}(aq) // Cr_2O_7^{2-}(aq), Cr^{3+}(aq), H^+(aq) / Pt(s)$

Note – The physical states must be correctly indicated and Pt **must not miss**

(b) (i) Anode reaction: $Fe^{2+}(aq) \longrightarrow Fe^{3+}(aq) + e$

Cathode reaction: $Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e \longrightarrow 2Cr^{3+}(aq) + 7H_2O(l)$

(ii) $6Fe^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14H^+(aq) \longrightarrow 6Fe^{3+}(aq) + 2Cr^{3+}(aq) + 7H_2O(l)$

(c) (i) $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$

$= 1.33 - 0.771 = +0.559 volts$

(ii) Reaction is **feasible** because the e.m.f of the cell is **positive**

2. (a) $CH_3CH_2CH{=}CH_2 \xrightarrow[H_2O]{\text{Conc. } H_2SO_4} CH_3CH_2\underset{\displaystyle OH}{\overset{\displaystyle |}{C}}HCH_3$

(b) $CH_3CH_2CH_2COOH + CH_3CH_2OH \xrightarrow[\text{heat}]{\text{Conc. } H_2SO_4} CH_3CH_2CH_2COOCH_2CH_3 + H_2O$

(c) $CH_3CH_2\underset{\displaystyle OH}{\overset{\displaystyle |}{C}}HCH_2CH_3 \xrightarrow[180°C]{\text{Excess Conc. } H_2SO_4} CH_3CH_2CH{=}CHCH_3$

(d) $CH_3CH_2CH_2Br \xrightarrow[\text{heat}]{NaOH(aq)} CH_3CH_2CH_2OH$

NOTE; For questions of this type a mark is always awarded for the **major organic product.**

3. (a) **Observation; White solid** or **white precipitate** and a **brown solution**

Equation; $2Cu^{2+}(aq) + 4I^-(aq) \longrightarrow 2CuI(s) + I_2(aq)$

Or; $2Cu^{2+}(aq) + 4I^-(aq) \longrightarrow 2Cu_2I_2(s) + I_2(aq)$

(b) **Observations; Brown** solution turns **colourless** and a **white solid** remains

Equation ; $I_2(aq) + 2S_2O_3^{2-}(aq) \longrightarrow S_4O_3^{2-}(aq) + 2I^-(aq)$

4. (a) (i) mass of carbon in $Q = \frac{12}{44} \times 0.44 = 0.12g$

mass of hydrogen in $Q = \frac{2}{18} \times 0.09 = 0.01g$

mass of oxygen in $Q = 0.45 - (0.12 + 0.01) = 0.32g$

composition of Q;	C	H	O
moles;	$\frac{012}{12}$	$\frac{0.01}{1}$	$\frac{0.32}{16}$
	0.01	0.01	0.02
Mole ratio	$\frac{0.01}{0.01}$	$\frac{0.01}{0.01}$	$\frac{0.02}{0.01}$
	1 :	1 :	2

Emperical formula of Q is CHO_2

(ii) $(CHO_2)_n = 90$

$(1\times 12)n + (1\times 1)n + (2\times 16)n = 90$

$45n = 90$

$n = \frac{90}{45} = 2$

$\therefore$ Molecular formula of Q is $C_2H_2O_2$

(b) $\begin{matrix} COOH \\ | \\ COOH \end{matrix}$ or $HOOC - COOH$

(c) (i) **Purple** solution of potassium manganite(VII) turned **colourless** on **heating**

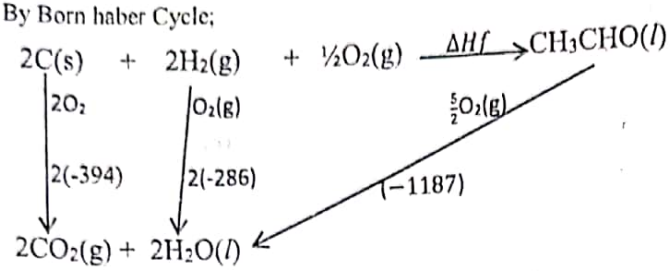
(ii) $MnO_4^-(aq) + 16H^+(aq) + 5C_2O_4^{2-}(aq) \longrightarrow 2Mn^{2+}(aq) + 10CO_2(aq) + 8H_2O(l)$

or $H_2C_2O_4(aq) + 6H^+(aq) + 2MnO_4^-(aq) \longrightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$

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5. (a) $CH_3CHO(l) + \frac{5}{2}O_2(g) \longrightarrow 2CO_2(g) + 2H_2O(l)$

(b) By Born haber Cycle;



From Hess's law; $\Delta Hf = 2(-394) + 2(-286) - (-1187)$

$\Delta Hf = -173Kjmol^{-}$

Alternatively;

1. $C(s) + O_2(g) \longrightarrow CO_2(g)$; $\Delta H_1 = {}^{-}394KJmol^{-1}$
2. $H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(g)$; $\Delta H_2 = {}^{-}286KJmol^{-1}$
3. $CH_3CHO(l) + \frac{5}{2}O_2(g) \longrightarrow 2CO_2(g) + 2H_2O(l)$; $\Delta H_2 = {}^{-}1187KJmol^{-1}$

$\Delta Hf = 2\Delta H_1 + 2\Delta H_2 - \Delta H_3$

$= 2(-394) + 2(-286) - (-1187)$

$= -173Kjmol^{-1}$

6. (a) (i) let the oxidation state of chlorine be x.

Hence; $x + 2(-2) = -1$

$x = {}^{+}3$

(ii) $x + 4(-2) = -1$

$x = {}^{+}7$

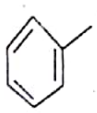
(b) (i) $Cl_2(g) + 2NaOH(aq) \longrightarrow NaOCl(aq) + NaCl(aq) + H_2O(l)$

(ii) $3Cl_2(g) + 6NaOH(aq) \longrightarrow NaClO_3(aq) + 5NaCl(aq) + 3H_2O(l)$

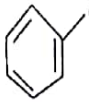
7. (a) **Reagent**; **Hot** sodium hydroxide **solution** followed by **silver nitrate solution**

Or; **Hot** sodium hydroxide **solution** followed by **dilute nitric acid** and then **silver nitrate solution.**

Observation



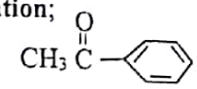
Forms a white precipitate,



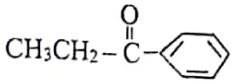
Gives no observable change

(b) **Reagent;** Sodium hydroxide solution and aqueous iodine solution

Observation;



gives a yellow precipitate



gives no observable change

8. (a) (i) vapour or gas

(ii) solid

(iii) liquid

(b) Transition curve

(c) E would sublime **or** E would change from solid to vapour

(d) Melting point of E would increase with increase in pressure.

9. (a) $Cr_2O_7^{2-}(aq) + 3N\bar{O}_2(aq) + 8H^+(aq) \longrightarrow 2Cr^{3+}(aq) + 3NO_3^-(aq) + 4H_2O(l)$

(b) $Cr_2O_3(s) + 6NaOH(aq) + 3H_2O(l) \longrightarrow 2Na_3Cr(OH)_6(aq)$

or, $Cr_2O_3(s) + 6\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Cr(OH)_6^{3-}(aq)$

or, $Cr_2O_3(s) + 2\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Cr(OH)_4^-(aq)$

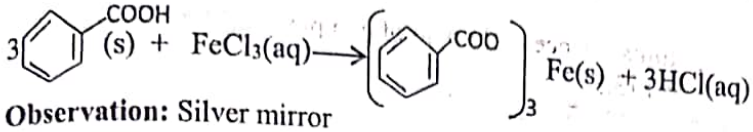
or, $Cr_2O_3(s) + 2\bar{O}H(aq) \longrightarrow 2CrO_2^-(aq) + H_2O(l)$

(c) $Ba^{2+}(aq) + CrO_4^{2-}(aq) \longrightarrow BaCrO_4(s)$

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10. (a) (i) **Observation** - reddish –brown solid

Equation



(ii) **Observation:** Silver mirror

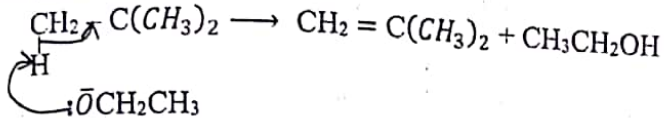
Equation; $2Ag^+(aq) + 2NH_3(aq) + HCOOH(aq) \longrightarrow 2Ag(s) + CO_2(g) + 2NH_4^+(aq)$

Or $HCO\bar{O}(aq) + 2Ag^+(aq) + 3\bar{O}H(aq) \longrightarrow 2Ag(s) + CO_3^{2-}(aq) + 2H_2O(l)$

(b) (i) $(CH_3)_3CBr + CH_3CH_2\bar{O}Na^+ \longrightarrow (CH_3)_2C = CH_2 + CH_3CH_2OH + NaBr$

Mechanism;

$(CH_3)_3CBr \rightleftharpoons (CH_3)_3C^+ + Br^-$



(ii) Elimination unimolecular.

11. (a) (i) $Ag_2C_2O_4(s) \rightleftharpoons 2Ag^+(aq) + C_2O_4^{2-}(aq)$

or $Ag_2C_2O_4(s) + (aq) \rightleftharpoons 2Ag^+(aq) + C_2O_4^{2-}(aq)$

(ii) $Ksp = [Ag^+]^2[C_2O_4^{2-}]$

(b) (i) let the $[C_2O_4^{2-}] = x moldm^{-3}$

Hence; $[Ag^+] = 2x$

$Ksp = (2x)^2 \times (x) = 4x^3$

$5.3 \times 10^{-2} = 4x^3$

$\therefore x = \sqrt[3]{\frac{5.3\times10^{-2}}{4}} = 0.2366M$

$[Ag^+] = 2 \times 0.2366 = 0.4732 moldm^{-3}$

(ii) $[C_2O_4^{2-}] = 0.2366$ moldm^{-3}

(c) New $[C_2O_4^{2-}] = \frac{1}{5} \times 0.2366 = 0.0473$ moldm^{-3}

$Ksp = [Ag^+]^2[C_2O_4^{2-}]$

$5.3 \times 10^{-2} = [Ag^+]^2 \times 0.0473$

$[Ag^+] = \sqrt[2]{\frac{5.3\times10^{-2}}{0.0473}} = \mathbf{1.058M}$

$[Ag^+]$ added $= 1.058 - 0.4732 = 0.5848M$

$RFM\ of\ AgNO_3 = 108 + 14 + (3 \times 16) = 170$

mass of $AgNO_3$ $added = 170 \times 0.5848 = \mathbf{99.416g}$

(d) The concentration of Silver ions decreased.

Reason;

Addition of sodium ethanedioate **increases** the **concentration of ethanedioate ions** which **reacted** with the silver ions to form solid silver ethanedioate.

$Cr_2O_4^{2-}(aq) + Ag^+(aq) \longrightarrow Ag_2C_2O_4(s)$

12. (a) (i) Pentaamminemonoaqua cobalt(III) chloride

Or, Pentaamminemonoaquo cobalt(III) chloride

(ii) 6

(b) (i) **Brown** solution turns **red**

(ii) $[Co(NH_3)_5H_2O]^{3+}(aq) + NH_3(aq) \longrightarrow Co(NH_3)_6^{3+}(aq) + H_2O(l)$

(c) (i) White precipitate

(ii) $[Co(NH_3)_5H_2O]Cl_3(aq) + 3AgNO_3(aq) \longrightarrow [Co(NH_3)_5H_2O](NO_3)_3(aq) + 3AgCl(s)$

Or, $Ag^+(ag) + Cl^-(aq) \longrightarrow AgCl(s)$

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(d) Moles of the complex in $10cm^3 = \frac{10}{1000} \times 0.5 = 0.005moles$

Moles of AgCl = $3 \times 0.005moles$ (since mole ratio of complex AgCl = 1:3)
RFM of AgCl= $108 + 35.5 = 143.5$
Mass of AgCl formed = $0.015 \times 143.5 = 2.1525g$

13. (a) (i) RFM of $PCl_5 = 31 + (5 \times 35.5) = 208.5$

Moles of $PCl_5 = \frac{40.2}{208.5} = 0.1928moles$

$RFM\ of\ Cl_2 = 2 \times 35.5 = 71$

$moles\ of\ Cl_2 = \frac{4.2}{71} = 0.0592moles$

Let; moles of PCl_5 which decomposed at equilibrium = x

	$PCl_5(aq)$	$\rightleftharpoons$	$PCl_3(aq)$ +	$Cl_2(g)$
Initially;	0.1928moles		O	O
Moles at Equilibrium;	(0.1928 – x)moles		x	x

Moles of PCl_3 = moles of Cl_2 at equilibrium = x = 0.0592 moles.

$[Cl_2] = [PCl_3]$ at equilibrium $= \frac{x}{4.5}$

$= \frac{0.0592}{4.5} = 0.013M$

$[PCl_5]at\ equilibrium = \frac{0.1928 - 0.0592}{4.5} = \mathbf{0.0297M}$

(ii) $Kc = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{(0.013)^2}{(0.0297)} = 5.69 \times 10^{-3} moldm^{-3}$

(b) (i) The value of the equilibrium constant **remains the same.**
Increasing pressure **shifts the equilibrium position from right to the left** since the back ward reaction proceeds with a **decrease in volume**. This implies that that chlorine and phosphorus (III) chloride react to give phosphorus (V) chloride. Thus, the concentration of chlorine and phosphorus (III) chloride **decreases** while that of phosphorus (V) chloride **increases**. The individual concentrations of reactants and products re-adjust to keep the value of the equilibrium constant **constant**

(ii) Equilibrium constant **remains constant.**
Removal of chlorine **reduces its concentration** at equilibrium. The **equilibrium position shifts from left to right** as the phosphorus (V) chloride **decomposes** to give **more** phosphorus (III) chloride and chlorine and hence equilibrium constant remains constant

14. (a)

Element	Formula of hydride	Name of the structure of hydride
Na	NaH	Giant ionic
Si	SiH_4	Simple molecular
S	H_2S	Simple molecular

(b) (i) Sodium hydride **reacts readily** with **effervescence** forming **sodium hydroxide solution** and **hydrogen**.

$NaH(s) + H_2O(l) \longrightarrow NaOH(aq) + H_2(g)$

(ii) Silicon hydride reacts with **water in presence of an alkali** forming a **silicate** and **hydrogen**.

$SiH_4(g) + H_2O(l) + 2\bar{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + 4H_2(g)$

Silicon hydride also reacts with **steam** to form **silicic acid** and **hydrogen**

$SiH_4(g) + 3H_2O(g) \longrightarrow H_2SiO_3(aq) + 4H_2(g)$

(iii) Sulphur hydride (hydrogen sulphide) reacts slowly or reversibly with water forming a weak acidic solution

$H_2S(g) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HS^-(aq)$

Or; $H_2S(g) + 2H_2O(l) \rightleftharpoons 2H_3O^+(aq) + S^{2-}(aq)$

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15. (a) $CH_3CH_2CHO \xrightarrow[\text{or } LiAlH_4,\ \text{dryether}]{H_2/Ni} CH_3CH_2CH_2OH$

$CH_3CH_2CH_2OH \xrightarrow[\text{heat}]{\text{Conc.}H_2SO_4} CH_3CH{=}CH_2$

$CH_3CH{=}CH_2 \xrightarrow{Br_2/CCl_4} CH_3CH(Br)CH_2Br$

(b) $CH_3CH{=}CH_2 \xrightarrow[2.\ H_2O/\text{warm}]{1.\ \text{conc.}H_2SO_4} CH_3CH(OH)CH_3 \xrightarrow[\text{heat}]{Cr_2O_7^{2-}/H^+} CH_3COCH_3$

$CH_3COCH_3 \xrightarrow[H^+]{C_6H_5NHNH_2} C_6H_5NH-N=C(CH_3)_2$

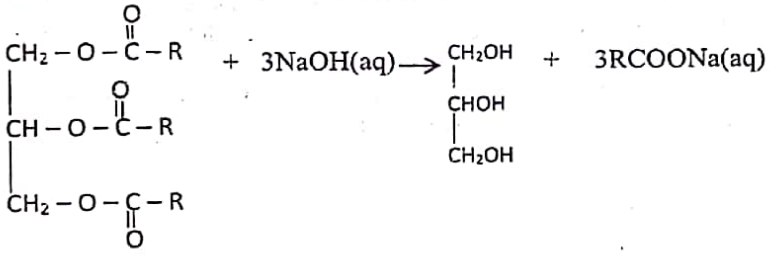
(c) $CH_3CH_2CH_2Br \xrightarrow[\text{heat}]{Et\bar{O}/EtOH} CH_3CH{=}CH_2$

$CH_3CH{=}CH_2 \xrightarrow[2.\ H_2O/\text{warm}]{1.\ \text{conc.}H_2SO_4} CH_3CH(OH)CH_3$

$CH_3CH(OH)CH_3 \xrightarrow[\text{heat}]{MnO_4^-/\text{conc.}H_2SO_4 \text{ or } Cr_2O_7^{2-}/H^+} CH_3COCH_3$

16. (a) Sun flower, simsim, groundnuts, soya beans, cashew nuts, cotton seeds, coconuts, palm oil seeds or castor oil seeds.

(b) The seeds are **roasted** or **dried** and **crushed** to make a paste with water until **oil floats** on top and then the oil is **decanted off.**
The oil is **mixed with excess sodium hydroxide solution** and **heated** with constant stirring for a long time. **Concentrated sodium chloride** solution is added to **precipitate the soap**

(c) (i)


(ii) $2RCO\bar{O}Na^+(aq) + Ca^{2+}(aq) \longrightarrow (RCOO)_2Ca(s) + 2Na^+(aq)$

(d) Rmm of ester, $CH_2OCOC_{15}H_{31}$ | $CHOCOC_{15}H_{31}$ | $CH_2OCOC_{15}H_{31}$ $= 3(12\times15+31+32)+(12\times3)+(5\times1) = 806$

Number of moles of ester $= \frac{9.5}{806} = 1.179\times10^{-2}$ moles

According to the equation in c (i)
1mole of the ester produces 3 moles of soap
$\therefore 1.179\times10^{-2}$ mole of the ester produces $(3\times1.179\times10^{-2})$ moles of soap
Rmm of soap formed; $C_{15}H_{35}CO\bar{O}Na = (12\times15)+35+12+32+23 = 282$
Mass of Soap formed $= 282\times(3\times1.179\times10^{-2})$ $= \mathbf{9.83g}$ **of soap.**

17. (a) (i) Atomic radius **increases down the group** from beryllium to barium
(ii) Down the group, from one element to the next, there is **increase in the number of protons** in the nucleus of an atom which **increases the nuclear charge.** At the same time **an extra full shell of electrons** is added which **increases the screening effect.**
However, the increase in screening effect **outweighs** the increase in the nuclear charge and therefore the **effective nuclear charge decreases** and hence the **attraction** for the outer most electrons by the nucleus **decreases** resulting into an increase in atomic radius.

(b) - Beryllium reacts with alkalis or beryllium is amphoteric
- Beryllium is rendered passive by concentrated nitric acid
- Beryllium forms many complexes
- Beryllium does not react with water or steam.

(c) As the atomic radius increases, the **reactivity of** group (II) elements with the water **increases.** This is because as **atomic radius increases,** the **ease** with which an element **releases its outer most energy level electrons increases.** (electropositivity increases)

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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2011

1. The atomic numbers and melting points of the oxides of elements of period III of the Periodic Table are shown in the table below

Element	Na	Mg	Al	Si	P	S	Cl
Atomic number	11	12	13	14	15	16	17
Oxide and melting point(°C)	Na_2O 1275	MgO 2827	Al_2O_3 2007	SiO_2 1607	P_2O_5 560	SO_2 30	Cl_2O_7 –91

(a) (i) Plot a graph of melting point of the oxides against the atomic numbers of the elements. (4 marks)
(ii) Explain the shape of the graph you have drawn in (a)(i) above. (6 ½ marks)

(b) Write equation to show the reaction between:
(i) water and P_2O_5 (1 ½ marks)
(ii) sodium hydroxide and
- Al_2O_3 (2 ½ marks)
- SiO_2 (2 ½ marks)
- SO_3 (1 ½ marks)

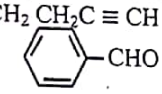
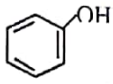
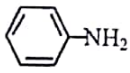
(iii) hydrochloric acid and Al_2O_3 (1 ½ marks)

2. (a) Define the term **partition coefficient** (1 mark)
(b) Describe how the partition coefficient for iodine between tetrachloromethane and water can be determined. (6 marks)
(c) $50cm^3$ of a solution containing 0.966g of iodine in tetrachloromethane was shaken with $50cm^3$ of water.
(i) Calculate the amount of iodine that remained in the tetrachloromethane layer. [$K_D = 85.25$]
(ii) Explain how your answer in (c)(i) would be affected if the iodine solution in the tetrachloromethane was shaken with aqueous potassium iodide instead of water. (3 ½ marks)

(d) Cobalt(II) ions form a complex, $Co(NH_3)_n$ with ammonia. The table below shows the result of result of partition of ammonia between 0.1M cobalt(II) sulphate solution and trichloromethane.

$[NH_3]_{(0.1M\ CoSO_4)}$	0.72	0.94	1.19	1.43	1.70	1.92
$[NH_3]_{CHCl_3}$	0.01	0.03	0.05	0.07	0.09	0.11

(i) Plot a graph of $[NH_3]_{(0.1M\ CoSO_4)}$ against $[NH_3]_{CHCl_3}$ (3 marks)
(ii) Determine the value of n in the complex, $Co(NH_3)_n$. (2 ½ marks)

3. Write equations to show how the following compounds can be synthesized
(a) $CH_3\ CH_2COOH$ from 1 – bromopropane (2 ½ marks)
(b) $CH_3\ CH_2\ CH_2C \equiv CH$ from ethane (5 ½ marks)
(c)  from benzene (2 marks)
(d)  (3 marks)
(e) from but – 2 – ene (2 ½ marks)
(f)  from benzoic acid (4½ marks)

4. (a) Describe an experiment that can be carried out to determine the enthalpy of solution of sodium chloride. (9 marks)
(b) In an experiment to determine the enthalpy of hydration of anhydrous copper(II) sulphate by indirect method, 4.0g of the anhydrous salt was added to 50.0g of water and the temperature of water rose by 8.0°C. When 4.0g of the hydrated salt was added to 50.0g of water, the temperature of water dropped by 0.9°C. [Specific heat capacity of solution = $4.2Jg^{-1}K^{-1}$; Cu = 64; S = 32; O = 16; H =1]
Calculate the enthalpy of solution of
(i) anhydrous copper(II) sulphate (3 marks)
(ii) hydrated copper(II) sulphate – 5 – water (3 marks)
(c) (i) State which of the two copper salts in (b) is more soluble in water and explain your answer. (3 marks)
(ii) Determine the enthalpy of hydration of anhydrous copper(II) sulphate. (2 marks)

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5. Explain what is meant by each of the following:
[Your answer should include acceptable mechanism for the reactions]
(a) Nucleophilic addition reaction (4 ½ marks)
(b) Nucleophilic substitution unimolecular reaction (5 marks)
(c) Electrophilic substitution reaction (5 marks)
(d) Electrophilic addition reaction (5½ marks)

6. (a) Describe an experiment that can be carried out to show that the catalytic decomposition of hydrogen peroxide is a first order reaction (9 marks)

(b) The rate of a certain reaction is
Rate = $k[A][B]^2[C]$
Where [ ] is concentration in moles per litre and k is the rate constant.
State how the rate of reaction would change if:
(i) [B] and [C] were kept constant and [A] was doubled. (1 marks)
(ii) [A] and [C] were kept constant and [B] was halved. (1 marks)
(iii) [A] and [C] were kept constant and [B] was doubled. (1 marks)
(iv) [A], [B] and [C] were doubled. (1 marks)

(c) The table shows the kinetic data that were obtained for the conversion of sucrose in acid solution.

Concentration of sucrose (mold m^{-3})	0.08	0.06	0.04	0.02	0.01
Rate of reaction (mold $m^{-3}s^{-1}$)	0.004	0.003	0.002	0.001	0.0005

(i) Plot a graph of rate of reaction against concentration of sucrose (3 marks)
(ii) State the order of reaction. Give a reason for your answer. (1½ marks)
(iii) Determine the rate constant for the reaction and indicate its units. (1½ marks)
(iv) Calculate the rate of reaction when the concentration of sucrose was 0.12 mold m^{-3}

7. Explain the following observations
(a) Phenolphthalein indicator can be used to determine the end-point in the titration of ethanoic acid with sodium hydroxide but methyl-orange is not used. (6 marks)
(b) Bromine in tetrachloromethane reacts with but-2-ene to form 2,3-dibromobutane as the major product whereas bromine in aqueous solution forms 3-bromobutane-2-ol as the major product. (7 ½ marks)
(c) When ammonium oxalate solution is added to a solution containing barium ions, a white precipitate is formed which dissolves on addition of dilute nitric acid. (1½ marks
(d) Carbon which is in the same group as lead in the Periodic Table shows one valency of four in its compounds but lead shows two valencies of two and four. (2 marks)

8. During the extraction of aluminium from bauxite, the ore is first heated, powdered and then the powdered material is heated with sodium hydroxide solution and finally filtered.
(a) State why the;
(i) ore is first heated before changing it to the powder (1 mark)
(ii) powdered ore is heated with sodium hydroxide solution and then filtered (2 marks)
(b) Write equations for the reaction between the powdered ore and sodium hydroxide solution (3 marks)
(c) Briefly describe how pure aluminium can be obtained from the product from the reaction in (b) (Your answer should include equations) (8 marks)
(d) Write equations for the reaction between aluminium an
(i) $Fe_2O_3(s)$
(ii) $Mn_3O_4(s)$ (4 ½ marks)
(iii) $Cr_2O_3(s)$
(e) Use equation to show how anhydrous aluminium chloride can be prepared. (1½ marks)

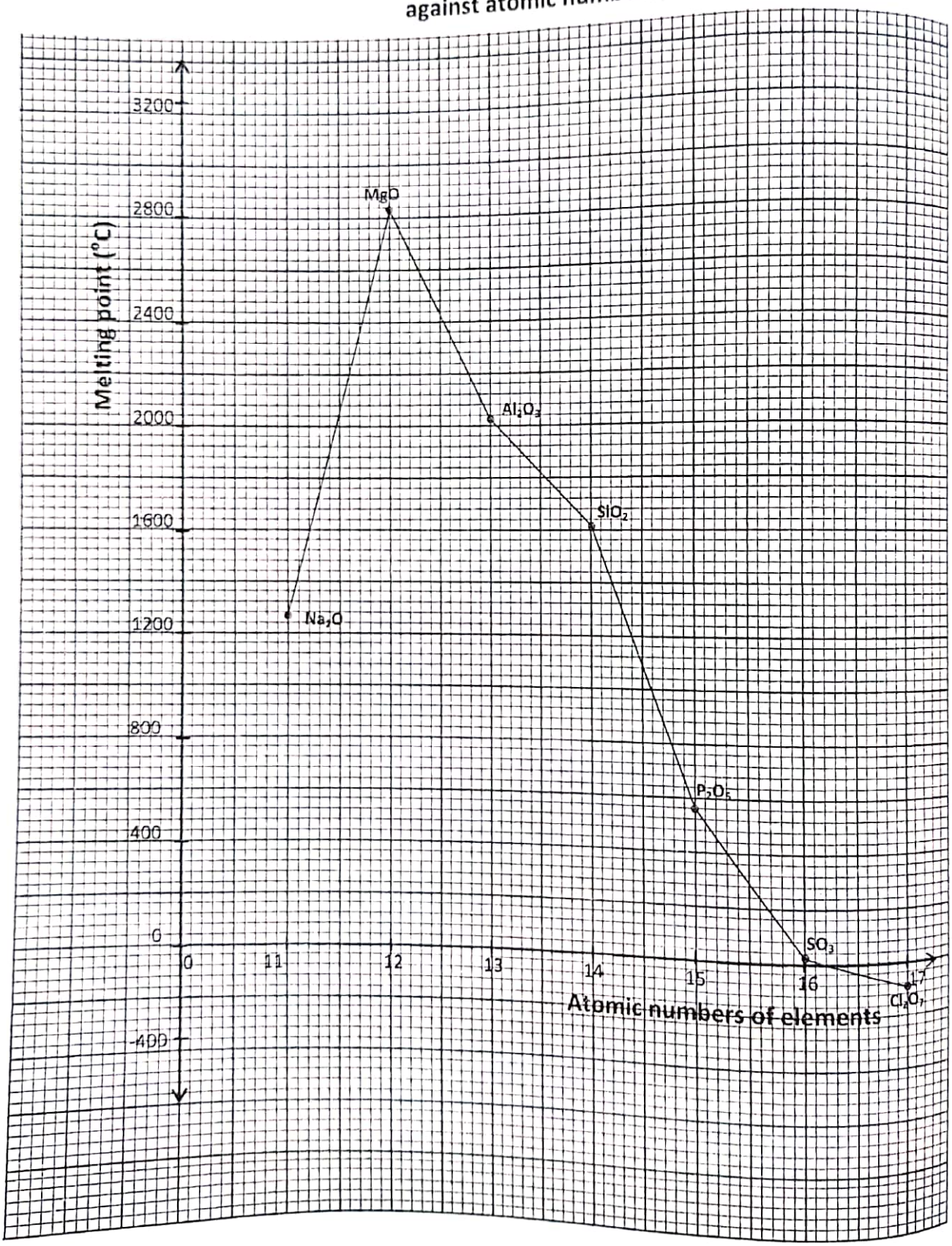
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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2011

Question. One.

(a)(i) A graph of melting points of oxides of elements of period 3 against atomic numbers



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(ii) The melting points **increase from sodium oxide to magnesium oxide**, then **decreases from magnesium oxide to dichlorine heptoxide.**
Sodium oxide, magnesium oxide and aluminium oxide are **ionic** and hence have **giant ionic structures** in which the ions are held together by **strong ionic bonds**. The melting point however increases from sodium oxide to magnesium oxide because of the **increase in charge on the cation** which results into **strong attraction** between oxide ion and the cation hence leading to **increased strength of the ionic bonds.**
The melting point of aluminium oxide is lower than that of magnesium oxide because the aluminium ion has a **higher charge density** and so **greatly polarizes** the oxide ion making aluminium oxide **partly covalent** or **less ionic**
Silicon (IV) oxide has a **giant covalent structure** in which the silicon and oxygen atoms are held together by **strong covalent bonds**
The rest of the oxides have **simple molecular structures** and the molecules are held together by **weak vander waal's forces**. However from phosphorus (V) oxide to dichlorine heptoxide there is **decrease in the difference in the electronegativity** of bonding atoms which leads to **decrease in the polarity** of the oxide hence decrease in the **strength of the vander waal's forces**

(b) (i) $P_2O_5(s) + 3H_2O(l) \longrightarrow 2H_3PO_4(aq)$

(ii) **Equation of reaction between sodium hydroxide and Aluminium oxide Al_2O_3**

$Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \longrightarrow 2NaAl(OH)_4(aq)$

or, $Al_2O_3(s) + 2\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2AlO_4^-(aq)$

or, $Al_2O_3(s) + 6NaOH(aq) + 3H_2O(l) \longrightarrow 2Na_3Al(OH)_6(aq)$

or, $Al_2O_3(s) + 6\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_6^{3-}(aq)$

or, $Al_2O_3(s) + 2NaOH(aq) \longrightarrow 2NaAlO_2(aq) + H_2O(l)$

or, $Al_2O_3(s) + 2\bar{O}H(aq) \longrightarrow 2AlO_2^-(aq) + H_2O(l)$

Equation of reaction between sodium hydroxide and SiO_2

$2NaOH(aq) + SiO_2(s) \longrightarrow Na_2SiO_3(aq) + H_2O(l)$

or, $2\bar{O}H(aq) + SiO_2(s) \longrightarrow SiO_3^{2-}(aq) + H_2O(l)$

Equation of reaction between sodium hydroxide and SO_3

$2NaOH(aq) + SO_3(s) \longrightarrow Na_2SO_4(aq) + H_2O(l)$

or, $2\bar{O}H(aq) + SO_3(s) \longrightarrow SO_4^{2-}(aq) + H_2O(l)$

(iii) $Al_2O_3(s) + 6HCl(aq) \longrightarrow 2AlCl_3(aq) + 3H_2O(l)$

Question. Two.

(a) Partition coefficient is the **constant ratio** of the concentrations of the solute in two **immiscible liquid solvents** in **contact** at a **given temperature.**

(b) A **known mass** of iodine is dissolved in a known (fixed) volume of tetra chloromethane in a separating funnel
A known volume of water is added to the separating funnel and the mixture shaken for some time and **left to stand** at a **fixed temperature**
A **fixed volume** of tetra chloromethane layer is pipetted and titrated with a **standard solution of sodium thiosulphate** in presence of **starch indicator.** The reaction that takes place is represented by the equation;

$$I_2(aq) + 2S_2O_3^{2-}(aq) \longrightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

The **concentration of iodine** in the tetra chloromethane is **calculated**
The concentration of iodine in water (or aqueous layer) is determined by **subtracting** the concentration of iodine in tetra chloromethane from the original concentration of iodine taken at the start.
The partition coefficient of iodine between tetra chloromethane and water is then obtained from the expression;

$$K_D = \frac{concentration\ of\ iodine\ in\ tetra\ chloromethane}{concentration\ of\ iodine\ in\ water}$$

Alternatively;
Iodine (any quantity) is added to a mixture of tetra chloromethane and water in a **separating funnel.**
The mixture is **shaken** for some time and allowed to settle at a **constant temperature.**
At equilibrium, **a known volume** of the tetra chloromethane layer is pipetted and titrated with a **standard solution of sodium thiosulphate** in the presence of starch indictor.
Sodium thiosulphate reacts with iodine according to the equation;

$$2S_2O_3^{2-}(aq) + I_2(aq) \longrightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

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The concentration of iodine in tetra chloromethane is then calculated
The same procedure is repeated for the aqueous layer
The partition coefficient; K_D for iodine between tetra chloromethane and water is calculated from the expression

$$K_D = \frac{concentration\ of\ iodine\ in\ tetra\ chloromethane}{concentration\ of\ iodine\ in\ water}$$

(c) (i) Let; mass of iodine extracted by water $= y\ grams$
Hence; mass of iodine remaining in $CCl_4 = (0.966 - y)g$
Concentration of iodine in $CCl_4 = \frac{(0.966-y)}{50}$
Concentration of iodine in water $= \frac{y}{50}$

$$K_D = \frac{concentration\ of\ iodine\ in\ CCl_4}{concentration\ of\ iodine\ in\ water}$$

$$85.25 = \frac{(0.966 - y)}{50} \times \frac{50}{y}$$

$$85.25y = 0.966 - y$$
$$y = 0.0112g$$

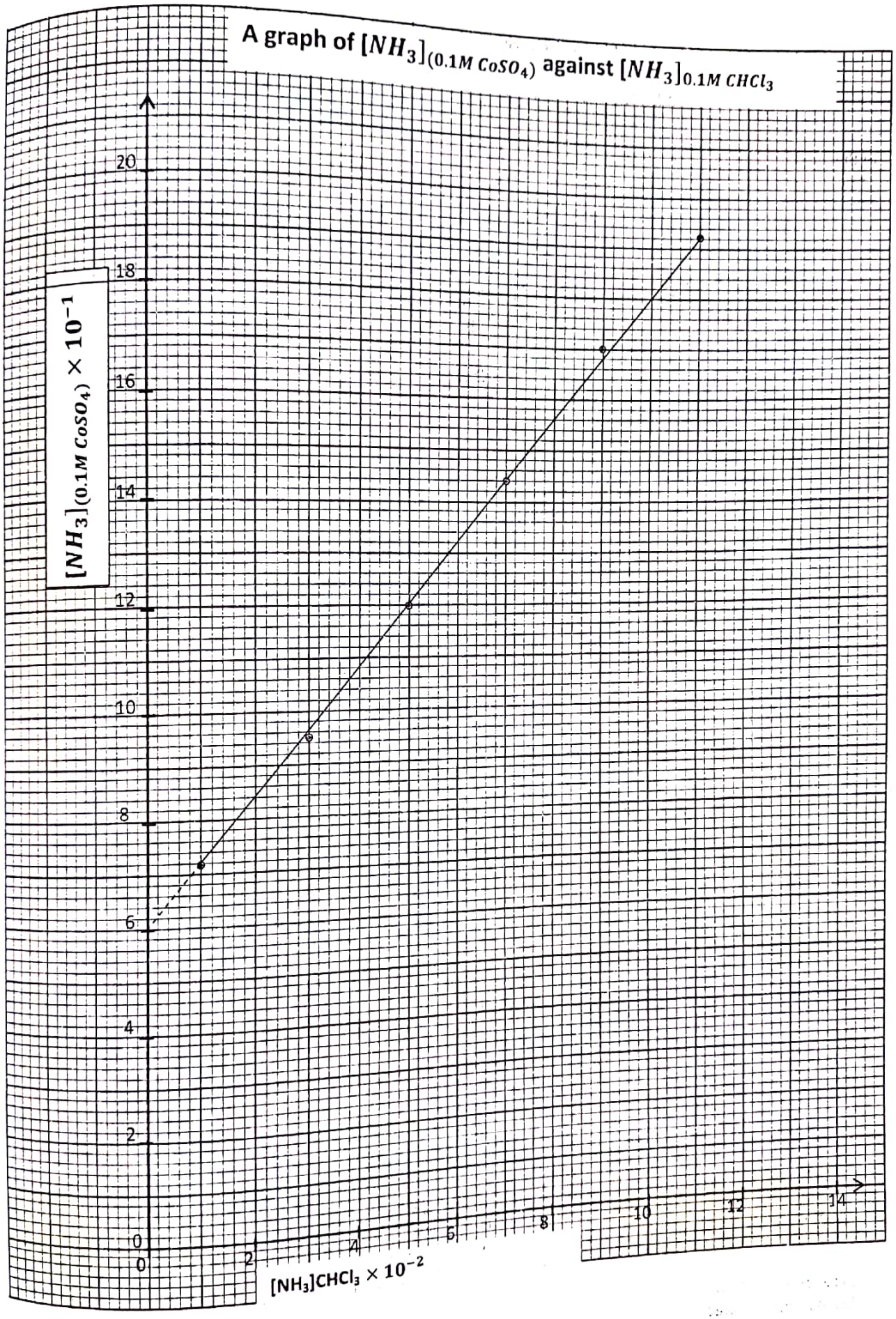
Hence; mass of iodine that remained in tetra chloromethane layer $= 0.966 - 0.0112g$
$= 0.9548g$

(ii) The mass of iodine that would remain in tetra chloromethane would be **lower** because iodine is **more soluble** in potassium iodide solution than in water **due to formation of a soluble complex of potassium tri iodide** than in water

$I_2(aq) + KI(aq) \longrightarrow KI_3(aq)$
or $I_2(aq) + I^-(aq) \longrightarrow I_3^-(aq)$

(d) (i) see graph next page
(ii) From the graph, on extrapolating the straight line until it touches the vertical axis, the intercept on the vertical axis equals to the concentration of ammonia that complexed with cobalt (II) ions and is equal to **0.6M**
Hence; 0.1mole of Co^{2+} complexes with 0.6 mole of NH_3
1mole of Co^{2+} complexes with $\frac{0.6}{0.1}$ mole of NH_3
$= 6$moles of NH_3
Thus; $value\ of\ n\ in\ the\ complex = 6$

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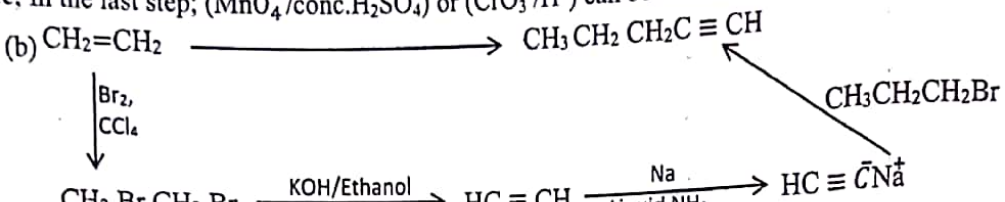
Question. Three.

(a)

$$CH_3CH_2CH_2Br \xrightarrow[\text{heat}]{NaOH(aq)} CH_3CH_2CH_2OH \xrightarrow[\text{heat}]{Cr_2O_7^{2-}/H^+} CH_3CH_2COOH$$

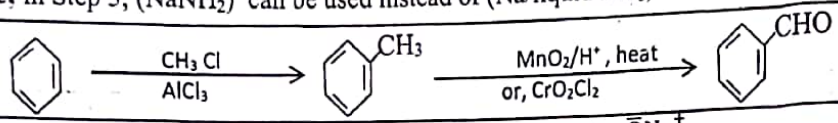
Note; In the last step; $(MnO_4^-/\text{conc.}H_2SO_4)$ or (CrO_3/H^+) can be used instead of $(Cr_2O_7^{2-}/H^+)$

(b)

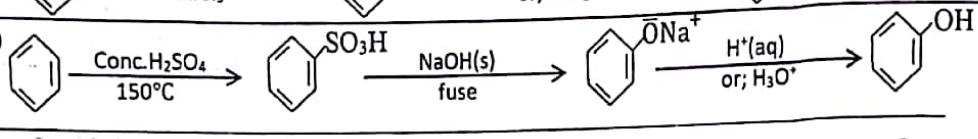


Note; in Step 3; $(NaNH_2)$ can be used instead of $(Na/\text{liquid } NH_3)$

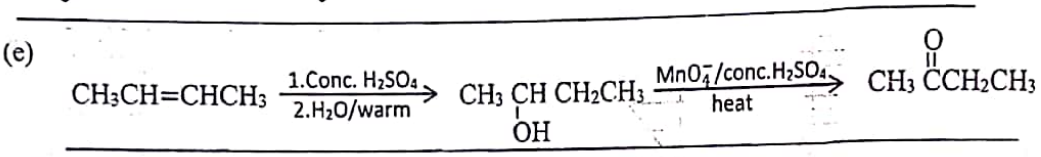
(c)



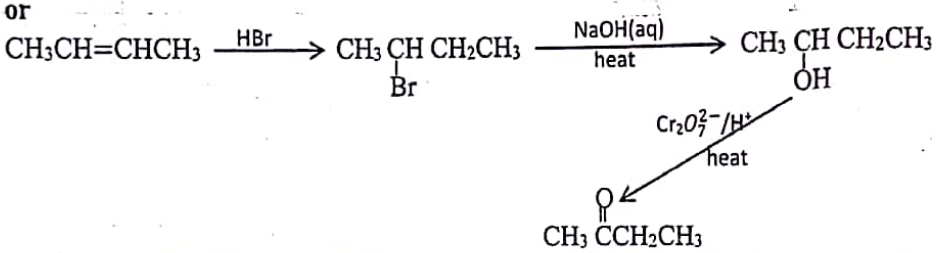
(d)



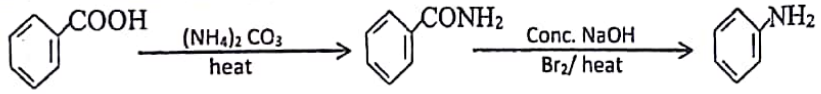
(e)



or

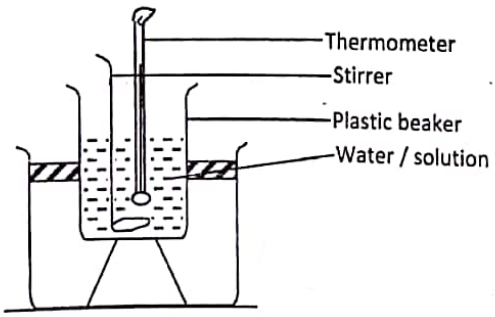


(f)



Question. Four.

(a)



- A known volume of water (Vcm^3) is put in a plastic beaker
- The initial temperature of water is measured using a thermometer and recorded ie $(T_1)°C$
- A known mass (m)g of sodium chloride is added to the water in a beaker
- The mixture is **stirred** and the final steady temperature attained by the solution mixture is recorded ie $(T_2)°C$

Treatment of results;

Temperature change = $(T_2 - T_1)°C$

Let; Specific heat capacity of solution = $4.2Jg^{-1}°C^{-1}$ and

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Density of water or solution $= 1gcm^{-3}$

Hence mass of water $= (V \times 1) = Vg.$ *and mass of solution* $= (V + m)$g

Let; Molecular mass of sodium chloride $= mr$

Heat change= *mass of solution* × *specific heat capacity* × *Temperature change*

$= (V + m) \times 4.2 \times (T_2 - T_1)$Joules

Mg of sodium chloride cause an enthalpy change of $= (V + m) \times 4.2 \times (T_2 - T_1)$Joules

$\therefore (mr)$g of sodium chloride cause an enthalpy change of $\left[\frac{mr \times (V+m) \times 4.2 \times (T_2 - T_1)}{m}\right]$ J

Thus; enthalpy of solution of sodium chloride$= \left[\frac{mr \times (V+m) \times 4.2 \times (T_2 - T_1)}{m}\right]$Jmol^{-1}

(b) (i) Molar mass of anhydrous $CuSO_4 = (1 \times 64) + (1 \times 32) + (4 \times 16) = 160$g

Mass of solution $= (50.0 + 4) = 54g$

Heat evolved = *mass of solution* × *specific heat capacity* × *temperature rise*

$= 54 \times 4.2 \times 8$ *Joules* $= 1814.4$ *Joules*

Hence; 4g of anhydrous $CuSO_4$ liberate 1814.4 J of energy

Therefore; 160g of anhydrous $CuSO_4$ liberate $\left(\frac{160 \times 1814.4}{4}\right)$ J of energy

Enthalpy of solution $= -72576$ Jmol^{-1} (or -72.576KJmol^{-1})

(ii) Molar mass of hydrated $CuSO_4 \cdot 5H_2O$

$= (1 \times 64) + (1 \times 32) + (4 \times 16) + (10 \times 1) + (5 \times 16) = 250$g

Heat absorbed = *mass of solution* × *S.H.C* × *Temperature drop*

$= (54 \times 4.2 \times 0.9)J = 204.12J$

4g of $CuSO_4 \cdot 5H_2O$ dissolve with absorption of 204.12 J of energy

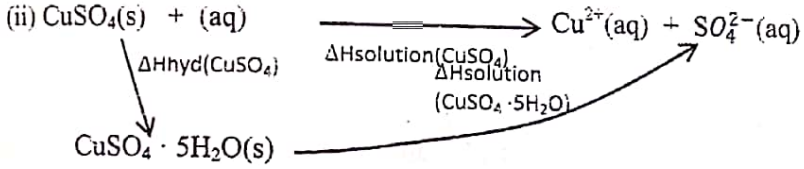
$\therefore$ 250g of $CuSO_4 \cdot 5H_2O$ dissolve with absorption of $\left(\frac{250 \times 204.12}{4}\right)$ J of energy

$= +12757.5$ J of energy

Hence; enthalpy of solution $= +12757.5$ Jmol^{-1} (or $+12.76$ KJmol^{-1})

(c) (i) Anhydrous Copper (II) sulphate is **more soluble** than hydrated copper (II) sulphate because its **enthalpy of solution is negative** (exothermic) while that of hydrated copper (II) sulphate is **positive** (endothermic)

(ii)



From Hess's law;

ΔH solution $(CuSO_4) = \Delta H$hydration$(CuSO_4) + \Delta H$solution $(CuSO_4 \cdot 5H_2O)$

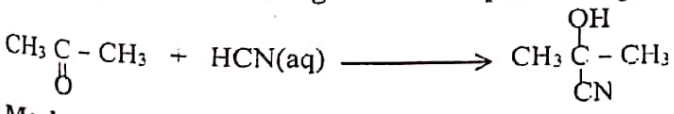
Hence; ΔHhydration$(CuSO_4)$ $= \Delta H$solution $(CuSO_4) - \Delta H$solution $(CuSO_4 \cdot 5H_2O)$

$= -72.576 - (12.76)$

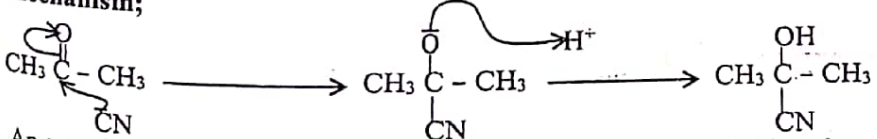
$= -85.336$ KJmol^{-1}

Question. Five.

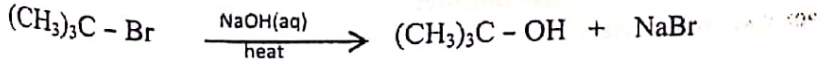
(a) A reaction of an electron rich species (nucleophile) and another compound with an electron deficient centre (electrophile) to form a **single saturated product**. Eg;



Mechanism;

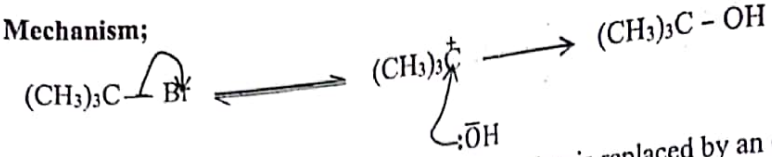


(b) An organic reaction in which an electron rich species (nucleophile) replaces another atom in another compound during which one species is involved in the rate determining step Eg; alkaline hydrolysis of tertiary or secondary alkyl halides

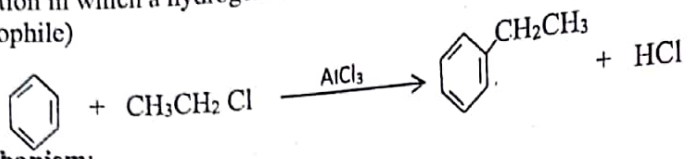


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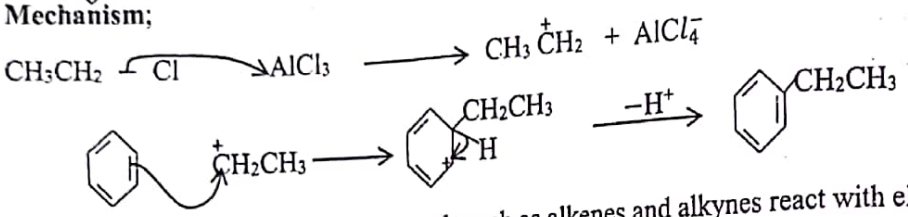
Mechanism;



(c) A reaction in which a hydrogen atom on the benzene ring is replaced by an electron deficient species (electrophile)



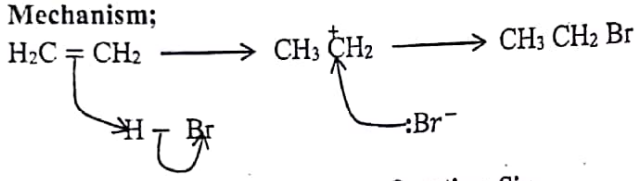
Mechanism;



(d) A reaction in which unsaturated compounds such as alkenes and alkynes react with electron deficient species (electrophiles) to form a single product.

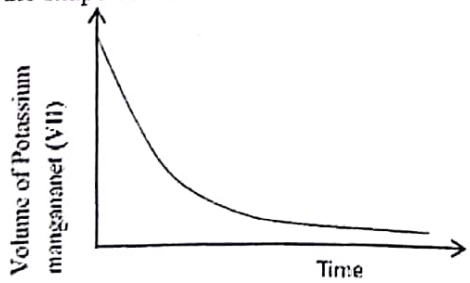
Eg; $CH_2 = CH_2 \xrightarrow{HBr} CH_3CH_2Br$

Mechanism;



Question. Six.

(a)
- A **known volume** of a standard solution of hydrogen peroxide is poured into a conical flask
- A fixed volume of **iron (III) chloride solution** followed by an equal volume of **sodium hydroxide solution** are added and the stop **clock simultaneously started.**
- The mixture in the conical flask is allowed to stand for some time at room temperature
- After a specific time interval, a known volume of the mixture is pipetted into another conical flask containing dilute sulphuric acid and then this mixture is titrated against a standard solution of potassium manganate (VII)
- The volume of the potassium manganate (VII) solution used is recorded
- The procedure is repeated at different time intervals by withdrawing fixed volumes of the reaction solution mixture.
- A graph of volume of potassium manganate (VII) used is plotted against time and from the graph, the half life is determined and is found to be constant indicating that the reaction is **first order**. The graph has the shape below.



(b) (i) Rate of reaction would **double**

Note;

When the $[B]$ and [C] are kept constant, the rate of reaction depends only on the [A]

hence; Rate = k[A]

Rate $= k \times 2 = 2k$; hence rate of reaction **also doubles**

(ii) The rate of reaction would **decrease by four times**

Note;

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When the [A] and [C] are kept constant and [B] halved the rate of reaction depends only on the concentration [B]

Hence; Rate $= k[B]^2$

Rate $= k(½)^2 = ¼k$; hence rate **reduces by four times** the initial rate

(iii) The rate of reaction **increases by four times**

Note;

When the [A] and [C] are kept constant and [B] doubled, the rate of reaction only depends on the [B];

Hence; Rate $= k[B]^2$

Rate $= k(2)^2 = 4k$; hence rate **increases by four times**

(iv) The rate of reaction **increases by 16times**

Note;

If [A], [B] and [C] are **doubled** then the rate of reaction depends on the concentrations of A, B and C and So;

$Rate = k[A][B]^2[C]$

$Rate = k \times (2)(2)^2(2) = 16k$; hence rate **increases by 16times**

(c) (i) see graph next page

(ii) First order; because the graph of rate of reaction against concentration of sucrose is a **straight line** and **passes through the origin** indicating that rate of reaction is directly proportional to the concentration of sucrose.

(iii) Rate equation for the reaction is

$Rate = k[sucrose]$ $\quad$ *where* $k = rate\ constant$

But; $Rate\ constant; k = Slope\ of\ the\ graph$

Hence; $Slope = \frac{(37.5-7.5)\times10^{-4}}{(7.5-1.5)\times10^{-2}} = 0.005\ second^{-1}$

Therefore rate constant; $k = 0.05\ second^{-1}$

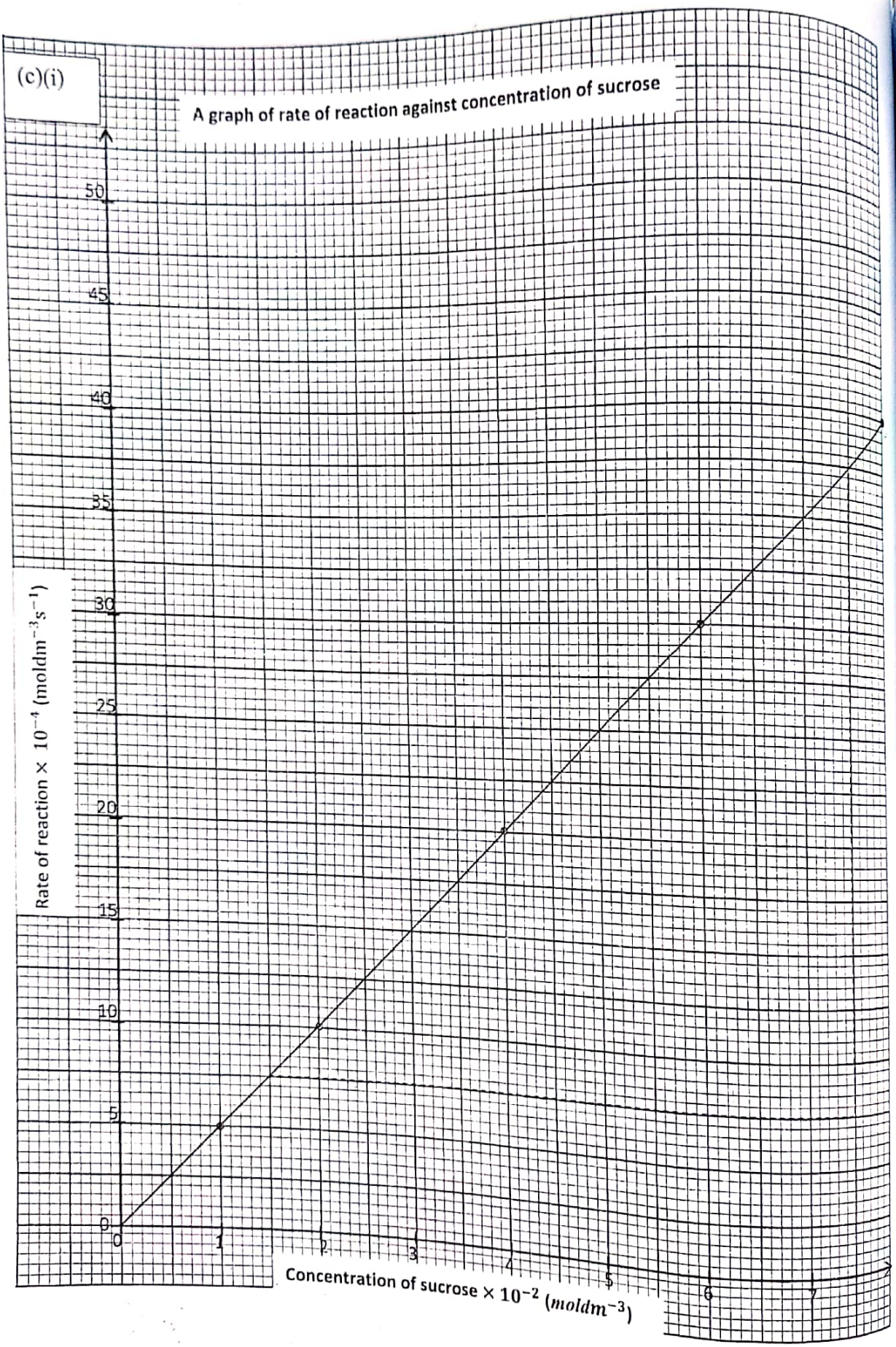
(iv) From the rate equation; $Rate = k[sucrose]$

Thus; rate of reaction $= 0.05 \times 0.12$

$= 0.006 moldm^{-3}s^{-1}$

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(c)(i)



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Question. Seven.

(a) Ethanoic acid is a **weak acid** while sodium hydroxide is a strong base and on titration, these two react to form **sodium ethanoate salt** which at end point **undergoes hydrolysis** to produce an **alkaline solution** with a **high pH** that is **within the working range of phenolphthalein indicator** which is a **weak organic acid**

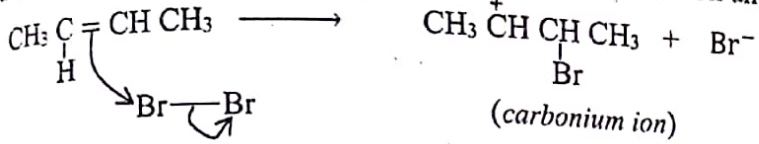
$CH_3COOH(aq) + NaOH(aq) \longrightarrow CH_3COONa(aq) + H_2O(l)$

$CH_3COONa(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + NaOH(aq)$; or

$CH_3CO\bar{O}(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + \bar{O}H(aq)$

However, the pH at end point of this titration is outside the working range of methyl orange indicator which is a **weak organic base**

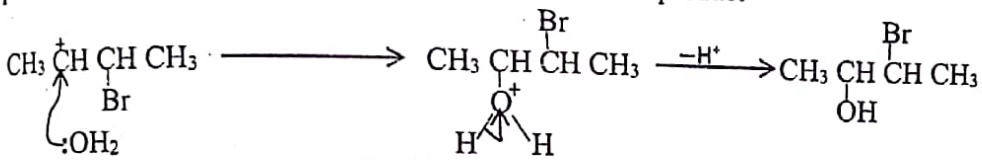
(b) In presence of tetra chloromethane which is an **inert solvent**; the **nucleophilic** (electron rich) but-2-ene reacts with the **electrophilic** bromine to form a **carbonium ion** and a **bromide ion**



(*carbonium ion*)

Since; tetra chloromethane is an inert solvent, then the electrophilic carbonium ion is attacked by the nucleophilic bromide ion to form 2, 3-dibromobutane as the major product ie

However, bromine in aqueous solution forms 3-bromobutan-2-ol because the **nucleophilic** water molecules are in **higher concentration than the nucleophilic bromide ions**, hence **more carbonium ions are attacked by water molecules than the bromide** ions hence forming 3-bromobutan-2-ol as the **major product** while 2, 3-dibromobutane is formed as aminor product



(c) The barium ions **react** with oxalate ions from ammonium oxalate solution to form **insoluble barium oxalate ie**

$Ba^{2+}(aq) + C_2O_4^{2-}(aq) \longrightarrow BaC_2O_4(s)$.

However, the barium oxalate formed reacts with dilute nitric acid to form **soluble barium nitrate and oxalic acid**

$BaC_2O_4(s) + 2HNO_3(aq) \longrightarrow Ba(NO_3)_2(aq) + H_2C_2O_4(aq)$

(d) Both carbon and lead have **four electrons in their outer most energy levels** and can use electrons from both the s and p orbitals for chemical bonding hence have a valency of 4, but due to the **higher atomic radius** of lead than carbon the outer s-electrons in lead are **unable to participate in bonding** (inert pair effect) and thus lead is able to form another oxidation state of +2 unlike carbon

Question. Eight.

(a) (i) In order to convert the Iron (II) oxide present as an impurity to Iron (III) oxide

(ii) The powdered ore is heated with sodium hydroxide so as to **dissolve aluminium oxide** as it is amphoteric and **silicon(IV) oxide** as it is acidic and then filtered to **remove the insoluble** (un dissolved) iron (III) oxide as it is basic

(b)

$Al_2O_3(s) + 2NaOH(aq) \longrightarrow 2NaAlO_2(aq) + H_2O(l)$

or, $Al_2O_3(s) + 2\bar{O}H(aq) \longrightarrow 2AlO_2^-(aq) + H_2O(l)$

or, $Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \longrightarrow 2NaAl(OH)_4(aq)$

or, $Al_2O_3(s) + 2\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_4^-(aq)$

or, $Al_2O_3(s) + 6NaOH(aq) + 3H_2O(l) \longrightarrow 2NaAl(OH)_6(aq)$

or, $Al_2O_3(s) + 6\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_6^{3-}(aq)$

and; $SiO_2(s) + 2NaOH(aq) \longrightarrow Na_2SiO_3(aq) + H_2O(l)$

or, $SiO_2(s) + 2\bar{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + H_2O(l)$

(c) The products from (b) ie the sodium aluminate and sodium silicate are separated from the un dissolved Iron (III) oxide by filtration and the products from (b) are obtained as the filtrate

Aluminium hydroxide is then added to the filtrate to precipitate out aluminium hydroxide from solution

$Al(OH)_4^-(aq) \longrightarrow Al(OH)_3(s) + \bar{O}H(aq)$

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or, $Al(OH)_4^-(aq) + Al(OH)_3(s) \longrightarrow 2Al(OH)_3(s) + \bar{O}H(aq)$

or, $Al(OH)_6^{3-}(aq) \longrightarrow Al(OH)_3(s) + 3\bar{O}H(aq)$

or, $Al(OH)_6^{3-}(aq) + Al(OH)_3(s) \longrightarrow 2Al(OH)_3(s) + 3\bar{O}H(aq)$

Aluminium hydroxide is then **filtered** off and **heated** to obtain aluminium oxide

$$2Al(OH)_3(s) \longrightarrow Al_2O_2(s) + 3H_2O(l)$$

Aluminium oxide is then dissolved in **molten cryolite** and **electrolysed** at **high temperatures** between **graphite electrodes** using a current of **low voltage** and pure Aluminium is then produced at the cathode according to the equation;

$$Al^{3+}(l) + 3e \longrightarrow Al(s)$$

Note; Instead of adding aluminium hydroxide to the filtrate, carbon dioxide can be added to precipitate out aluminium hydroxide ie

$$2Al(OH)_4^-(aq) + CO_2(g) \longrightarrow 2Al(OH)_3(s) + CO_3^{2-}(aq) + H_2O(l)$$

or, $2AlO_2^-(aq) + CO_2(g) + 3H_2O(l) \longrightarrow 2Al(OH)_3(s) + CO_3^{2-}(aq)$

or, $2Al(OH)_6^{3-}(aq) + 3CO_2(g) \longrightarrow 2Al(OH)_3(s) + 3CO_3^{2-}(aq) + 3H_2O(l)$

(d) (i) $Fe_2O_3(s) + 2Al(s) \longrightarrow 2Fe(s) + Al_2O_3(s)$

(ii) $3Mn_3O_4(s) + 8Al(s) \longrightarrow 9Mn(s) + 4Al_2O_3(s)$

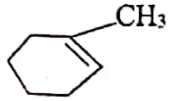
(iii) $Cr_2O_3(s) + 2Al(s) \longrightarrow 2Cr(s) + Al_2O_3(s)$

(e) $Al(s) + 6HCl(g) \longrightarrow 2AlCl_3(s) + 3H_2(g)$

or, $Al(s) + 3Cl_2(g) \longrightarrow 2AlCl_3(s)$

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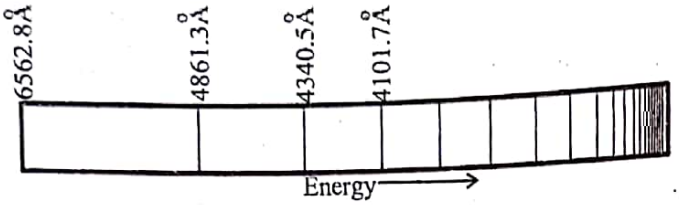
QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2010

1. (a) Complete the following equations.
   (i) $^{236}_{92}U \longrightarrow {}^{92}_{36}Kr + \ldots\ldots\ldots\ldots + {}^{141}_{56}Ba$
   (ii) $^{214}_{83}Bi \longrightarrow {}^{0}_{-1}e + \ldots\ldots\ldots\ldots$ (1 mark)
   (b) The half-life of bismuth is 20 minutes. Determine the time taken for bismuth to decay by 75%. (1 mark) (2½ marks)
2. (a) (i) Write the electronic configuration of phosphorous. (1 mark)
   (ii) State the common oxidation of phosphorous (1 mark)
   (b) Draw the structure and name the shape of phosphorous trichloride molecule. (1 mark)
   (c) The enthalpy of formation of phosphorous trichloride is $-306 kJmol^{-1}$ and enthalpies of atomization of phosphorous and chlorine are +314 and +242 $k Jmol^{-1}$ respectively. Calculate the average bond energy of the $P - Cl$ Bond. (2½ marks)
3. Complete the following equations and in each case outline the accepted mechanism for the reaction.
   (a) $(CH_3)_2NH + CH_3-\overset{\overset{O}{\|}}{C}-Br \longrightarrow$ (3 marks)
   (b)  (3 marks)
4. A sample of methylamine was placed at one end A of a 0.8 metre glass tube held horizontally. At the other end B of the tube was placed a sample of hydrochloric acid both ends of the tube closed. When the tube was left for sometime, a white ring was formed inside the tube.
   (a) Write equation for the reaction leading to the formation of the white ring. (1 mark)
   (b) Calculate the distance between end B and the white ring. (3 marks)
5. Name one reagent that can be used to distinguish between each of the following pairs of ions and in each case, state what would be observed if each member of the pair is treated with the reagent you have named.
   (a) $Cl^-(aq)$ and $I^-(aq)$ (3 marks)
   (b) $SO_3^{2-}(aq)$ and $S_2SO_3^{2-}(aq)$ (2½ marks)
6. (a) State the conditions for the formation of polyvinyl chloride. $\left(CH_2\underset{Cl}{CH}\right)_n$ (1½ marks)
   (b) The osimotic pressure of a solution containing 4.00gdm^{-3} of polyvinyl chloride in dioxin is 65 Pa at 20°C. Calculate the number of monomers (3 marks)
   (c) State one use of polyvinyl chloride. (½ mark)
7. (a) State what would be observed and write equation for the reaction that would take place if: (2 marks)
   (i) Excess hydrogen peroxide was added to acidified solution of potassium manganate (VII). (1½ marks)
   (ii) 3-phenylpropene was added to a solution of bromine in tetrachloromethane. (1 mark)
   (b) Give a reason for the observation in (a) (i) above.
8. Dimethyl ammonium chloride undergoes hydrolysis in water according to the following equation:
   $(CH_3)_2NH_2^+(aq) + H_2O(l) \rightleftharpoons (CH_3)_2NH(aq) + H_3O^+(aq)$
   (a) Write the expression for the hydrolysis constant (K_h) of dimethyl ammonium chloride. (1 mark)
   (b) When 4.0mol dm^{-3} of dimethyl ammonium chloride was hydrolysed 25.0cm^3 of the resulting solution required 7.5cm^3 of 0.01 mol dm^{-3} of sodium hydroxide for complete neutralization.
   (i) pH of the solution (2 marks)
   (ii) hydrolysis constant (K_h) and state any assumptions made (2½ marks)
9. write equation for the reaction(s) between
   (a) lead (IV) oxide and concentrated hydrochloric acid on warming. (1½ Marks)
   (b) aqueous lead (II) nitrate and excess sodium hydroxide solution. (3 marks)
   (c) tin (II) chloride and water. (3 marks)
10. Beryllium is in group II of the Periodic Table but it shows some similarities with aluminium which is in group III of the Periodic Table.
    (a) Give a reason why aluminium shows some similarities in properties with beryllium (1 mark)
    (b) Write equation for the reaction between water and (1½ marks)
    (i) beryllium carbide. (1½ marks)
    (ii) calcium carbide (1 mark)
    (c) Thallium and aluminium are both in group III of the Periodic Table. State one difference between aluminium oxide and thallium oxide. (2 marks)
    (d) Write eqution for the reaction between sodium hydroxide and (2 marks)
    (i) aluminium
    (ii) beryllium
11. A compound R contains 40% carbon and 6.67% hydrogen, the rest being oxygen.

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(a) Calculate the empirical formula of R.
(b) A solution containing 28.145g of R in 250g of water frozen at -3.490°C.
(i) Determine the molecular formula of R. (3 marks)
(the freezing point constant K_f of water is 1.86°C mol^{-1} per 100g.)
(ii) Write the structural formula and the I.U.P.A names of all the possible isomers of R. (2 marks)

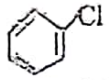
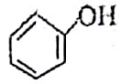
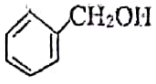
12. The diagram below shows the atomic emission spectrum of hydrogen.



(a) State:
(i) The information that can be obtained from the separate lines about the electronic structure of the hydrogen atom. (1½ marks)
(4 marks)
(b) Explain your answer(s) in (a)(ii) and (a) (iii)
(c) An organic compound X was steam distilled at 95°C at 760mmHg pressure. If the distillate contained 0.8g of water by mass, calculate the relative molecular mass of X.
(*the saturated vapour pressure of water at 95°C is 732.7 mmHg*) (2 marks)

14. Write equations to show how the following compounds can be synthesized. Indiated the condition(s) for the reaction(s).
(a) But-2yne from butan-2-ol. (3½ marks)
(b) Ethylamine from ethanal. (3½ marks)
(c) Propanone from propene. (2 mark)

15. Nitrogen reacts with hydrogen to form ammonia according to the following equation.
$N_{2(g)} + 3H_2(g) \rightleftharpoons 2NH_3(g); \Delta H = -92kJmol^{-1}$
(a) State the conditions for the reaction which would give maximum yield of ammonia. (1½ marks)
(b) Write equation for the reaction that took place during the manufacture of nitric acid from ammonia. (4½ marks)
(c) Write equation for the reaction between copper and
(i) Dilute nitric acid (1½ marks)
(ii) Concentrated nitric acid (1½ marks)

16. Name one reagent that can be used to distinguish between each of the following pairs of compounds. In each case, state what is observed if each member of the pair is treated with the reagent.
(a)  and $CH_3CH_2CH_2Cl$
(b)  and 
(c) $CH_3COCH_2CH_2CH_3$ and $CH_3CH_2COCH_2CH_3$

17. Hydrogen and iodine react to form hydrogen iodide according to the following equation.
$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
(a) (i) Write the expression for the equilibrium constant, K_c for the reaction. (1 mark)
(ii) 1 mole of hydrogen and ⅓ mole of iodine were heated together at 450°C until equilibrium was attained. Calculate the mixture of moles of hydrogen iodide present in the equilibrium, mixture at 45°C.
(*The equilibrium constant K_c for the reaction between hydrogen and iodine is 50*). (4 marks)
(b) Briefly describe how the concentration of iodine in the equilibrium mixture can be determined. (4 marks)

END

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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1) – 2010

1. (a) (i) $^{236}_{92}U \longrightarrow {}^{92}_{36}Kr + 3\,{}^{1}_{0}n + {}^{141}_{56}Ba$

(ii) $^{214}_{83}Bi \longrightarrow {}^{0}_{-1}e + {}^{214}_{84}Po$

(b) $\lambda t½ = In2 = 0.693$

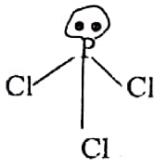
$\lambda = \frac{0.693}{20} = 3.465 \times 10^{-2} minute^{-1}$

$using; In\left(\frac{mo}{mt}\right) = \lambda t \; or \left(2.303log\left(\frac{mo}{mt}\right) = \lambda t\right)$

$t = \frac{In\left(\frac{100}{25}\right)}{3.465\times10^{-2}} = \mathbf{40 minutes}$

2. (a) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

(ii) +3 and +5

(b) 

Trigonal pyramidal

(c) $¼P_4(s) + \frac{3}{2}Cl_2(g) \xrightarrow{-306} PCl_3(l)$

+314 ↓ ; 3(242) ↓ ; 3(B.E) ↑

$P(g) + 3Cl(g)$

From Hess' law;

$-306 = 314 + 3(242) + 3BE(P-Cl)$

$B.E(P-Cl) = \frac{-1346}{3} = \mathbf{-448.67 KJmol^{-1}}$

Alternatively

$-306 = 314 + 3(242) + BE(PCl_3)$

$B.E(PCl_3) = -1346\ KJmol^{-1}$ of PCl_3

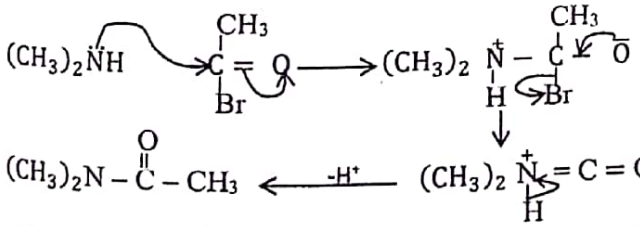
Hence; 3(P – Cl) bonds are formed with evolution of $-1346\ KJ$

$\therefore$1(P – Cl) bond is formed with evolution of $\frac{-1346}{3}\ KJmol^{-1}$

Hence average bond energy of P – Cl bond = $\mathbf{-448.67 KJmol^{-1}}$

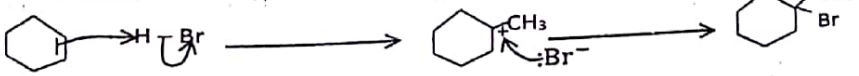
3. (a) $(CH_3)_2NH + CH_3-\overset{O}{\overset{\|}{C}}-Br \longrightarrow (CH_3)_2N-\overset{O}{\overset{\|}{C}}-CH_3 + HBr$

Mechanism;



(b) 

Mechanism;



4. (a) $CH_3NH_2(g) + HCl(g) \longrightarrow CH_3\overset{+}{N}H_3Cl^-(s)$

(b) $\frac{\text{Rate (Amine)}}{\text{Rate (HCl)}} = \sqrt{\frac{\text{Rmm HCl}}{\text{Rmm(Amine)}}}$

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Let the distance moved by the amine = x metres.

Hence; Rate (Amine) $= \frac{x}{t}$

Rate (HCl) $= \frac{0.8-x}{t}$

Thus; $\frac{x}{0.8-x} = \sqrt{\frac{36.5}{31}}$ $\quad x = 0.416$ **metre**

Hence; Distance between end B and white ring

$= 0.8 - 0.416 \quad = 0.38$ **meters**

5. (a) **Reagent**: Silver nitrate solution

Observation; Cl^- (aq) gives a white precipitate

I^- (aq) gives a yellow precipitate

or; Reagent: Lead (II) nitrate solution or lead (II) ethanoate solution

Observation; Cl^-(aq) gives a white precipitate

I^- (aq) gives a yellow precipitate

or; Reagent: Copper (II) sulphate solution

Observation; Cl^-(aq) gives no observable change

I^- (aq) gives a **white precipitate** with a **brown solution**

(b) **Reagent**: Dilute hydro chloric acid or sulphuric acid or nitric acid.

Observation; SO_3^{2-}(aq) – forms effervescence or bubbles of a colourless gas

$S_2O_3^{2-}$(aq) – forms a yellow solid and bubbles of a colourless gas

Or; Reagent: Ammonium molybdate solution and concentrated hydrochloric acid

Observation; SO_3^{2-}(aq) –gives no observable change

$S_2O_3^{2-}$(aq) –gives a blue ring at the liquid junction

6. (a) – Heat or high temperature

– Presence of a peroxide e.g Dibenzoyl peroxide or ROOR

– High pressure

(b) Using; $\pi v = \frac{m}{mr}RT$

$65 \times 10^{-3} = \frac{4}{mr} \times 8.31 \times (20 + 273)$

$mr = \frac{4 \times 8.31 \times (20+273)}{65 \times 10^{-3}}$ $\quad = 149,835.69$

Molar mass of monomer (CH_2=$CHCl$) = $(2 \times 12) + (3 \times 1) + (35.5) = 62.5$

Hence; $(62.5)n = 149835.69$

$$\therefore n = \frac{149835.69}{62.5}$$

$$n = 2397$$

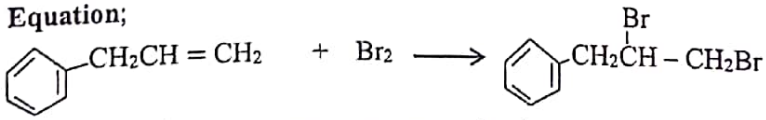
(c) – Making pipes, making films, making records, making insulators for cables, making curtains, making rain coats.

7. (a) (i) **Observation**; **Purple** solution of Potassium manganate (VII) turns **colourless**

Equation; $2MnO_4^-(aq) + 6H^+(aq) + 5H_2O_2(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 5O_2(g)$

(ii) **Observation; Brown solution** or **Reddish brown** solution turns **colourless**

Equation;



(b) Manganate(VII) ion is reduced to manganese (II) ion

8. (a) $Kh = \frac{[(CH_3)_2NH][H_3O^+]}{[(CH_3)_2\overset{+}{N}H_2]}$

(b) (i) Moles of NaOH in $7.5cm^3 = \frac{7.5}{1000} \times 0.01 mole$ $= 7.5 \times 10^{-5} mole$

The resultant solution contains H_3O^+ which react with NaOH according to the equation:

$H_3O^+(aq) + \bar{O}H(aq) \longrightarrow 2H_2O(l)$

Since; mole ratio of $H_3O^+ : \bar{O}H = 1 : 1$

Moles of H_3O^+ in $25cm^3 = 7.5 \times 10^{-5} moles$

Concentration of $H_3O^+ = \frac{1000 \times 7.5 \times 10^{-5}}{25}$ $= 3 \times 10^{-3} moldm^{-3}$

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$pH = -\log_{10}[H_3O^+]$

$= -\log_{10}(3 \times 10^{-3}) = 2.52$

(ii) Assumptions

- $[H_3O^+] = [(CH_3)_2NH]$
- $[(CH_3)_2\overset{+}{N}H_2] = [\text{salt}] = 4.0\text{moldm}^{-3}$

hence $Kh = \frac{[H_3O^+]^2}{[(CH_3)_2\overset{+}{N}H_2]}$

$= \frac{(3\times10^{-3})^2}{4}$ $= 2.25 \times 10^{-6}\text{moldm}^{-3}$

9. (a) $PbO_2(s) + 4HCl(aq) \longrightarrow PbCl_2(aq) + Cl_2(g) + 2H_2O(l)$

(b) $Pb^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Pb(OH)_2(s)$

Then; $Pb(OH)_2(s) + 2\bar{O}H(aq) \longrightarrow Pb(OH)_4^{2-}(aq)$

or, $Pb(OH)_2(s) + 4\bar{O}H(aq) \longrightarrow Pb(OH)_6^{4-}(aq)$

or, $Pb(OH)_2(s) + 2\bar{O}H(aq) \longrightarrow PbO_2^{2-}(aq) + 2H_2O(l)$

(c) $SnCl_2(s) + H_2O(l) \rightleftharpoons Sn(OH)Cl(s) + HCl(aq)$

10. (a) -The atoms of aluminium and beryllium have the **same electro negativity**

-The atoms of aluminium and beryllium have the **same standard electrode potential**

-The aluminum ion and beryllium ion have the **same charge density or polarizing power.**

(b) (i) $Be_2C(s) + 4H_2O(l) \longrightarrow 2Be(OH)_2(s) + CH_4(g)$

(ii) $CaC_2(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(aq) + C_2H_2(g)$

(c) Aluminium oxide is **amphoteric** whereas Thallium oxide is **basic**

(d) (i) $2Al(s) + 2OH^-(aq) + 6H_2O(l) \longrightarrow 2Al(OH)_4^-(aq) + 3H_2(g)$

or, $2Al(s) + 2OH^-(aq) + 2H_2O(l) \longrightarrow 2AlO_2^-(aq) + 3H_2(g)$

(ii) $Be(s) + 2OH^-(aq) + 2H_2O(l) \longrightarrow Be(OH)_4^{2-}(aq) + H_2(g)$

or, $Be(s) + 2OH^-(aq) \longrightarrow BeO_2^{2-}(aq) + H_2(g)$

11. (a) % of oxygen $= 100 - (40 + 6.67) = 53.33$

Composition;	C	H	O
moles;	$\frac{40}{12}$	$\frac{6.67}{1}$	$\frac{53.33}{16}$
	3.33	6.67	3.33
mole ratio;	$\frac{3.33}{3.33}$	$\frac{6.67}{3.33}$	$\frac{3.33}{3.33}$
	1 :	2 :	1

∴Emperical formula of R is CH_2O

(b) 250g of water dissolved 28.145g of R.

∴ 1000g of water dissolved $\frac{1000\times28.145}{250} = 112.58g\ of\ R$

Freezing point depression $= 0 - (-3.490) = 3.490°C$

3.490°C is freezing point depression caused by 112.58g of R

∴ 1.86°C is freezing point depression caused by $\frac{1.86\times112.58}{3.490}\ g$ of R

Hence; Rmm of R = 60

Thus, $(CH_2O)_n = 60$

$12n + 2n + 16n = 60$

$n = \frac{60}{30} = 2$

Molecular formula of R is $C_2H_4O_2$

(ii) CH_3COOH – Ethanoic acid

$CH_3 - O - \overset{O}{\overset{\|}{C}} - H$ – methyl methanoate

HOCH=CHOH– Ethene –1,2 –diol

(c) (i) CH_3COOH or Ethanoic acid

(ii) $CH_2 = CH_2 \xrightarrow[2.\ H_2O/warm]{1.\ conc.\ H_2SO_4} CH_3CH_2OH \xrightarrow[\text{heat}]{Mn\bar{O}_4/conc.\ H_2SO_4} CH_3COOH$

Recall; in step (ii) $(Cr_2O_7^{2-}/H^+)$ or (CrO_3/H^+) can be used instead of $(Mn\bar{O}_4/\text{conc. } H_2SO_4)$

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12. (a) (i) The separate lines indicate that there are **discrete (definite) energy levels** in the hydrogen atom.

(ii) When the hydrogen atom is **heated** or when an **electric spark is passed**, the electron **absorbs energy** and **moves from a lower energy level to a higher energy level**. On **falling back to lower energy level, energy is emitted** in form of radiations of specific wave length and frequency

(b) The energy levels get closer as the energy difference decreases. This is due to **decreased nuclear attraction on electrons** in the energy levels which **nearly becomes** constant resulting into a **continuum.**

(c) The main energy level of an atom which determines the energy of an electron.

13. (a)

Substance added to water	Effect on	
	Vapour pressure of water	Total vapour pressure of the system
(i) Sodium chloride	decreases	decreases
(ii) Propanone	increases	increases
(iii) Tetrachloro methane	remains constant	increases

(b) In (a)(ii), the **hydrogen bonds** in water are **stronger than** the **intermolecular forces between** water and propanone. The **escaping tendency** of molecules of component into vapour phase **increases** causing increased vapour pressure of both water and the system.

In a(iii) carbon tetra chloride is **immiscible** with water. Each component escapes into vapour phase **independent** of the other and therefore the vapour pressure of water remains constant.
Also, each component **contributes its own vapour pressure** to the system and thus the vapour pressure of the system increases.

(c) Vapour pressure of $x = 760 - 732.7 = 27.3mmHg.$

$mass\ of\ compound\ x = 1 - 0.8 = 0.2g$

$$\frac{mass\ of\ x\ in\ distillate}{mass\ of\ H_2O\ in\ distillate} = \frac{vapour\ pressure\ of\ x\ (Rmm\ of\ x)}{vapour\ prssure\ of\ H_2O \times Rmm\ of\ H_2O}$$

$$\frac{0.2}{0.8} = \frac{27.3 \times Rmm\ of\ x}{732.7 \times 18}$$

$$Rmm\ of\ x = \frac{0.2 \times 732.7 \times 18}{0.8 \times 27.3} = \mathbf{120.77}$$

14. (a) $CH_3CH(OH)CH_2CH_3 \xrightarrow[heat]{conc.\ H_2SO_4} CH_3CH=CHCH_3 \xrightarrow{Br_2/CCl_4} CH_3CH(Br)CH(Br)CH_3$

$$CH_3C{\equiv}CCH_3 \xrightarrow[heat]{KOH/Ethanol} CH_3CH(Br)CH(Br)CH_3$$

Recall; In step (i) (conc.H_3PO_4/360°C) can be used instead of ($conc.\ H_2SO_4$ /heat)
In step (iii) candidates must avoid using (NaOH/Ethanol) instead of (KOH/Ethanol)

(b) $CH_3CHO \xrightarrow[heat]{Cr_2O_7^{2-}/H^+} CH_3COOH \xrightarrow{PCl_5} CH_3COCl \xrightarrow[heat]{conc.\ NH_3} CH_3CONH_2 \xrightarrow[dryether]{LiAlH_4} CH_3CH_2NH_2$

Alternatively;

$$CH_3CHO \xrightarrow[or\ LiAlH_4/\ dry\ ether\ or\ NaBH_4]{H_2/Ni,heat} CH_3CH_2OH \xrightarrow{PCl_5} CH_3CH_2Cl \xrightarrow[heat]{Conc.\ NH_3} CH_3CH_2NH_2$$

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Alternatively;

$CH_3CHO \xrightarrow[heat]{Cr_2O_7^{2-}/H^+} CH_3COOH \xrightarrow{(NH_4)_2CO_3} CH_3COO^-NH_4^+$

$CH_3CH_2NH_2 \xleftarrow[dry\ ether]{LiAlH_4} CH_3CONH_2 \xleftarrow{heat}$

(c) $CH_3CH{=}CH_2 \xrightarrow[2.\ H_2O/heat]{1.\ conc.\ H_2SO_4} CH_3\underset{OH}{C}HCH_3 \xrightarrow[heat]{CrO_3/H^+} CH_3\overset{O}{\overset{\|}{C}}CH_3$

or (Cu/300°C)

or (MnO_4^-/conc.H_2SO_4)

Alternatively;

$CH_2CH{=}CH_2 \xrightarrow{Cl_2/CCl_4} CH_3\underset{Cl}{C}HCH_2Cl \xrightarrow[heat]{KOH/ethanol} CH_3C{\equiv}CH$

$CH_3\overset{O}{\overset{\|}{C}}CH_3 \xleftarrow[HgSO_4,\ 60°C]{H^+/H_2O} CH_3C{\equiv}CH$

Alternatively;

$CH_3CH{=}CH_2 \xrightarrow{HCl} CH_3\underset{Cl}{C}HCH_3 \xrightarrow[heat]{NaOH(aq)} CH_3\underset{OH}{C}HCH_3 \xrightarrow{Cr_2O_7^{2-}/H^+} CH_3\overset{O}{\overset{\|}{C}}CH_3$

15. (a) - Use of iron catalyst
- High pressure or pressure of 200 – 350 atm
- Low temperature or Temperature of 450 - 550°C

(b) $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$

$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$

$4NO_2(g) + 2H_2O(l) + O_2(g) \longrightarrow 4HNO_3(aq)$

Alternatively;

$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$

$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$

$2NO_2(g) + H_2O(l) \longrightarrow HNO_3(aq) + HNO_2(aq)$

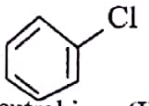
$2HNO_2(aq) + O_2(g) \longrightarrow 2HNO_3(aq)$

(c) (i) $3Cu(s) + 8HNO_3(aq) \longrightarrow 3Cu(NO_3)_2(aq) + 4H_4O(l) + 2NO(g)$

(ii) $Cu(s) + 4HNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + 2H_2O(l) + 2NO_2(g)$

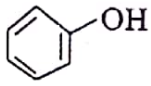
16. (a) (i) Reagent: **Hot** sodium hydroxide **solution** followed by silver nitrate **solution**

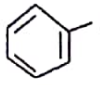
(ii) $CH_3CH_2CH_2Cl$ – white precipitate or white solid



- No observable change

(b) (i) Neutral iron (III) chloride solution

(ii)  Gives a violet or purple colouration



No observable change.

(c) (i) **Aqueous** iodine **solution** and sodium hydroxide solution

(ii) $CH_3COCH_2CH_2CH_3$ – yellow precipitate formed

$CH_3CH_2COCH_2CH_3$ – no observable change

17. (a) (i) $K_C = \frac{[HI]^2}{[H_2][I_2]}$

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(ii) *let* x = *number of moles of* H_2 *which reacted at equilibrium*

	$H_2(g)$ +	$I_2(g)$ ⇌	$2HI(g)$
initially	1mole	⅓mole	0
At equilibrium	$1-x$	$⅓-x$	$2x$

Hence; $50 = \frac{(2x)^2}{(1-x)(⅓-x)}$

$\Rightarrow 69x^2 - 100x + 25 = 0$

$\therefore x = \frac{-b \pm\sqrt{b^2-4ac}}{2a}$

$x = \frac{-(-100)\pm\sqrt{(-100)^2-4(69\times25)}}{2\times69}$

$x = 1.12\ or\ 0.32$

Thus; the appropriate value of $x = 0.32mole$

Hence; number of moles of hydrogen iodide at equilibrium

$= 2 \times 0.32 = \mathbf{0.64mole}$

(b) The equilibrium mixture is **dissolved in aqueous potassium** iodide solution and the resultant solution **titrated** against **standard sodium thiosulphate solution** using **starch indicator**.
The concentration of iodine can then be calculated using the equation;

$I_2(aq) + 2S_2O_3^{2-}(aq) \longrightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$

QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2010

1. (a) (i) Define the term radioactivity (1 mark)
(ii) Name three types of radiations emitted during radioactivity and stated how they affect the nucleus of radioisotope. (4 marks)

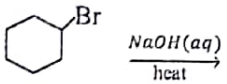
(b) The table below shows how the mass of radioactive protactinium, $^{234}_{91}Pa$ varies with time.

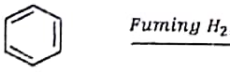
Mass of Protactinium (g)	60.0	38.5	26.0	17.2	11.1
Time (s)	0	40	80	120	160

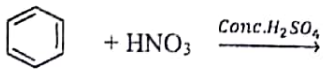
(i) Plot a graph of protactinium against time. (3 marks)
(ii) Use your graph to determine the half-life of protactinium (1 mark)
(iii) Calculate the radioactive decay constant of protactinium. (2 marks)
(iv) Determine the time taken for 8 g of protactinium to decay to 1g (2 marks)

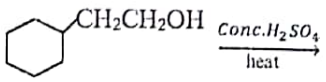
(c) Briefly describe how;
(i) carbon – 14 can be used to determine the age of archeological objects. (3 marks)
(ii) oxygen – 18 can be used to determine the mechanism for esterification of a mono carboxylic acid with a primary alcohol. (4 marks)

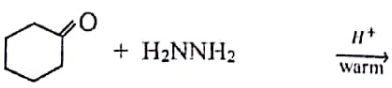
2. Complete the following equations and outline a possible mechanism for the reaction in each case.

(a)  (2 ½ marks)

(b)  (4 marks)

(c)  (4 marks)

(d)  (4 marks)

(f)  (5 ½ marks)

3. Carbon, silicon, germanium tin, and lead are elements in group (IV) of the Periodic Table.
(a) State the trend in the metallic nature of the elements and explain your answer. (3 ½ marks)

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(b) Using carbon dioxide, silicon(IV) oxide and lead(IV) oxide to illustrate your answer, explain the trend in the acidic nature of the oxides of the group IV elements. (7 ½ marks)

(c) Write equation(s) for the reaction between silicon(IV) oxide and

(i) magnesium (1 ½ marks)

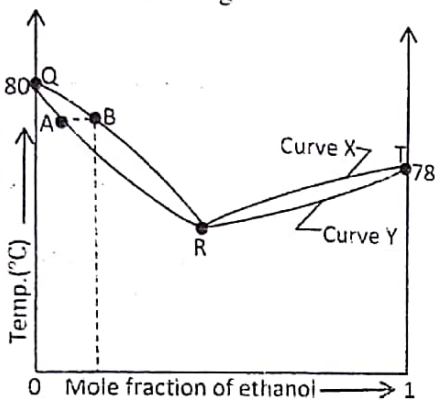
(ii) hydrofluoric acid. (3 marks)

(d) Concentrated hydrochloric acid was added drop-wise to lead(II) nitrate solution until it was in excess. State what was observed and write equations for reactions which took place. (4 ½ marks)

4. (a) Explain why a solution containing 2.5g of glucose, $C_6H_{12}O_6$, in 100g of ethanol boils at 83°C at 760mmHg pressure whereas pure ethanol boils at 78°C at the same pressure. (3 ½ marks)

(b) Using the data in (a), calculate the molar boiling point constant, Kb f ethanol . (4 marks)

(c) The figure below shows the boiling



(i) Identify curves X and Y, and R (3 marks)

(ii) A mixture at point R was boiled, state what was happen to its composition. (1 marks)

(iii) State the relationship between A, B and C. (2 marks)

(iv) Explain the shape of curve Y, between T and R (3 marks)

(v) Draw a labelled diagram to illustrate the vapour pressure – composition diagram for the benzene – ethanol system (3 ½ marks)

5. Explain the following observations:

(a) An aqueous solution of iron(III) chloride is acidic to litmus. (3 marks)

(b) Copper(I) chloride is a white solid whereas copper(II) chloride is a green solid. (3 marks)
(Atomic number of copper is 69)

(c) Methanoic acid is a stronger acid than ethanoic acid. (3 marks)

(d) When aqueous ammonia is added dropwise to solution of nickel(II) sulphate a green precipitate is formed which dissolves in excess ammonia to form a blue solution. (5 marks)

(e) Alkenes undergoes electrophilic addition reactions whereas carbonyl compounds undergo nucleophilic addition reactions. (4 marks)

6. (a) Hydrochloric acid was added to 25cm^3 of 0.1M ammonia solution and pH of the solution was measured at intervals. The data obtained are given in the table below.

Volume of hydrochloric acid (cm^3)	10.0	15.0	16.5	17.0	20.0	25.0
pH of the mixture	9.08	8.30	6.70	2.97	1.96	1.60

(i) Plot a graph of pH against volume of hydrochloric acid. (3 marks)

(ii) Explain the shape of the graph (6 ½ marks)

(iii) Calculate the molarity of the hydrochloric acid. (3 ½ marks)

(b) The pH ranges of some indicators are given below:

Indicator	**pH range**
Thymol blue	1.2 – 2.8
Methyl red	4.8 – 6.0
Phenolphthalein	6.6 – 8.0

Which one of the above indicators is most suitable for use in above titration? Give reasons for your answer. (1 ½ marks)

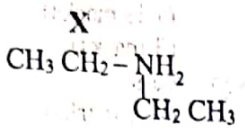
(c) (i) Calculate the molarity ammonium chloride at the end-point. (2 ½ marks)

(ii) Determine the hydrolysis constant for ammonium chloride. (3 marks)

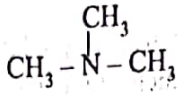
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7. The structural formula of the amines, X, Y and Z are shown below.

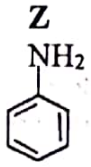
X



Y



Z



(a) (i) Describe the reactions of the amines with nitric(III) or nitrous acid.
(*Your answer should include observations and equations*) (8 marks)
(ii) The basicity of the amines is in the order X > Y > Z. (5 marks)

(b) (i) Write equation(s) to show how Z can be prepared from nitrobenzene.
(*Your answer should include observations and conditions*) (4 marks)

(c) Z can be used in the manufacture of azo-dye. Outline the steps you would follow in preparing azo-dye Starting from Z. (*Your answer should include observations and equations*) (4 marks)

8. (a) Aluminium can be extracted from Bauxite which is impure, hydrated aluminium oxide. Describe how,
(i) pure aluminium oxide is obtained from bauxite (10 marks)
(ii) aluminium is obtained from pure aluminium oxide. (*Your answer should include equations*) (3 ½ marks)
(b) Discuss the reactions of aluminium with hydrochloric acid, sulphuric acid and nitric acid. (3 ½ marks)
(c) Explain why aluminium utensils should not be washed using soap solutions. (3 marks)

END

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2010

Question. One.

(a) (i) Radio activity is the spontaneous disintegration of an **unstable atom** or nucleus or element into a **stable atom** or nucleus or element with emission of radiations

(ii)
- Alpha particles
- Beta particles
- Gamma rays

Effect of emission alpha particles on the nucleus of the radioisotope
The mass number of the atom **reduces by four units** while the atomic number **reduces by two units**
Effect of emission of beta particles on the nucleus of the radioisotope
Emission of a beta particle **increases the atomic number of the atom by one unit** but has **no effect** on the mass number
Effect of emission of Gamma rays;
Emission of gamma rays has **no effect on both the atomic number and mass number** but just reduces the energy content of the nucleus

(b) (i) See graph next page

(ii) Half life $= \frac{1^{st}t½ + 2^{nd}t½}{2}$

$= \frac{64+68}{2} = 66 seconds$

(iii) Using; $\lambda t½ = In2 (\lambda = decay\ constant, t½ = half\ life)$

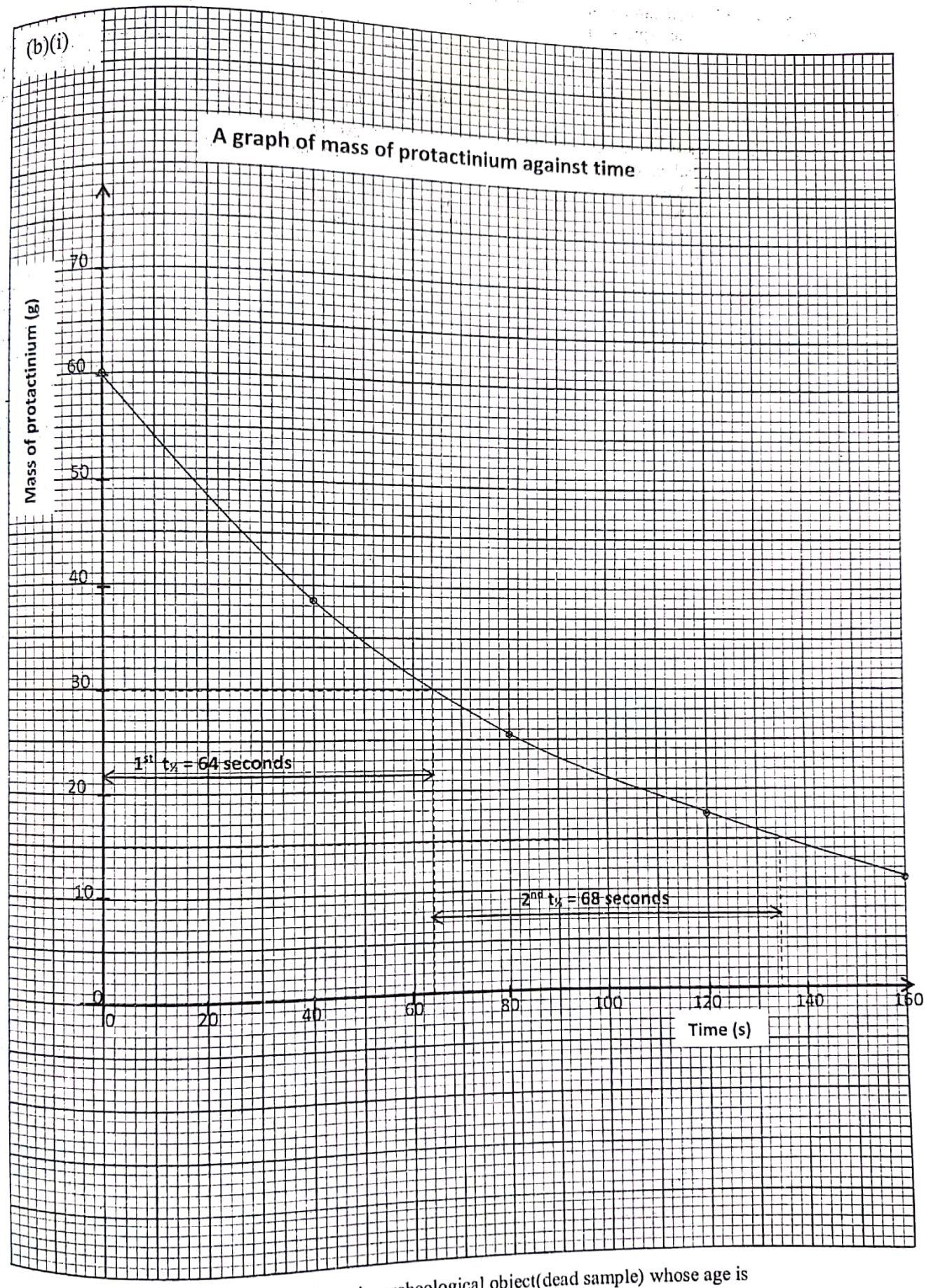
$\lambda = \frac{In2}{t½} = \frac{0.693}{66} = 0.0105 second^{-1}$

(iv) Using; $\lambda t = 2.303 \log_{10}\left(\frac{No}{Nt}\right)$ $(where;\ No = 8, Nt = 1)$

$Hence;\ time;\ t = \frac{2.303 \log_{10}\left(\frac{8}{1}\right)}{0.0105} = 198.08 seconds$

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(b)(i)



(c) (i) The concentration of carbon-14 in the archeological object(dead sample) whose age is being required is measured ie No
The concentration of carbon-14 in a similar object that is still alive is also measured ie Nt

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Since the half life of carbon-14 is known, using these values the age of the archeological object can be calculated using the expression;

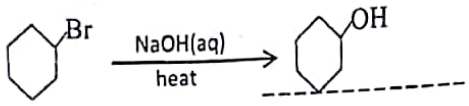
$$\lambda t = 2.303 \log\left(\frac{No}{Nt}\right)$$

$$\left(where;\ \lambda = decay\ constant = \frac{0.693}{half\ life}\right)$$

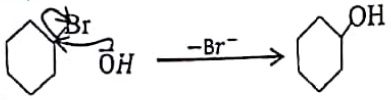
(ii) The primary alcohol whose oxygen has been **labeled with oxygen-18** is reacted with a mono carboxylic acid (with the usual oxygen-16 atoms), using a **mass spectrometer**, the molecular mass of the ester and water formed are determined.
The results show that the oxygen -18 is found in the ester only but not in water, indicating that, in the primary alcohol, the carbon-hydroxyl bond (C–OH bond) is broken while in the ester it is the oxygen-hydrogen bond (O–H bond) that breaks, hence the mechanism of reaction can be determined.

Question. Two.

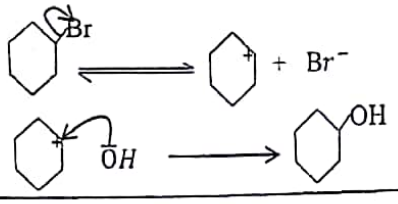
(a)



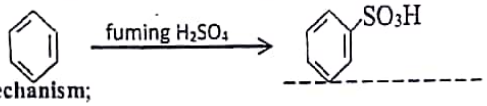
Mechanism;



Alternatively;

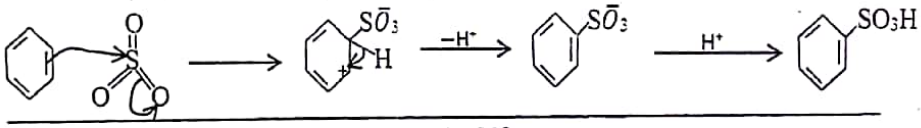


(b)

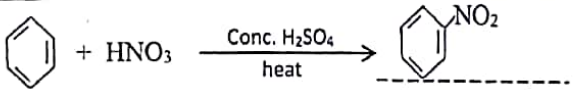


Mechanism;

$$2H_2SO_4(l) \rightleftharpoons SO_3 + H_3O^+ + HSO_4^-$$

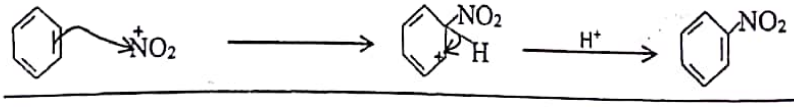


(c)

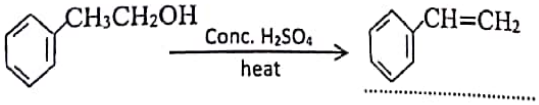


Mechanism;

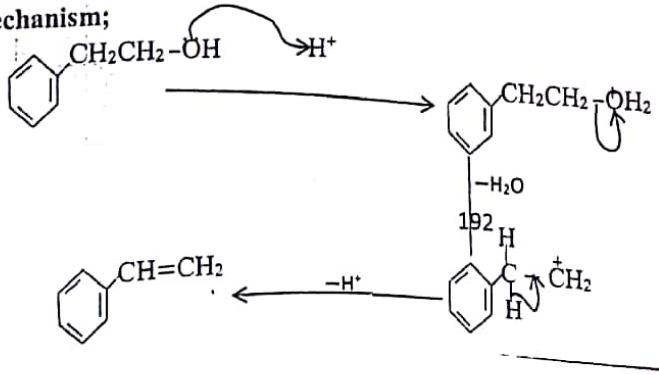
$$HNO_3 + H_2SO_4 \longrightarrow \overset{+}{N}O_2 + HS\bar{O}_4 + H_2O$$



(d)

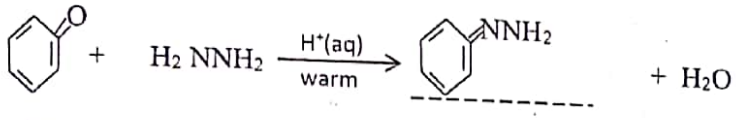


Mechanism;

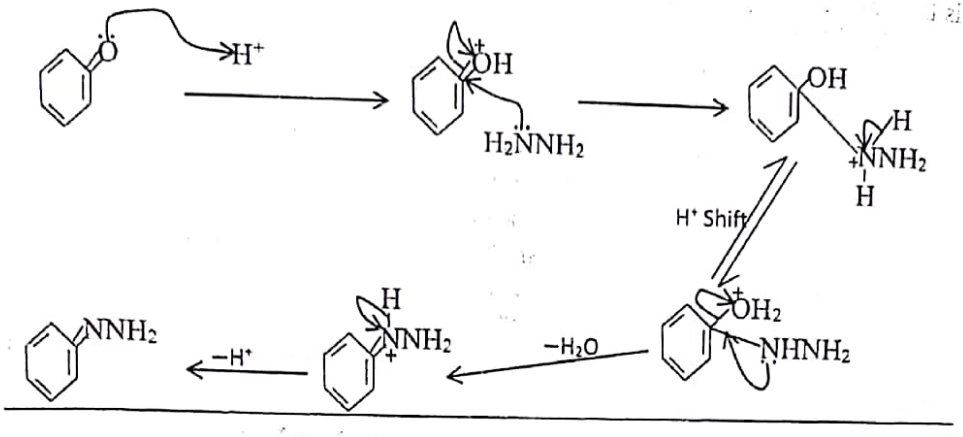


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(e)



Mechanism;



Question. Three.

(a) Trend; -The metallic nature of the elements **increases from carbon to lead**
Explanation;
From carbon to lead, the **atomic radius increases** which results into a **decrease in the nuclear attraction for the outer most energy level electrons** and thus the **tendency of the element to lose these electrons increases** hence the **increase in the metallic character** down the group from carbon to lead

(b) The acidic nature of the oxides of group (IV) elements **decreases from carbon dioxide to lead (IV) oxide**
For example, carbon dioxide and silicon (IV) oxide are **acidic** while lead (IV) oxide is **amphoteric**
Carbon dioxide reacts with alkalis to form **a carbonate salt** and **water**

$$2\overline{O}H(aq) + CO_2(g) \longrightarrow CO_3^{2-}(aq) + H_2O(l)$$

Silicon (IV) oxide reacts with **hot concentrated** alkalis to form a **silicate** and **water**

$$SiO_2(s) + \overline{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + H_2O(l)$$

Lead (iv) oxide reacts with **cold concentrated** hydrochloric acid to form **lead (IV) chloride** and **water**

$$PbO_2(s) + 4HCl(aq) \longrightarrow PbCl_4(aq) + 2H_2O(l)$$

Lead (IV) oxide also reacts with **hot concentrated** alkalis to form a **plumbate (IV) complex**

$$PbO_2(s) + 2\overline{O}H(aq) + 2H_2O(l) \longrightarrow C\ Pb(OH)_6^{2-}(aq)$$

or, $PbO_2(s) + 2\overline{O}H(aq) \longrightarrow PbO_3^{2-}(aq) + H_2O(l)$

(c) (i) $2Mg(s) + SiO_2(s) \longrightarrow 2MgO(s) + Si(s)$
or, $4Mg(s) + Si\ O_2(s) \longrightarrow 2MgO(s) + Mg_2Si(s)$

(ii) $SiO_2(s) + 6HF(aq) \longrightarrow H_2SiF_6(aq) + 2H_2O(l)$
or, $SiO_2(s) + 4HF(aq) \longrightarrow SiF_4(g) + 2H_2O(l)$

(d) **White precipitate** formed **dissolved** in excess acid to form a colourless solution

$$Pb^{2+}(aq) + 2Cl^-(aq) \longrightarrow PbCl_2(s)$$

or, $PbCl_2(s) + 2Cl^-(aq) \longrightarrow PbCl_4^{2-}(aq)$

Question. Four.

(a) A solution of ethanol and glucose contains glucose molecules which are **non volatile** and these **occupy part of the surface** of the solution there by **reducing the escaping tendency** of the volatile ethanol molecules from solution into vapour phase hence leading to low vapour pressure and therefore to raise the vapour pressure of the solution to 760mmHg (which is the atmospheric pressure) in order for the boiling to occur, **more heating** is required and hence the solution boils at a **higher temperature** of 83°C than pure ethanol.

(b) Molecular mass of Glucose; $C_6H_{12}O_6 = (6 \times 12) + (12 \times 1) + (6 \times 16) = 180g$
Boiling point elevation caused $= (83 - 78) = 5°C$
100g of ethanol dissolved 2.5g of Glucose
$\therefore$1000g of ethanol dissolved $\left(\frac{1000 \times 2.5}{100}\right) g$ of Glucose
$= 25g$ of Glucose

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25g of Glucose cause a boiling point elevation of 5°C

∴ 180g of Glucose cause a boiling point elevation of $\left(\frac{180\times5}{25}\right)$ °C

Therefore; molar boiling constant; kb of ethanol = 36°C $mol^{-1}kg^{-1}$

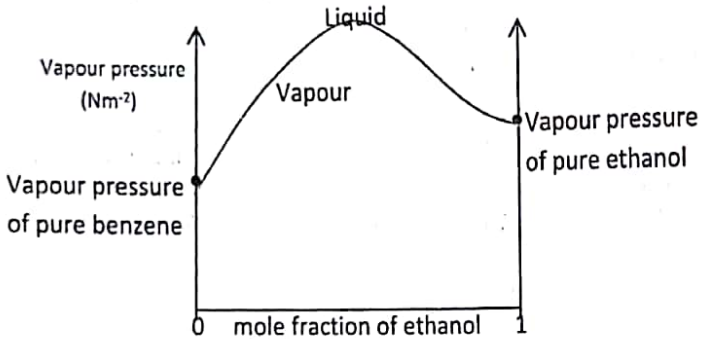
(c) (i) Curve X is the **vapour composition curve**
Curve Y is the **liquid composition curve**
Point R is the **azeotropic mixture**

(ii) Composition **remained the same**

(iii) A is a **liquid mixture** and B is the **vapour** attained from liquid mixture A when heated, while C is the **liquid mixture** obtained when vapour B is condensed

(iv) As the **mole fraction** of ethanol in solution **decreases**, the intermolecular forces of attraction between the unlike molecules of ethanol and benzene (ie ethanol-benzene) become **weaker in strength** than the intermolecular forces between pure liquid components (ie ethanol-ethanol or benzene-benzene). This results into **increased escaping tendency** of the ethanol and benzene molecules in solution into vapour phase and this leads to an **increase in the vapour pressure** of solution, hence a **decrease in boiling point** along TR.

(v) **Vapour pressure-composition diagram for the benzene ethanol system**



Question. Five.

(a) The iron (III) ion in Iron (III) chloride has a **high charge of +3** and a **small ionic radius** thus making it to have a **high charge density** or polarizing power and so in aqueous solution, iron (III) ion exists as hexaaqua iron (III) ion which undergoes **hydrolysis** to form **hyroxonium ions** that make the solution **acidic to litmus.**

$Fe(H_2O)_6^{3+}(aq) + H_2O(l) \rightleftharpoons [Fe(H_2O)_5OH]^{2+}(aq) + H_3O^+(aq)$

(b) Electronic configuration of Cu^+ is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$ and that of Cu^{2+} is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$ copper (I) ions have **completely filled 3d-orbitals** hence copper (I) ions are **non transition** hence **not coloured** but copper (II) ions have nine electrons in the **3d-orbitals hence partially filled** and thus **absorb energy from visible light** which causes the **d to d orbital electron transitions.** The remaining green light of the visible light which is not absorbed is reflected hence making copper (II) ion green.

(c) In methanoic acid, (structure, H –C(=O)–OH), the **hydrogen atom** bonded to the carboxylic group **does not neither release nor withdraw bonding electrons** to another atom or towards its self (ie has **no inductive effect**), hence the oxygen-hydrogen bond is **relatively weak** and can **easily be broken** hence the ease with which a hydrogen ion is lost in solution.

But in ethanoic acid; (structure, CH_3 –C(=O)–O–H), the **methyl group** bonded to the carboxylic group **pushes the bonding electrons towards** the carboxylic group (has a positive inductive effect). This makes the oxygen-hydrogen bond to be **less polar** and hence **more strengthened** and thus **cannot easily be broken** and so the hydrogen ion is **not easily lost** in solution, thus making ethanoic acid a weaker acid than methanoic acid

(d) The nickel (II) ions in nickel (II) sulphate **react** with aqueous ammonia to form **insoluble nickel (II) hydroxide.**

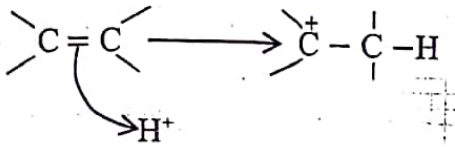
$Ni^{2+}(aq) + 2\overline{O}H(aq) \longrightarrow Ni(OH)_2(s)$

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This nickel (II) hydroxide then **reacts** with excess aqueous ammonia to form a **soluble complex of hexaammine nickel (II) ion**;

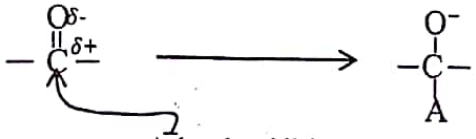
$$Ni(OH)_2(s) + 6NH_3(aq) \longrightarrow Ni(NH_3)_6^{2+}(aq) + 2\bar{O}H(aq)$$

(e) In alkenes, there is a **double bond** which **non polar** because it is between similar atoms (carbon atoms) and thus have **similar electronegativity values.**
Therefore, the double bond is a **centre of high electron density** (nucleophile) and thus can attack or react with electron deficient species (**electrophiles**) hence undergoing electrophilic addition reactions



(Electrophile)

But, in carbonyl compounds, the **oxygen atom** is **more electronegative** than the carbon to which it is bonded, and this makes the carbon acquire a **partial positive charge** and thus **electron deficient** (electrophilic) and therefore is attacked by the electron rich species (nucleophile) hence undergoing nucleophilic addition reactions ie



A (nucleophile)

Question. Six.

(a) (i) See graph next page

(ii) Initially at point A before the addition of hydrochloric acid, the pH is **high** (9.08) because of the **high concentration** of ammonia solution which is a **weak base**
Along AB, the **pH decreases gradually** because ammonia solution is **being neutralized** by the hydrochloric acid added and also because the **un neutralized ammonia and the ammonium chloride salt** formed constitute a buffer solution which resists change in pH.
Point B is the **end point** and addition of a very small amount of hydrochloric acid causes a **sharp decrease** in pH.
The pH at and point is **4.8** which is below seven because the **ammonium chloride salt** formed undergoes **hydrolysis** to form an acidic solution

$$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$$

The pH **decreases gradually** along CD due to **excess hydrochloric** acid added.

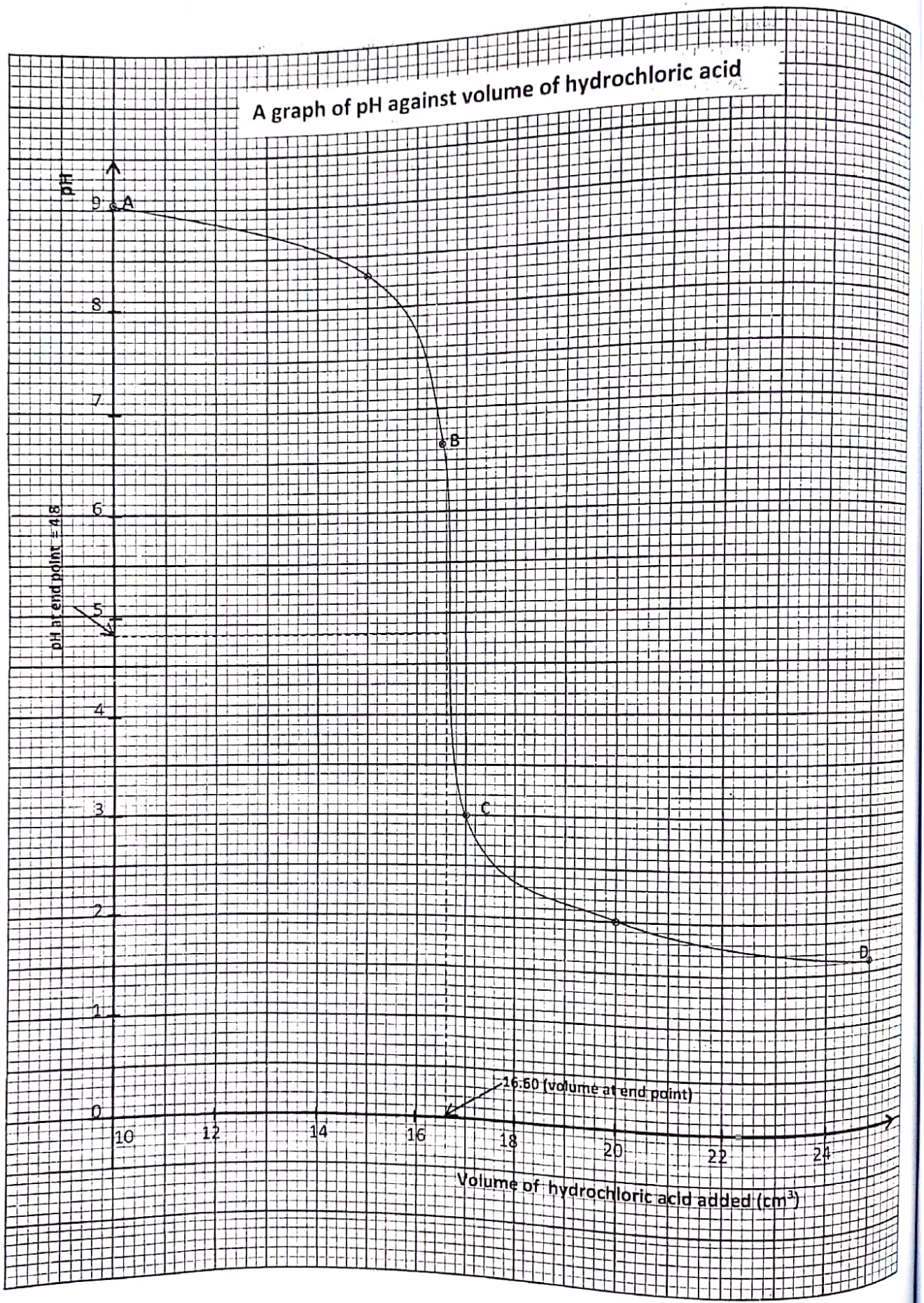
(iii) From the graph;
Volume of hydrochloric acid required for complete neutration of $25cm^3$ of ammonia solution $= 16.6cm^3$ (volume of acid at end point)

Hence;
$1000cm^3$ of solution contain 0.1mole of ammonia
$\therefore 25cm^3$ of solution contain $\left(\frac{25\times0.1}{1000}\right)$ moles of ammonia
Moles of NH_3 which reacted $= 0.0025moles$
Ammonia reacts with hydrochloric according to the equation;

$$NH_3(aq) + HCl(aq) \longrightarrow NH_4Cl(aq)$$

Thus; mole ratio of NH_3: HCl = 1: 1
Hence; moles of HCl which reacted $= 0.0025moles$
$16.6cm^3$ of solution 0.0025 moles of HCl
$\therefore 1000cm^3$ of solution contain $\frac{1000\times0.0025}{16.6}$ moles of HCl
Hence; molarity of hydrochloric acid $= 0.15moldm^{-3}$

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(b) Methyl red, because the pH at end point (4.8) is within the working range of methyl red indicator .

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(c) (i) Since mole ratio of $NH_3 : NH_4Cl = 1:1$

Hence; moles of ammonium chloride formed $= 0.0025 moles$

Total volume of resultant solution at end point $= (25 + 16.6) = 41.6cm^3$

Thus; $41.6cm^3$ of solution contain 0.0025 moles of NH_4Cl

$1000cm^3$ of solution contain $\frac{1000 \times 0.0025}{41.6}$ mole of NH_4Cl

Molarity of NH_4Cl at end point $= 0.06M$

(ii) pH at end point $= 4.8$

From $pH = -\log_{10}[H_3O^+]$

Hence; $[H_3O^+] = 10^{-pH} = 10^{-4.8} = \mathbf{1.585 \times 10^{-5} moldm^{-3}}$

Equation of hydrolysis of NH_4Cl is

$$\overset{+}{N}H_4(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$$

$$Kh = \frac{[NH_3][H_3O^+]}{[\overset{+}{N}H_4]}$$

But; $[NH_3] = [H_3O^+]$ and $[\overset{+}{N}H_4] = [NH_4Cl] = 0.06M$

Hence; $Kh = \frac{[H_3O^+]^2}{[\overset{+}{N}H_4]}$

$$= \frac{(1.585 \times 10^{-5})^2}{0.06} = \mathbf{4.187 \times 10^{-9} moldm^{-3}}$$

Question. Seven.

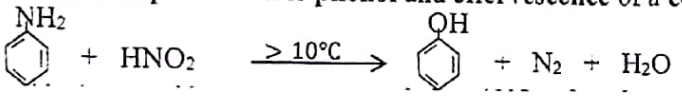
(a) (i) X which is secondary amine reacts with nitrous acid to form a **yellow oily liquid** which is **nitrosodiethyl amine**

$$CH_3CH_2 - \underset{\underset{CH_2CH_3}{|}}{NH} + HNO_2 \longrightarrow CH_3CH_2 - \underset{\underset{CH_2CH_3}{|}}{N} - N=O + H_2O$$

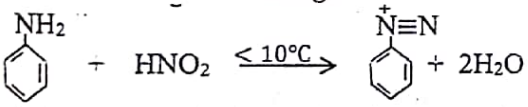
Y which is a tertiary amine reacts with nitrous acid to give **trimethyl ammonium nitrite salt**, and hence **no observable change occurs.**

$$CH_3 - \underset{\underset{CH_3}{|}}{\overset{CH_3}{|}}{N} - CH_3 + HNO_2 \longrightarrow CH_3 - \underset{\underset{CH_3}{|}}{\overset{CH_3}{|}}{\overset{+}{N}}HNO_2^-$$

Z which is a primary aromatic amine reacts with nitrous acid at a **temperature above 10°C** to give a **colourless liquid** which is **phenol** and **effervescence** of a **colourless gas** which is **nitrogen.**



Z also reacts with nitrous acid at a **temperature below 10°C** to form **benzene diazonium salt** and hence **no observable change occurs**



(ii) The basic strength of an amine depends on the **availability of the lone pair of electrons** on the nitrogen atom

X is the strongest base because it has **two ethyl groups** bonded to the nitrogen atom and these **push the bonding electrons towards** the nitrogen atom (ie ethyl groups have a positive inductive effect), and this makes the lone pair of electrons on the nitrogen atom **more available** to accept a proton

Y is a weaker base than X because the **three methyl groups crowd around** the nitrogen atom and **hinder** the proton from easily being accepted by the amine

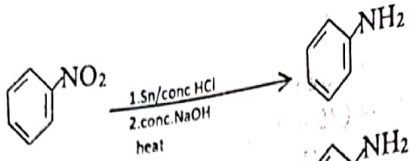
(**or; X lacks nitrogen – hydrogen bonds** and hence is **less solvated** thus X is a weaker base than Y.)

NOTE: *Solvation is a process in which there is some chemical association between the molecules of a solute and those of a solvent.*

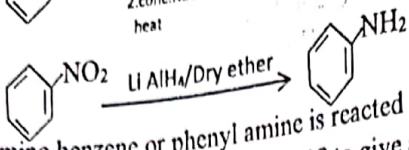
Z is the weakest base because the **benzene ring withdraws bonding electrons** from nitrogen atom (ie has a negative inductive effect) and this makes the lone pair of electrons on the nitrogen atom **less available to accept a proton.**

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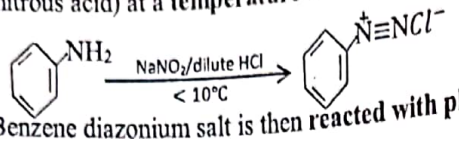
(b) (i)



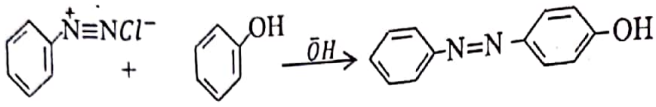
or



(ii) Z which amino benzene or phenyl amine is reacted with **sodium nitrite and dilute hydrochloric acid** (nitrous acid) at a **temperature below 10°C** to give a **colourless solution** of **benzene diazonium salt**



Benzene diazonium salt is then **reacted with phenol** under **alkaline medium** to form an azodye which is **yellow**.



Question. Eight.

(a) (i) Bauxite is first **crushed** into powder and then **heated** with **excess sodium hydroxide solution** under high pressure. The aluminium oxide being amphoteric and the silicon (IV) oxide impurity being acidic **dissolve** in the alkaline sodium hydroxide solution

$Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \longrightarrow 2NaAl(OH)_4\ (aq)$

or, $Al_2O_3(s) + 2\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_4^-(aq)$

and $SiO_2(s) + 2NaOH(aq) \longrightarrow Na_2SiO_3(aq) + H_2O(l)$

or, $SiO_2(s) + 2\bar{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + H_2O(l)$

The iron (III) oxide impurity being basic **does not** dissolve in alkaline sodium hydroxide solution, therefore the resultant mixture is **filtered** to remove the iron (III) oxide. The filtrate contains sodium aluminium; $NaAl(OH)_4$ and sodium silicate; Na_2SiO_3.

Aluminium hydroxide or **carbon dioxide** is added to the filtrate **to precipitate out aluminium hydroxide** from solution;

i.e, $Al(OH)_4^-(aq) \longrightarrow Al(OH)_3(s) + \bar{O}H(aq)$

or, $2Al(OH)_4^-(aq) + CO_2(g) \longrightarrow 2Al(OH)_3(s) + CO_3^{2-}(aq) + H_2O(l)$

Aluminium hydroxide is then filtered off and then **heated** to form **alumina (anhydrous aluminium oxide)**

$Al(OH)_3(s) \longrightarrow Al_2O_3(s) + 3H_2O(l)$

(ii) Aluminium oxide is **dissolved** in **molten cryolite** and **electrolysed** between **graphite electrodes** at **900°C** under low voltage. Aluminium is formed at the cathode according to the equation;

$Al^{3+}(l) + 3e \longrightarrow Al(l)$

(b) Aluminium reacts with **concentrated** hydrochloric acid to form **aluminium chloride** and **hydrogen gas.**

$2Al(s) + 6HCl(aq) \longrightarrow 2AlCl_3(aq) + 3H_2(g)$

Aluminium is **oxidized** by **hot concentrated** sulphuric acid to **aluminium sulphate** and the acid is reduced to **sulphur dioxide** and **water**

$2Al(s) + 6H_2SO_4(aq) \longrightarrow Al_2(SO_4)_3(aq) + 6H_2O(l) + 3SO_2(g)$

Nitric acid (both dilute and concentrated) render aluminium passive.

(c) Soap contains **hydroxyl ions** produced by **hydrolysis** of soap; ie

$RC\bar{O}O(aq) + H_2O(l) \rightleftharpoons RCOOH(aq) + \bar{O}H(aq)$

from soap

Then, these hydroxyl ions **react** with the aluminium in the utensils which is **amphoteric** to form the aluminate ions

$Al(s) + 2\bar{O}H(aq) + 6H_2O(l) \longrightarrow 2Al(OH)_4^-(aq) + 3H_2(g)$

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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2009

1. (a) The enthalpies of some reactions are given below.

		$\Delta H_f^\theta / kJmol^{-1}$
(i)	$Na_2O(s) + H_2O(l) \longrightarrow 2NaOH(s)$	$\Delta H_1^\theta = -205$
(ii)	$NaOH(s) + (aq) \longrightarrow NaOH(aq)$	$\Delta H_2^\theta = -56.5$
(iii)	$Na(s) + H_2O(l) + (aq) \longrightarrow NaOH(aq) + ½H_2(g)$	$\Delta H_3^\theta = -410$
(iv)	$H_2(g) + ½O_2(g) \longrightarrow H_2O(l) \quad \Delta H_1^\theta = -205$	$\Delta H_4^\theta = -285.8$

Calculate the standard enthalpy of formation of sodium oxide from (4 marks)

(b) (i) from your answer in (a); state whether sodium oxide is a stable compound or not. (1½ mark)

(ii) Give a reason for your answer in (b) (i) above. (1 mark)

2. Complete the following reaction equations and write the I.U.P.A.C. names of the main organic product in each case.

(a) $CH_3-CH=\underset{\displaystyle CH_3}{\overset{|}{C}}-CH_3 \xrightarrow{MnO_4^-(aq)\,/\,\bar{O}H(aq)}$ (1 mark)

(b) OH $\xrightarrow[\text{Heat}]{\text{Conc. } H_2SO_4}$ (½ mark)

(c) COOH $\xrightarrow[\text{Heat}]{\text{Excess NaOH (aq)}}$ (½ mark)

3. State the conditions and write equation for the reaction between water and

(i) Silicon (2½ marks) (ii) Lead (2½ marks)

4. (a) polonium, $^{216}_{84}Po$ undergoes radio-active decay to give elements X and Y according to following equation $^{216}_{84}Po \longrightarrow X + \beta \longrightarrow Y + a$.

Write the:

(i) Atomic numbers of X and Y. (1 mark)

(ii) Mass numbers of X and Y (1 mark)

(b) Calculate the half-life of Y. (The decay constant of Y is $6.54\times 10^{-4} min^{-1}$ (2 marks)

5. Write equations to show how 1-bromopropane can be

(a) Methoxypropane.

(b) Propanal (1½ marks)

6. Both lithium and magnesium exhibit diagonal relationship. (3 marks)

(a) State:

(i) What is meant by the term diagonal relationship? (2 marks)

(ii) Three properties in which lithium and magnesium show similarities. (3 marks)

(b) Name two other pairs of elements that show diagonal relationship. (1 mark)

7. Name one reagent that can be used to distinguish between the following pairs of compounds and in each case, state what would be observed if each member of the pair was treated with the reagent you have named.

(a) HCOOH and CH_3COOH. (3 marks)

(b) OH and $CH_3\underset{\displaystyle OH}{\overset{|}{C}}HCH_3$

8. (a) Write: (3 marks)

(i) Equation for the hydrolysis of sodium benzoate in water

(ii) The expression for the hydrolysis constant, K_h of sodium benzoate. (1 mark)

(b) A solution contains 0.2 moles of sodium benzoate per litre at 25°C. (1 mark)

(i) Calculate the pH of the solution

[the hydrolysis constant of sodium benzoate is $1.6 \times 10^{-10} mol\ dm^{-3}$, Kw is $1.0\times 10^{-4}\ mol^2\ dm^{-6}$ at 25°C]. (3 marks)

(ii) State the assumptions you have made in (b) (i) above. (1 mark)

9. State what would be observed and write equation for the reaction that would take place if the following was added to acidified potassium dichromate (VI) solution.

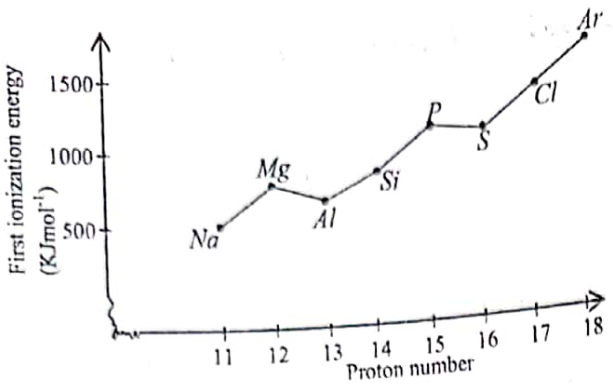
(a) Hydrogen peroxide

(b) A solution of hydrogen sulphide

10. (a) Define the term First ionization energy.

(b) The graph below shows the variation of first ionization energy with the atomic number across period 3 elements in the Periodic Table.

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Explain why:
(i) The first ionization energy increases overall, across the period (3 marks)
(ii) The first ionization energy of aluminium is less than that of magnesium. (2 marks)
(iii) The first ionization energy of sulphur is less than that of phosphorus. (2 marks)
(iv) The first ionization energy of magnesium is very high (1 mark)

11. Complete the following equations and in each case, write a mechanism for the reaction.

(a)  $CH_2CH_2Br \xrightarrow[heat]{NaOH(aq)} \ldots\ldots\ldots\ldots \xrightarrow{H^+(aq)} \ldots\ldots\ldots\ldots$ (4 marks)

(b)  $+ (CH_3)_2C = CH_2 \xrightarrow{H_2SO_4(aq)} \ldots\ldots\ldots\ldots$ (3 marks)

(c) $CH_3CH_2Cl + HC \equiv C^-Na^+ \xrightarrow[Dry\ ether]{Liq.NH_3}$ (3 marks)

12. Strontium hydroxide is sparingly soluble in water.
(a) Write
(i) Equation for the solubility of strontium hydroxide in water. (1 mark)
(ii) An expression for the solubility product, K_{sp} of strontium hydroxide. (1 mark)
(b) The solubility of strontium hydroxide is 0.524g per $100cm^3$ of water at 20°C. Calculate the:
(i) Solubility product of strontium hydroxide at 20°C and state its units. (3½ marks)
(ii) Volume of 0.01M potassium chromate (VI) solution that must be added to $1dm^3$ of a saturated solution of strontium hydroxide to precipitate strontium chromate (VI) (2 marks)
(c) Sodium hydroxide was added to a saturated solution of strontium hydroxide.
(i) State what happened to the solubility strontium hydroxide. (½ mark)
(ii) Give a reason for your answer in (c) (i) above. (1 mark)

13. State what would be observed and write equation for the reaction that would take place when:
(a) Tin (II) chloride is added to acidified aqueous solution of sodium dichromate (VI) (2½ marks)
(b) 2-3 drops of 2,4-dinitrophenyl hydrazine is added to a diluted aqueous solution of methanol (2 marks)
(c) A mixture of acidified potassium manganate (VII) and ethane-1-2-dioic acid is heated (2½ mks)
(d) Dilute hydrochloric acid was added to sodium thiosulphate solution. (2 marks)

14. A compound, W, on combustion gave 0.629g of carbon dioxide and 0.257g of water.
(a) Determine the empirical formula of W. (2½ marks)
(b) When 0.10g of W was vapourised, it occupied a volume of $53.5cm^3$ at s.t.p.
(i) Calculate the molecular mass of W. (1½ marks)
(ii) Determine the molecular formula of W. (1 mark)
(iii) Write the structural formula of W. (½ mark)
(c) Write equation to show how W can be convered into pent-2-yne. (3½ marks)

15. (a) Write the general outermost electronic configuration of group (VII) elements in the Periodic Table. (1 mark)
(b) The boiling points and reduction electrode potentials of group (VII) elements in the Periodic table are given in the table below

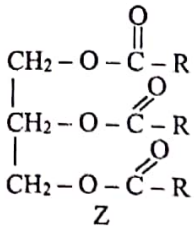
Element	F	Cl	Br	I
Boiling point/°C	−187	−35	59	18.3
Electrode potential /V	+2.87	+1.36	+1.07	+0.54

(i) State the trend in the boiling points of the elements and explain your answer. (3 marks)
(ii) Which one of the elements is the strongest oxidizing agent? (1 mark)
(c) Chlorine was bubbled through a solution containing bromide ions.
(i) State what was observed and give reasons for your answer. (2½ marks)

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(ii) Write equation of the reaction that took place. (1½ marks)

16. (a) The structural formula of a fat, Z is shown below.



Z

During the preparation of soap from Z, 1.108g of Z heated with 10.0cm^3 of 1.0M sodium hydroxide for some time and then cooled. The un-reacted alkali required 4.0cm^3 of a 0.1M hydrochloric acid for complete neutralization.

(i) Write equation for the reaction between Z and sodium hydroxide. (1 mark)

(ii) Determine the relative formula mass of Z. (3 marks)

(b) Explain the cleaning action of soap. (3 marks)

(c) the structural formulae of salt A and B are shown below.



A B

Which one of the salts would you expect to be more effective as a cleaning agent? Give a reason for your answer. (2 marks)

17. (a) Differentiate between order of reaction and molecularity. (2 marks)

The table below shows kinetics data for the following reaction

$5Br^-(aq) + BrO_3^-(aq) + 6H^+(aq) \longrightarrow 3Br_2(aq) + 3H_2O(l)$

Volume of BrO_3^-/cm^3	3.0	4.0	5.0	6.0	8.0	10.0
Time *(t)/s*	69.0	45.0	35.0	31.0	24.0	18.5

(i) Plot a graph of $\frac{1}{t}$ against volume of bromated (V), BrO_3^- in the space provided next page

(ii) Determine the order of the reaction with respect to bromate(V) and give a reason for your answer (1 mark)

(iii) Determine the rate constant for the reaction and state its units (1 mark)

(iv) Write equation for the rate of the reaction in terms of concentration of BrO_3^- (1 mark)

END

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2009

1. (a) **Equation of reaction leading to formation of sodium oxide**

$2Na(s) + ½O_2(g) \longrightarrow Na_2O(s);\ \Delta H_f^\theta = ??$

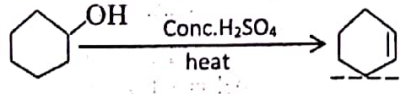
$$\Delta H_f^\theta = 2\Delta H_3^\theta - \Delta H_1^\theta + \Delta H_4^\theta - 2\Delta H_2^\theta$$
$$= 2(-410) - (-205) + (-285.8) - 2(-56.5)$$
$$= 787.8KJmol^{-1}$$

(b) (i) Sodium oxide is a **stable compound**.

(ii) The enthalpy of formation of sodium oxide is **negative** or the enthalpy of formation of sodium oxide is **exothermic.**

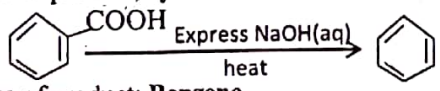
2. (a) $CH_3-CH=\overset{CH_3}{\overset{|}{C}}-CH_3 \xrightarrow{Mn\bar{O}_4(aq)/\bar{O}H} CH_3\,CH(OH)\,C(OH)(CH_3)_2$

Name of product; **2- methylbutane – 2, 3 – diol**

(b) 

or C_6H_{10}

Name of product; **cyclo hexene.**

(c) 

or  or C_6H_6

Name of product; **Benzene**

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3. (i) **Red hot** silicon or **heated** silicon and **steam.**

$Si(s) + 2H_2O(g) \longrightarrow SiO_2(s) + 2H_2(g)$

(ii) **Soft** water and **air (oxygen)** or **aerated soft** water

$2Pb(s) + 2H_2O(l) + O_2(g) \longrightarrow 2Pb(OH)_2(s)$

4. (a) (i) X; 85 Y; 83 (ii) X; 216 Y 212

(b) Half-life $t\frac{1}{2} = \frac{0.693}{\lambda}$

$= \frac{0.693}{6.54\times10^{-4}} = \mathbf{1059.63 minutes}$

5. (a) $CH_3CH_2CH_2Br + CH_3\bar{O}Na^+ \xrightarrow{heat} CH_3CH_2CH_2OCH_3$

or $CH_3CH_2CH_2Br \xrightarrow[heat]{CH_3OH/NaOH} CH_3CH_2CH_2OCH_3$

(b) $CH_3CH_2CH_2Br \xrightarrow[\bar{O}H(aq)]{NaOH(aq)\text{ or}} CH_3CH_2CH_2OH \xrightarrow[heat]{CrO_3/H^+ \text{ or } Cr_2O_7^{2-} \text{ or } MnO_4^-/\text{conc. } H_2SO_4} CH_3CH_2CHO$

6. (a) (i) **Similarity in chemical properties** between elements in period two to their diagonal neighbours in period three and in adjacent groups in the periodic table.

(ii) –Both Lithium and magnesium **react with nitrogen** when **heated** to form **nitrides**

- Both Lithium and magnesium form hydrogen carbonates which exist in solution.
- Both Lithium and magnesium when heated in oxygen form normal oxides.
- Both Lithium and magnesium form carbonates and hydroxides which are sparingly soluble in water.

(b) Boron and Silicon, Beryllium and aluminium

7. (a) **Reagent;** Acidified potassium manganate (VII) solution

Observation; $HCOOH$ - **purple** solution turns **colourless**

CH_3COOH - No observable change

Alternatively;

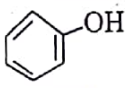
Reagent; Ammoniacal silver nitrate solution

Observation; $HCOOH$ – gives a **silver mirror**

CH_3COOH – gives **no observable change**

(b) **Reagent;** Neutral Iron (III) chloride solution

Observation;



- Purple colouration or violet colouration

$CH_3\overset{OH}{\overset{|}{C}}HCH_3$ – No observable change

8. (a) (i) $C_6H_5CO\bar{O}(aq) + H_2O(l) \rightleftharpoons C_6H_5COOH(aq) + \bar{O}H(aq)$

(ii) $Kh = \frac{[C_6H_5COOH][\bar{O}H]}{[C_6H_5CO\bar{O}]}$

(b) (i) $[\bar{O}H] = [C_6H_5COOH]$ and $[C_6H_5CO\bar{O}][C_6H_5COONa] = 0.2M$

Hence; $Kh = \frac{[\bar{O}H]^2}{[C_6H_5CO\bar{O}]}$

$[\bar{O}H] = \sqrt{Kh \times [C_6H_5CO\bar{O}]}$

$= \sqrt{1.6\times10^{-10}\times0.2}$

$= 5.66\times10^{-6} moldm^{-3}$

$pOH = -\log_{10}[\bar{O}H]$

$= -\log_{10} 5.66\times10^{-6} = 5.25$

$pH = 14 - pOH$

$= 14 - 5.25 = 8.75$

Alternatively;

$[H^+] = \frac{Kw}{[\bar{O}H]}$

$= \frac{1\times10^{-4}}{5.66\times10^{-6}}$

$= 1.77\times10^{-9} moldm^{-3}$

$pH = -\log_{10}[H^+]$

$= -\log_{10} 1.77\times10^{-9}$

$= 8.75$

(ii) $[C_6H_5COOH] = [\bar{O}H]$

$[C_6H_5CO\bar{O}] = 0.2M = [salt]$

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9. (a) **Observation:** The solution of potassium dichromate (VI) changes from **orange** to **blue**
Equation; $Cr_2O_7^{2-}(aq) + 6H_2O_2(aq) + 2H^+(aq) \longrightarrow 2CrO_5(aq) + 7H_2O(l) + O_2(g)$

(b) **Observation: Orange** solution of potassium dichromate (VI) turns **green** and a **yellow solid** formed
Equation; $Cr_2O_7^{2-}(aq) + 3H_2S(aq) + 8H^+(aq) \longrightarrow 2Cr^{3+}(aq) + 3S(s) + 7H_2O(l)$

10. (a) The amount of **energy required** to remove an electron from a **gaseous** atom to form a **unipositively** charged **gaseous** ion.
or; The amount of **energy required** to remove **one mole** of electrons from **one mole** of gaseous atoms forming **one mole** of **unipositively** charged **gaseous** ions

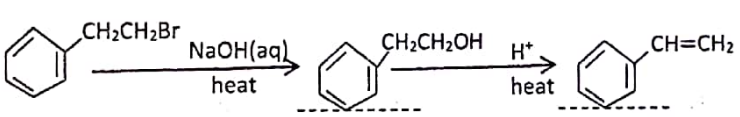
(b) (i) Across the period from one element to the next, there is **addition of a proton** to the nucleus of an atom which **increases the nuclear charge**. There is also **increase in the number of electrons** on the **same outer most energy screening effect**. The increase in nuclear charge **outweighs** the increase in screening effect and hence **effective nuclear charge increases**. Atomic **radius decreases** and this results into increase in the **attraction** of the outer most electrons hence the increase in the first ionization energy.

(ii) Electronic configuration of:
Al; $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$, Mg; $1s^2\ 2s^2\ 2p^6\ 3s^2$
Magnesium has **one electron** in the 3p- subshell and therefore **unstable** and thus **little energy** is required to remove the electron.

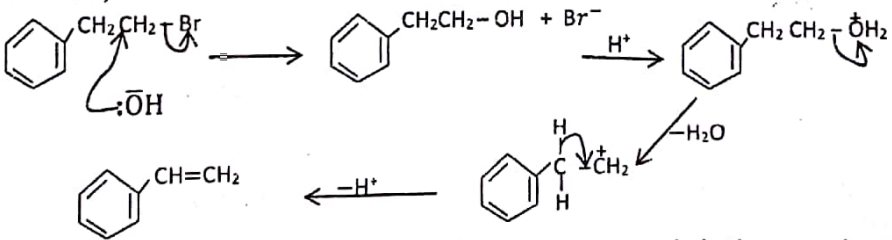
(iii) Electronic configuration of:
P; $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$, S; $1s^2\ 2s^2\ 2p^6\ 3s^2 3p^4$
Phosphorus has a **half filled 3p-subshell** and therefore **stable**. Sulphur has **four electrons** in the 3p-subshell therefore unstable.

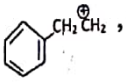
(iv) Electronic configuration of:
Mg; $1s^2\ 2s^2\ 2p^6\ 3s^2$. This is because the 3s – subshell is **filled** with electrons and hence **stable**.

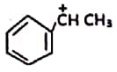
11. (a)

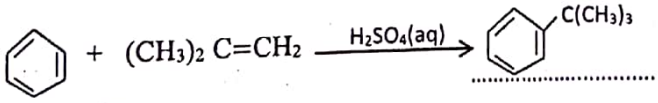


Mechanism;

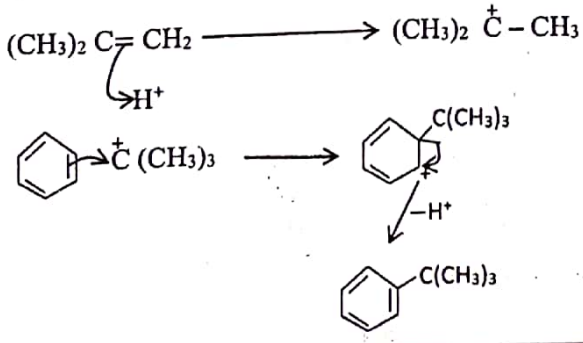


Note; instead of formation 

, the mechanism can proceed via the secondary carbonium ion;


(b) 

Mechanism;



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(c) $CH_3CH_2Cl + HC\equiv \bar{C}Na^+ \xrightarrow[\text{Dry ether}]{\text{Liq } NH_3} CH_3CH_2C\equiv CH + Cl^-$

Mechanism

$CH_3CH_2\overset{\curvearrowright}{\underset{\curvearrowleft}{C}}\equiv CH \longrightarrow CH_3CH_2C\equiv CH + Cl^-$

$\overset{\curvearrowright}{\underset{\curvearrowleft}{Cl}}$

12. (a) (i) $Sr(OH)_2(s) \rightleftharpoons Sr^{2+}(aq) + 2\bar{O}H(aq)$
or $Sr(OH)_2(s) + (aq) \rightleftharpoons Sr^{2+}(aq) + 2\bar{O}H(aq)$

(ii) $K_{sp} = [Sr^{2+}][\bar{O}H]^2$

(b) RFM of $Sr(OH)_2 = 87.6 + (2\times 16) + (2\times 1) = 121.6$

Solubility of $Sr(OH)_2$ in $gdm^{-3} = \frac{0.524\times 1000}{100} = 5.24 gdm^{-3}$

solubility of $Sr(OH)_2$ in $moldm^{-3} = \frac{5.24}{121.6} = 0.043 moldm^{-3}$

$[Sr^{2+}] = 0.043M;\ [\bar{O}H] = 2\times 0.043 = 0.086M$

$K_{sp} = (0.043)(0.086)^2$

$= 3.18\times 10^{-4} mol^3dm^{-9}$

(ii) $K_{sp} = [Sr^{2+}][CrO_4^{2-}]$

$[CrO_4^{2-}] = \frac{3.6\times 10^{-5}}{0.043} = 8.37\times 10^{-4}M$

0.01mole of CrO_4^{2-} is contained in $1000cm^3$

$\therefore 8.37\times 10^{-4}$moles of CrO_4^{2-} is contained in $\frac{8.37\times 10^{-4}\times 1000cm^3}{0.01}$

$= 83.7cm^3$

(c) (i) Solubility decreases.

(ii) Sodium hydroxide provides a **high concentration** of hydroxide ions which **react with** strontium ions to precipitate more strontium hydroxide.

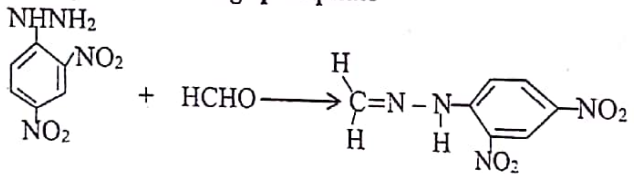
$2\bar{O}H(aq) + Sr^{2+}(aq) \longrightarrow Sr(OH)_2(s)$

13. (a) **Observation:** Solution of potassium dichromate (VI) changes from **orange** to **green.**

Equation; $3Sn^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14H^+(aq) \longrightarrow 3Sn^{4+}(aq) + 2Cr^{3+}(aq) + 7H_2O(l)$

(b) **Observation: yellow** or **orange precipitate**

Equation



(c) **Observation:** Solution mixture changes from **purple** to **colourless**

Equation;

$2MnO_4^-(aq) + 16H^+(aq) + 5C_2O_4^{2-}(aq) \longrightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$

or, $2MnO_4^-(aq) + 6H^+(aq) + 5H_2C_2O_4(aq) \longrightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$

(d) **Observation: yellow precipitate** or **yellow solid**

Equation; $S_2O_3^{2-}(aq) + 2H^+(aq) \longrightarrow S(s) + SO_2(g) + H_2O(l)$

or; $Na_2S_2O_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + S(s) + SO_2(g) + H_2O(l)$

14. (a) Mass of carbon in $W = \frac{12}{44}\times 0.629 = 1715g.$

Mass of hydrogen in $W = \frac{2}{18}\times 0.257 = 0.0286g$

Composition of W;

	C	H
Moles;	$\frac{0.1715}{12}$	$\frac{0.0286}{1}$
	0.0143	0.0286
Mole ratio;	$\frac{0.0143}{0.0143}$	$\frac{0.0286}{0.0143}$
	1 :	2

$\therefore$Emperical formula of W is CH_2

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(b) (i) $53.3cm^3$ of W weigh 0.10g

$\therefore 22400cm^3$ of W weigh $\frac{22400\times0.10}{53.3}g$

Molecular mass of $W = 42g$

Alternatively;

Molecular mass; $Mr = \frac{mRT}{pv}$

$= \frac{0.1\times8.31\times273}{101325\times53.3\times10^{-6}} = 42g$

(ii) $(CH_2)_n = 42$

$12n + 2n = 42$

$14n = 42$

$\therefore n = \frac{42}{14} = 3$

$\therefore$ Molecular formula of W is C_3H_6

(iii) $CH_3\ CH{=}CH_2$

(c) $CH_3CH{=}CH_2 \xrightarrow{Cl_2/CCl_4} CH_3\underset{H}{\overset{Cl}{C}}CH_2Cl \xrightarrow[heat]{\text{Alcohol /KOH}} CH_3C{\equiv}CH$

$CH_3C{\equiv}CCH_2CH_3 \xleftarrow{CH_3CH_2Br} CH_3C{\equiv}CNa \xleftarrow[\text{or } (NaNH_2/liquidNH_3)]{Na/\text{liquid } NH_3} CH_3C{\equiv}CH$

15. (a) $ns^2\ np^5$

(b)(i) The boiling points of elements **increase** from **fluorine to bromine** and **decrease from bromine to iodine. Or** The boiling point is in the order $(F_2 < Cl_2 < Br_2 > I_2)$

Explanation;

From fluorine to bromine, **molecular mass increases** which causes **increase in the strength** of the vander waal's forces between the molecules,

Note; - The Explanation for the decrease in boiling point from bromine to iodine is **not applicable** because the boiling point of iodine indicated is **not a true value**. The boiling point of Iodine must be higher than that of bromine because iodine molecules a held together by stronger vander waal's forces due to the higher molecular mass of iodine molecules than bromine molecules.

(ii) Flourine or F_2

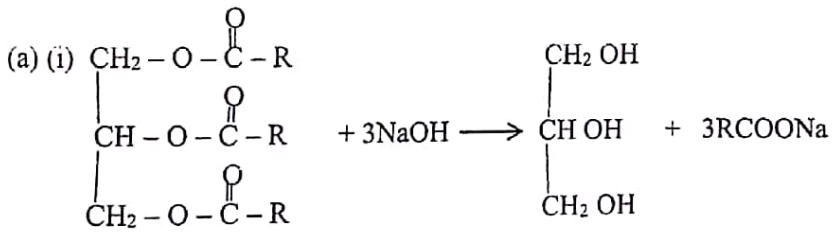
(c) (i) Solution changes from **colorless** to **brown.**

This is because chlorine **oxidises** the bromide ions to **bromine** which is brown. Also chlorine has a higher positive electrode potential than bromine

(ii) $Cl_2(g) + 2Br^-(aq) \longrightarrow 2Cl^-(aq) + Br_2(aq)$

16.

(a) (i)



(ii) $NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$

Moles of HCl which reacted $= \frac{4}{1000} \times 1.0 = 4\times10^{-3}moles$

moles of NaOH which reacted $= 4\times10^{-3}moles$

Original number of moles of NaOH $= \frac{10}{1000}\times1 = 0.01mole$

moles of NaOH which reacted with $Z = 0.01 - 4\times10^{-3} = 0.006$

moles of Z that reacted $= \frac{1}{3}\times0.006 = 0.002moles$

Hence; $0.002mole$ of Z weigh $1.108g$

$\therefore 1mole$ of Z weighs $\frac{1.108}{0.002}$

$\therefore$ Formula mass of $Z = 554g$.

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(b) Soap acts by **lowering the surface tension** between water and the dirt. This is so because soap contains a **hydrophobic** (non polar) water hating part which **dissolves** (attracts) the dirt and the **hydrophilic** (water loving part) which is **attracted to the water** and with **agitation** the **dirt is dispersed in the water**

(c) A is more effective
This is because the hydrophobic part (non polar) or water hating part in A is **longer** than the **hydrophobic** part in B, and there **more dirt** is **dissolved** with A than B.

17. (a) Order of reaction is the sum of the powers to which the **molar** concentrations of the reactants are raised in the **experimentally** determined rate equation while; molecularity is the total **number of species** (atoms, molecules or ions) which take part in the **rate determining step** of a chemical reaction.

(b) (i)

Volume of BrO_3^-/cm^3	3.0	4.0	5	6	8	10
$\frac{1}{t}(s^{-1})$	0.0145	0.0222	0.0286	0.0323	0.0417	0.0541

Graph is on next page

(ii) First order. This is because a graph of $\frac{1}{t}$ against volume of bromate (V) is a **straight line passing through the origin.**

(iii) From the graph;

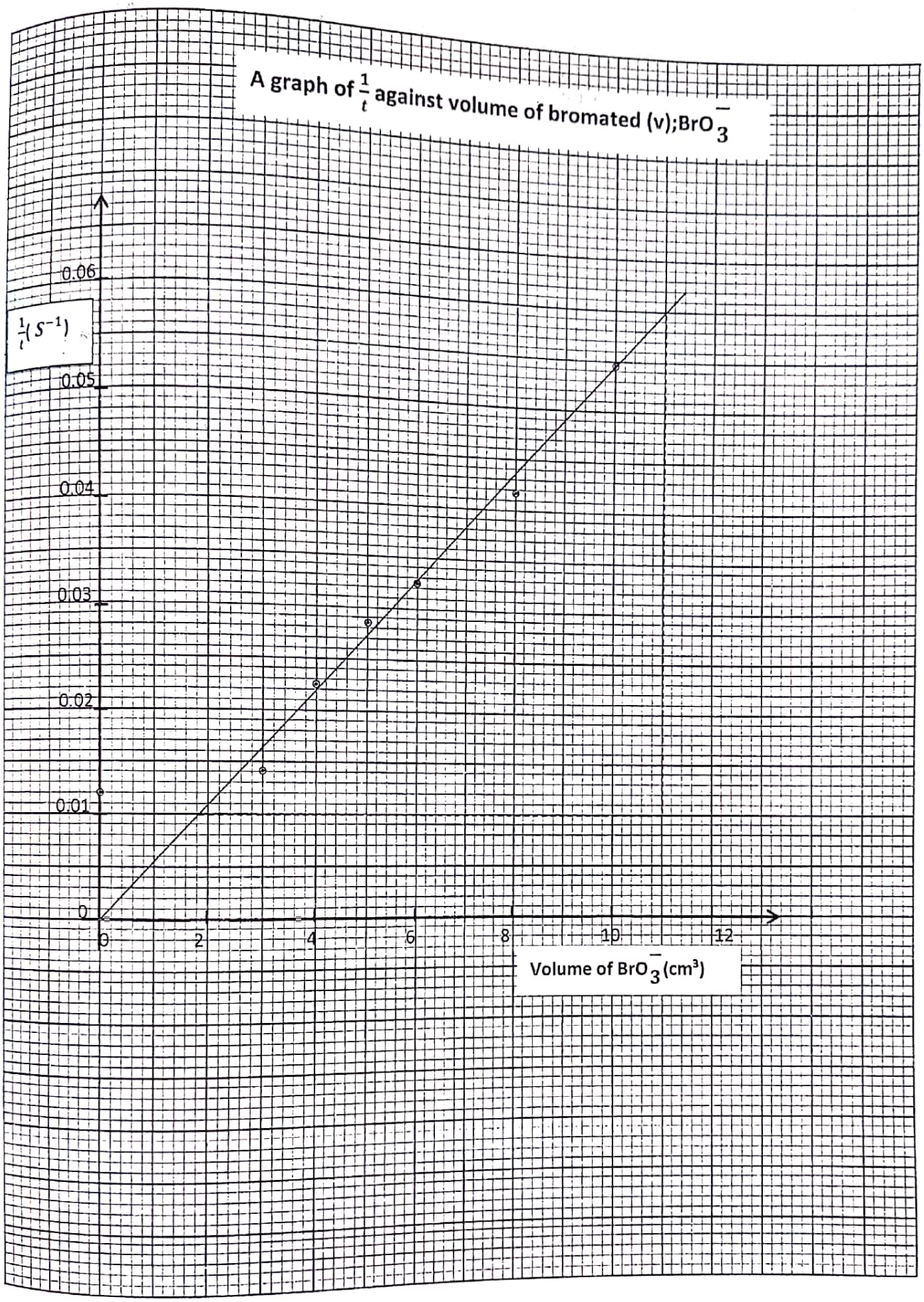
Rate constant; $K = Gradient\ of\ the\ graph$

$= \frac{0.06-0.01}{11-1.8}$

$= 5.43 \times 10^{-3} s^{-1} cm^{-3}$

(iv) Rate $= 5.43 \times 10^{-3}[BrO_3^-]$

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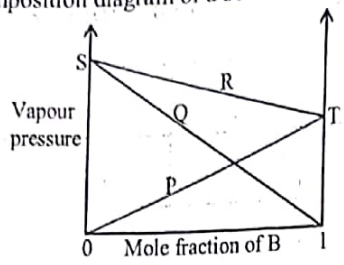


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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2 (P525/2), 2009

1. (a) State three properties of an ideal solution. (1 ½ marks)

(b) The vapour pressure – composition diagram of a solution of liquids A and B is shown below.



(i) Identify lines P, Q and R and the points S and T (2 ½ marks)

(ii) Draw a fully labeled boiling point – composition diagram for a mixture of liquids A and B (3 marks)

(iii) State what would be observed as the distillate and the residue if a liquid mixture containing 40% of A is fractionally distilled. (2 marks)

(c) A mixture of benzene and methylbenzene from an ideal solution.

(i) Calculate the vapour pressure of a solution containing 1.95g of benzene and 4.8g of methylbenzene at 20°C. [*The vapour pressure of pure benzene and pure methylbenzene at 20°C are 10.0kPa and 8.2 kPa*] (5 marks)

(ii) Determine the composition of the vapour of the mixture in (c)(i) above. (2 marks)

(d) Briefly, describe what takes place during fractional distillation. (4 marks)

2. Explain each of the following statements.
[*Where necessary write equations to illustrate your answer*]

(a) Magnesium oxide dissolves in dilute sulphuric acid whereas barium oxide does not. (4 marks)

(b) When dilute sulphuric acid is added to a solution of potassium manganate(VI), the colour of the solution changes from green to purple and a black solid is formed. (3 ½ marks)

(c) Lithium is in Group I in the Periodic Table but its properties resemble those of magnesium which is in Group II. (3 marks)

(d) The boiling points of the hydrolysis of oxygen, sulphur, selenium and tellurium are in the order. $H_2O > H_2S > H_2Se > H_2Te$. [$H_2O = 18$; $H_2S = 34$; $H_2Se = 81$; $H_2Te = 128$] (3 ½ marks)

(e) Sodium hydroxide solution for use in volumetric analysis should be prepared using freshly distilled water. (3 marks)

(f) Titrations with sodium thiosulphate are not carried out in acidic media. (3 marks)

3. (a) Discuss the reactions of bromoethane with potassium hydroxide.
[*Include mechanism for the reactions*] (7 marks)

(b) (i) Briefly, describe a test that can be carried out to distinguish between bromoethane and bromobenzene (3 marks)

(ii) Account for the difference(s) in reactivity of bromoethane and bromobenzene. (5 marks)

(c) Write equation to show how:

(i) bromobenzene can be prepared from ethanol. (1 mark)

(ii) bromobenzene can be prepared from benzene (1 mark)

(d) Write the mechanism for the reaction in (c)(ii) above. (3 marks)

4. (a) Define the term **enthalpy of reaction** (1 mark)

(b) Excess zinc was added to 25cm^3 of 1M Copper(II) sulphate solution in a plastic beaker and the temperature of the solution recorded at some time intervals. The data obtained is shown below.

Time/minutes	0	2.5	3.0	3.5	5.0	6.0	7.0
Temperature/°C	27.2	66.0	69.5	68.5	65.0	62.0	59.5

(i) Plot a graph of temperature against time.

(ii) Use the graph to determine the molar enthalpy of reaction. (3 ½ marks)
[*Assume specific heat capacity of the solution is 4.2Jg^{-1}K^{-1}*]

(c) The standard electrode potentials of some half-cells are shown below. (4 marks)

Half-cell	**Standard electrode potential**
$Cu^{2+}(aq) / Cu(s)$	+0.34V
$Zn^{2+}(aq) / Zn(s)$	–0.76V

(i) Write the cell notation for the cell formed by combining the two half cells. (1 mark)

(ii) Draw a labelled diagram of the cell. (3 ½ marks)

(iii) Write equations for the reactions taking place at the anode and at the cathode of the cell. (2 marks)

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(iv) Calculate the maximum obtainable energy from the cell when one mole of copper(II) ions is displaced by zinc. [*1 Faraday = 96,500C*]

(d) Comment on the answers you have obtained in (b)(ii) and (c)(iv) above. (1 ½ marks)

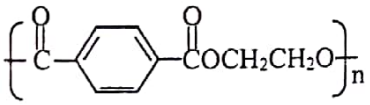
5. X and Y react to form W and Z according to the following equation.
$X(g) + Y(g) \rightleftharpoons W(g) + Z(g)$; $\Delta H = +50KJmol^{-1}$.
The table below shows the rates of the reaction when various concentrations of X and Y were used at 298K.

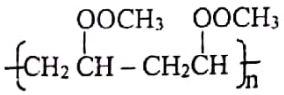
Experiment	[X] / mold m^{-3}	[Y] / mold m^{-3}	Rate / mold $m^{-3}s^{-1}$
1	2.0×10^{-2}	1.0×10^{-2}	1.0×10^{2}
2	2.0×10^{-2}	2.0×10^{-2}	2.0×10^{2}
3	4.0×10^{-2}	2.0×10^{-2}	4.0×10^{2}

(a) (i) Differentiate between the terms order and rate of constant of a reaction. (2 marks)
(ii) Determine the order of the reaction with respect to X and Y (2 marks)
(iii) Write an equation for the rate equation (1 mark)
(iv) Calculate the rate constant for the reaction at 298K and indicate its units (2 marks)
(b) (i) Define the terms activation energy and enthalpy of reaction. (2 marks)
(ii) Draw a fully labeled potential energy versus reaction co-ordinate for the reaction of X and Y. (4 marks)
(iii) Calculate the activation energy for the backward reaction.
[*The activation energy for the forward reaction is +200KJ*] (1 mark)
(c) State how you would expect the:
(i) activation energy to change if a catalyst is used. Give a reason for your answer. (2 marks)
(ii) rate of the reaction to change if the reaction was carried out at a temperature above 298K. Give a reason for your answer. (2 marks)
(d) The reaction was carried out as a temperature T_1 and T_2 where $T_2 > T_1$. Sketch on the same axes Graphs to show how the concentration of Z varies with time during the reactions at T_1 and T_2 (2 marks)

6. Explain each of the following observations.
(a) Lead(IV) oxide decomposes when heated to give lead(II) oxide and oxygen but carbon dioxide does not. (2 marks)
(b) Water is liquid while hydrogen sulphide is a gas at room temperature. (3 ½ marks)
(c) Graphite conducts electricity in solid state but solid sodium chloride does not. (2 marks)
(d) The solubility of the sulphates of Group II elements of the Periodic Table decreases down the group. (2½mks)
(e) The boiling point of beryllium chloride is 487°C and that of magnesium chloride is 1418°C (4 marks)
(f) The pH of aqueous ammonium chloride is less than 7 while that of aqueous sodium chloride is 7. (3 marks)
(g) Across the transition elements series, the atomic radius remains almost constant. (3 marks)

7. (a) Explain what is meant by:
(i) Addition polymerization (2 marks) (ii) Condensation polymerization (2 marks)
(b) The molecular structures of Terylene and Perpex are shown below.


Terylene


Perspex

For each of the above polymers,
(i) write the structural formula of the monomer(s) (3 marks)
(ii) name the type of polymerization involved in the formation of each of the polymers. (2 marks)
(iii) state one use of each of the polymers (2 marks)
(c) Explain the differences in properties of thermosetting and thermoplastic polymers. (5 marks)
(d) State how:
(i) vulcanization of rubber is carried out (1 mark)
(ii) vulcanization improves the properties of natural rubber. (3 marks)

8. (A) Describe how zinc is extracted from zinc sulphide. (7 marks)
(b) Explain the following observations:
(i) Zinc belongs to the d-block in the Periodic Table and yet it is not a transition metal. (2 marks)
[*Atomic number of zinc = 30*]
(ii) Zinc chloride dissolves in water to give a solution whose pH is less than seven. (3 marks)
(c) State two reactions in which zinc resembles magnesium and write equations for the reactions. (5 marks)
(d) Dilute ammonium hydroxide solution was added drop-wise until in excess to zinc sulphate solution.
State what was observed and write equation for the reaction. (3 marks)END

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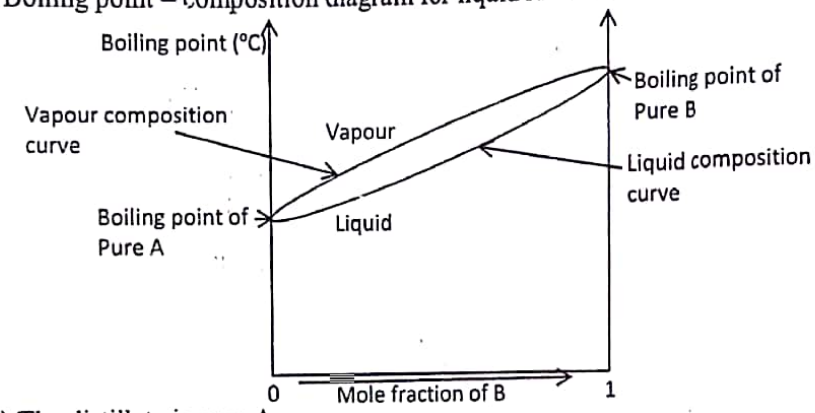
SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2 (P525/2), 2009

Question. One.

(a) - The intermolecular forces between like and unlike molecules of an ideal solution are equal in strength (ie A – A or B – B ≃ A - B)
- An ideal solution is formed without change in heat
- An ideal solution is formed without change in total volume.

(b) (i) Line P is the partial vapour pressure of B (or variation of Partial vapour pressure of B with compostion of an ideal solution)
Line Q is the partial vapour pressure of A (or variation of Partial vapour pressure of A with compostion of ideal solution)
Line R is the vapour pressure of the solution of A and B (or variation of the vapour pressure of solution with compostion)
Point S is the vapour pressure of pure A
Point T is the vapour pressure of pure B

(ii) Boiling point – composition diagram for liquid A and B



(iii) The distillate is pure A
The residue is pure B

(c) (i) Molecular mass of benzene; $C_6H_6 = (6 \times 12) + (6 \times 1) = 78$
Molecular mass of methyl benzene; $C_7H_8 = (7 \times 12) + (8 \times 1) = 92$

Moles of C_6H_6 in 1.95g $= \frac{1.95}{78} = 0.025 moles$

Moles of C_7C_8 in 4.6 $= \frac{4.6}{92} = 0.05 moles$

Mole fraction of benzene $= \frac{0.025}{(0.025+0.05)} = 0.333$

Mole fraction of methyl benzene $= \frac{0.05}{(0.025+0.05)} = 0.667$

$$\begin{pmatrix}\text{Partial pressure of}\\ \text{benzene}\end{pmatrix} = \begin{pmatrix}\text{vapour pressure of}\\ \text{pure benzene}\end{pmatrix} \times \begin{pmatrix}\text{mole fraction of}\\ \text{benzene}\end{pmatrix}$$

$$= 10 \times 0.333 = 3.33 \text{ KPa}$$

$$\begin{pmatrix}\text{Partial pressure of}\\ \text{methyl benzene}\end{pmatrix} = \begin{pmatrix}\text{vapour pressure of}\\ \text{pure methyl benzene}\end{pmatrix} \times \begin{pmatrix}\text{mole fraction of}\\ \text{methyl benzene}\end{pmatrix}$$

$$= 8.2 \times 0.667 = 5.47 \text{ KPa}$$

Hence, $\begin{pmatrix}\text{vapour pressure}\\ \text{of solution}\end{pmatrix}$ = vapour pressure of benzene × vapour pressure of methyl benzene

$= 3.33 + 5.47 = 8.80$KPa

(ii) Mole fraction of benzene in vapour $= \frac{\text{Partial pressure of benzene}}{\text{Vapour pressure of solution}}$

$= \frac{3.33}{8.80} = \mathbf{0.378}$

Or % of benzene in vapour $= \frac{3.33}{8.80} \times 100\% = 37.8\%$

Mole fraction of methyl benzene = 1 – 0.378 = **0.622**

Or; % of methyl benzene in vapour = 62.2%

(d) The mixture is **heated**, it boils and gives off a vapour which is **richer in the more volatile component of the mixture.**
At each point in the column, equilibrium is setup between the liquid and the vapour

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The column becomes progressively cooler from the bottom to the top
The vapour comes out of the column at its boiling point (or as a pure component)

Question. Two.

(a) Magnesium oxide **reacts** with dilute sulphuric acid to form **magnesium sulphate** which is a **soluble salt.**
$MgO(s) + H_2SO_4(aq) \longrightarrow MgSO_4(aq) + H_2O(l)$
Barium oxide reacts with dilute sulphuric acid to form **barium sulphate** which is **insoluble** in water
$BaO(s) + H_2SO_4(aq) \longrightarrow BaSO_4(s) + H_2O(l)$
Barium sulphate forms a **coating** on the unreacted barium oxide **hence preventing further reaction**

(b) Potassium manganate (VI) **disproportionates** (under goes both oxidation and reduction) to form **potassium manganate (VII)** solution which purple and **manganese (IV) oxide** which is a black solid.
$3MnO_4^{2-}(aq) + 4H^+(aq) \longrightarrow 2MnO_4^-(aq) + MnO_2(s) + 2H_2O(l)$
or, $3K_2MnO_4(aq) + 2H_2SO_4(aq) \longrightarrow 2KMnO_4(aq) + MnO_2(s) + 2H_2O(l) + 2K_2SO_4(aq)$

(c) Both lithium and magnesium have the **same electronegativity** or **electropositivity values** and their cations have **similar charge densities** or **polarizing powers.**

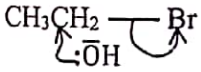
(d) H_2S, H_2Se and H_2Te molecules are held together by weak **vander waal's forces** whose strength increases with **increase in molecular mass** from H_2S to H_2Se to H_2Te
The boiling point of water is **higher than expected** because the oxygen atom in water has a **small atomic radius** and a **high electronegativity value**
This makes the oxygen-hydrogen bond in water to be **more polar** and as a result water molecules associate through **intermolecular hydrogen bonds** which are **stronger** than vander waal's forces and hence require **more heat energy** to be broken.

(e) Freshly prepared distilled water is **free from acidic carbon dioxide** which would react with the **alkaline** sodium hydroxide to form sodium carbonate and water.
$2NaOH(aq) + CO_2(g) \longrightarrow Na_2CO_3(aq) + H_2O(l)$
Distilled water is also **free from other impurities** which would react with sodium hydroxide to **form precipitates. Ie**
$Mg^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Mg(OH)_2(s)$
$Ca^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Ca(OH)_2(s)$

(f) Sodium thiosulphate **reacts with acids** to form **sulphur, sulphur dioxide** and **water**
$S_2O_3^{2-}(aq) + 2H^+(aq) \longrightarrow S(s) + SO_2(g) + H_2O(l)$
or $Na_2S_2O_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(l) + SO_2(g) + S(s)$

Question. Three.

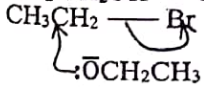
(a) Bromo ethane reacts with **aqueous** potassium hydroxide on **heating** to form **ethanol** and this is a **hydrolysis** or **substitution reaction**



$\longrightarrow CH_3CH_2OH + Br^-$

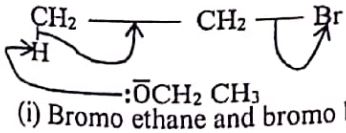
Bromo ethane reacts with a solution of potassium hydroxide in **ethanol** (an alcohol) on **heating** to form **ethoxyethane** (ether) and this is a **substitution reaction**

$CH_2CH_2OH + \bar{O}H \longrightarrow CH_3CH_2\bar{O} + H_2O$



$\longrightarrow CH_3CH_2OCH_2CH_3 + Br^-$

Ethene is also formed as a **minor product** and this is an **elimination** or dehydrohalogenation reaction



$\longrightarrow CH_2 = CH_2$

(b) (i) Bromo ethane and bromo benzene are each **heated** with **sodium hydroxide, dilute nitric acid** added followed by **silver nitrate solution**
Bromo ethane gives a **white (or cream) precipitate** while Bromo benzene gives **no observable change.**

(iii) Bromo benzene **does not undergo substitution** of the bromine atom since the lone pair of electrons on the bromine atoms **interacts** with **the delocalized electrons** of the benzene ring. This **strengthens** the carbon-bromine bond (makes the carbon –bromine bond partly double) and difficult to break.

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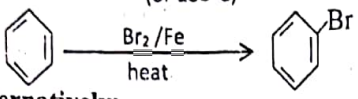
However, in bromo ethane, the carbon-bromine bond is **polar** since bromine atom is **more electronegative** than carbon. The carbon atom thus has a **partial positive charge** making it **elctrophilic** and hence easily attacked by the **nucleophilic** hydroxide ion leading to substitution of the bromine atom.

(c) (i) $CH_3CH_2OH \xrightarrow{PBr_3} CH_3CH_2Br$

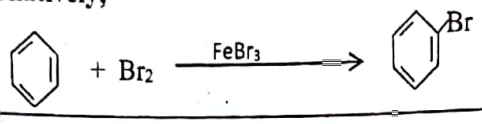
Alternatively;

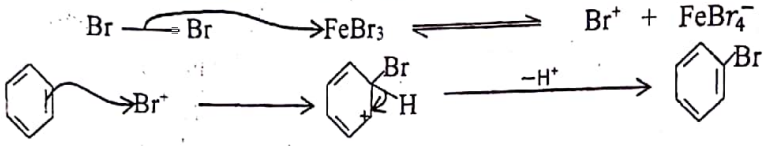
$CH_3CH_2OH \xrightarrow[\text{Heat}]{\text{Conc.}H_2SO_4} CH_2 = CH_2 \xrightarrow{HBr} CH_3CH_2Br$

(or 180°C)

(ii) 

Alternatively;



(d) 

Note; For the first alternative answer in (c)(ii), iron first reacts with bromine to form iron (III) bromide ie $2Fe + 3Br_2 \longrightarrow 2FeBr_3$, then the mechanism proceeds as shown above

Question. Four.

(a) Heat change that occurs when a reaction takes place in molar quantities as shown in the equation.

(b) (i) See graph next page

(ii) From extrapolation of the graph to touch the vertical axis; maximum temperature of solution = 78°C

Hence maximum temperature rise = $78 - 27.2 = 50.8°C$

Heat change = $mass\ of\ solution \times specific\ heat\ capacity \times temperature\ rise$

$= 25 \times 4.2 \times 50.8 Joules$

$= \frac{25 \times 4.2 \times 50.8}{1000} = 5.334KJ$

Moles of $CuSO_4$ (Cu^{2+}) which reacted;

$1000cm^3$ of $CuSO_4$ contain 1mole

$\therefore 25cm^3$ of $CuSO_4$ contain $\frac{25 \times 1}{1000} = 2.5 \times 10^{-2} moles$

Molar enthalpy of reaction

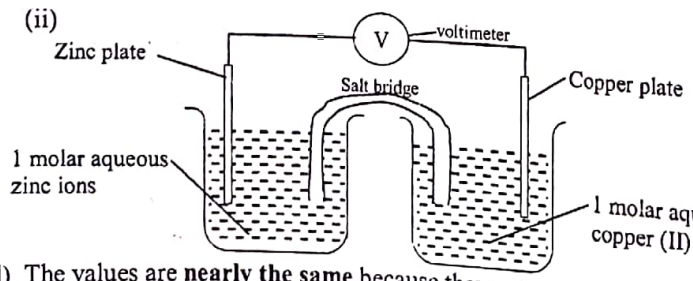
2.5×10^{-2} moles of Cu^{2+} causes an enthalpy change of $\frac{5.334}{2.5 \times 10^{-2}}$ KJ of energy

$\therefore$ 1 mole of Cu^{2+} causes an enthalpy change of $\frac{5.334}{2.5 \times 10^{-2}}$ KJ of energy

Hence; enthalpy of reaction = $-213.36 KJmol^{-1}$

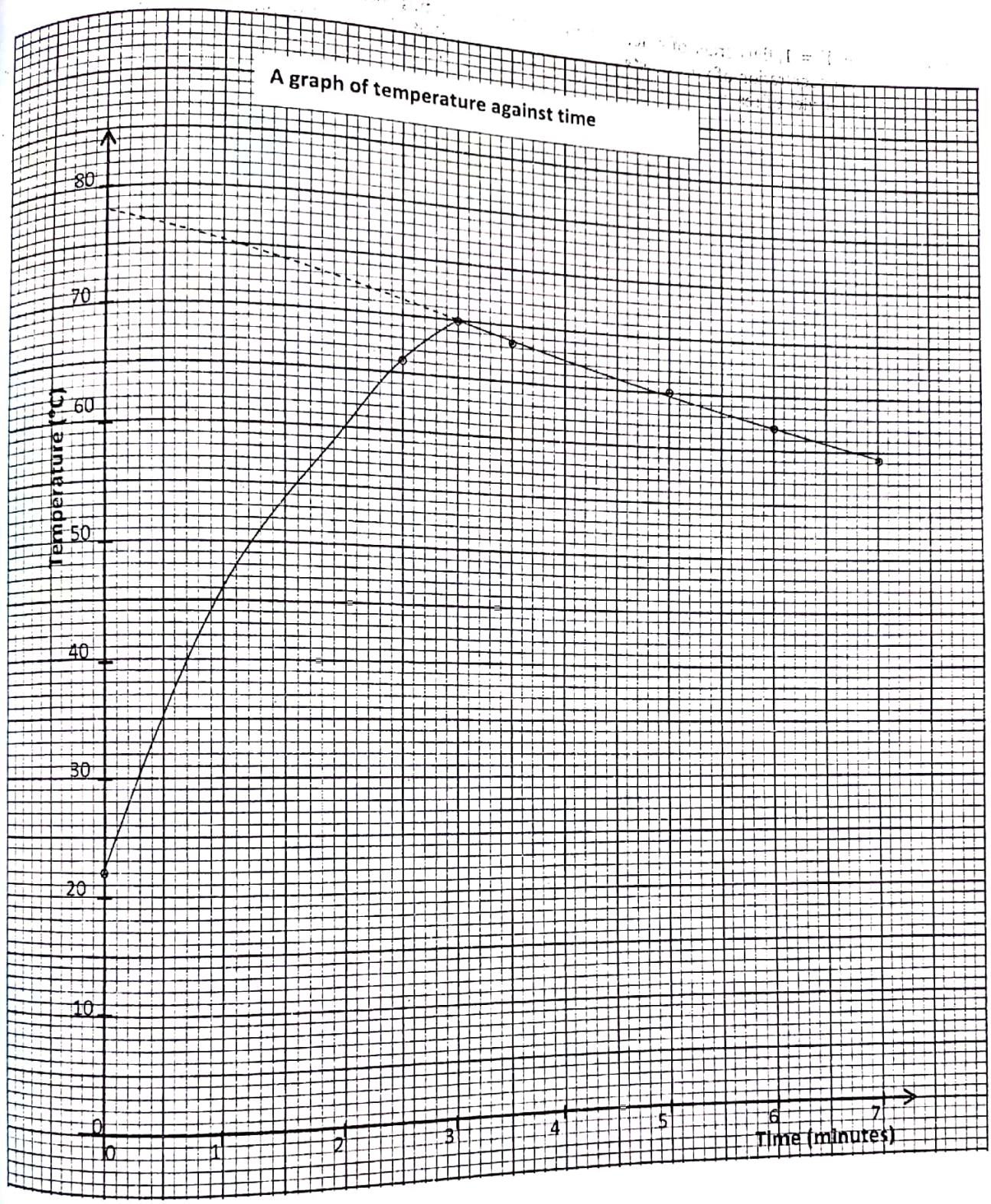
(c) (i) $Zn(s) \mid Zn^{2+}(aq) \parallel Cu^{2+}(aq) \mid Cu(s)$

(ii)



(d) The values are **nearly the same** because they represent the same raction, i.e displacement or reduction of copper (II) ion by zinc.

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Question five

(a) (i) Order of reaction is the sum of the powers of the **molar** concentrations of the reactants in the **experimentally** determined rate equation while;
Rate constant is the constant of proportionality in the experimentally determined rate equation.

(ii) Considering experiments 1 and 2, when the concentration of X is **constant** and that of Y **doubled, the rate of reaction also doubled**, indicating that the order of reaction with respect to Y is **first order**

Alternatively, Determining order by calculation;

$$\left(\frac{2.0 \times 10^{-2}}{1.0 \times 10^{-2}}\right)^{y} = \left(\frac{2.0 \times 10^{2}}{1.0 \times 10^{2}}\right)$$

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$2^y = 2^1$; Hence; $Y = 1$; thus order of reaction with respect to y is **first order**. Considering experiments 2 and 3, when the concentration of y is **constant** and that of X **doubled,** the rate of reaction also **doubled,** indicating that the order of reaction with respect to X is **first order.**

Alternatively, Determining order by calculation;

$$\left(\frac{4.0 \times 10^{-2}}{2.0 \times 10^{-2}}\right)^X = \left(\frac{4.0 \times 10^2}{2.0 \times 10^2}\right)$$

$2^X = 2^1$; Hence; $X = 1$; thus order of reaction with respect to X is **first order.**

(iii) Rate $= k[X][Y]$; where; $k = rate\ constant$

(iv) Rate constant; $k = \frac{Rate\ of\ reaction}{[X][Y]}$

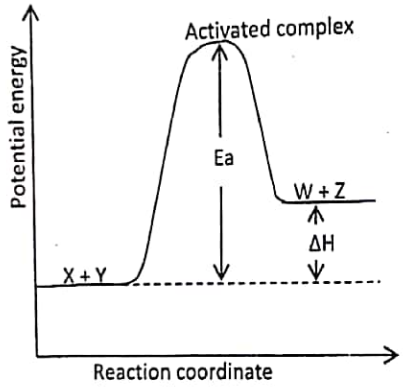
(using experiment 1)

$$k = \frac{1.0\times10^2}{(2.0\times10^{-2})\times(1.0\times10^{-2})} \qquad = \mathbf{5.0 \times 10^5 mol^{-1} dm^3 S^{-1}}$$

(b) (i) Activation energy is the minimum amount of energy which the reactants molecules must acquire in order to react

Enthalpy of reaction is the heat change that occurs when a reaction takes place in molar quantities as shown in a balanced equation

(ii)



$Ea = Activation\ energy$
$\Delta H = heat\ of\ reaction$

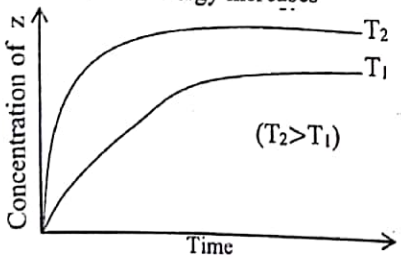
(iii) $\begin{pmatrix} Activation\ energy\ for \\ the\ back\ ward\ reaction \end{pmatrix} = \begin{pmatrix} Activation\ energy\ for \\ the\ forwad\ reaction \end{pmatrix} - (Enthalpy\ of\ reaction)$

$= 200 - 50 \quad = \mathbf{+150KJ}$

(c) (i)Activation energy **decreases**

A catalyst provides an **alternative path** (or mechanism) in which the activation energy is **lowered**

(ii) Rate of reaction **would increase** because the number of molecules with kinetic energy equal to or greater than the activation energy increases



Question six.

(a) Lead (IV) oxide is **less stable** than lead (II) oxide whereas carbon (IV) oxide (carbon dioxide) is **more stable** than carbon monoxide (carbon (II) oxide)

(b) Oxygen atom in water has a **smaller atomic radius** and **more electro negative** than sulphur in hydrogen sulphide . As a result, the **oxygen –hydrogen bonds** in water are **more polar** than the sulphur-hydrogen bonds in hydrogen sulphide.

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Thus water molecules associate through **intermolecular hydrogen bonds** while hydrogen sulphide molecules are ionized by **vander waal's forces** which are **weaker** than hydrogen bonds and require **lower temperatures** to break and thus hydrogen sulphide is a gas while water is a liquid at room temperature.

(c) Graphite has **delocalized** electrons which are **mobile**. Solid Sodium chloride has a **giant ionic structure** in which the ions are held together by **strong ionic bonds** and hence the ions are **not mobile** making the sodium chloride unable to conduct electricity in solid state.

(d) From Beryllium sulphate to Barium sulphate, the **cationic radius increases** which results into **decrease in both the lattice energy and hydration energy**. However, the hydration energy **decreases more rapidly** than lattice energy hence making the **enthalpy of solution to become more positive** hence a **decrease in solubility**.

(e) Beryllium ion in beryllium chloride has a **smaller ionic radius** than magnesium ion in magnesium chloride, hence Beryllium ion has a **higher charge density** (or polarizing power) than magnesium ion. This makes the chloride ion to be **more polarized** by beryllium ion than magnesium ion hence making beryllium chloride **covalent** with its molecules being held together by weak **vander waal's forces** while magnesium chloride is **ionic** with its ions held together by **strong ionic bonds** and these require more heat energy to break than the vander waal's forces.

(f) Ammonium chloride undergoes **hydrolysis** to form an **acidic solution**

$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$

Sodium chloride **does not** undergo hydrolysis hence its solution is **neutral**

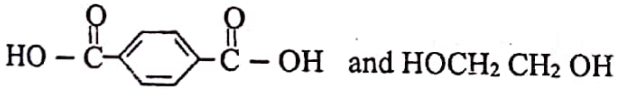
(g) A cross the transition elements series, **nuclear charge increases. The electrons are added to the inner 3d sub-energy levels, screening effect slightly increases.**
However, the increase in nuclear charge is **balanced** by the increase in screening effect and the **nuclear attraction** for the outer electrons **remains constant.**

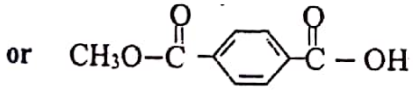
Question seven.

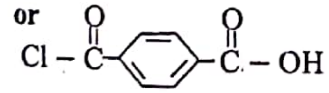
(a) (i) Addition polymerization is the building up of large molecules from a number of unsaturated simple molecules called monomers to form a single product.

(ii) Condensation polymerization is a process which occurs when bi functional monomers react together to form a polymer and another product with small molecules

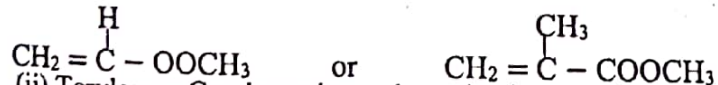
(b) (i) Terylene







Perspex



(ii) Terylene – Condensation polymerization
Perspex – Addition polymerisation

(iii) Perspex is used for making laboratory glass ware, windows of air planes, lenses and corrugated roof lights.
Terylene is used to make ropes and clothes

(c) Thermosetting polymers **do not soften** but **harden** on heating and **cannot be remolded** because they are held together by **much cross-linkages** between the polymer chains
Thermoplastic polymers **soften** on heating and can be **remoulded** because the binding forces between the polymer chains are **weak** (or have fewer cross-linkage between polymer chains)

(d) (i) **Raw rubber** is **heated** with **sulphur** or disulphur dichloride

(ii) Vulcanization **increases the tensile strength, durability** and **improves on the elasticity of rubber.**

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Question eight.

(a) Zinc sulphide is **purified** by **froth floatation**
The zinc sulphide is **crushed** and **agitated** by **water** containing **frothing agents**
Air is blown through to form **a froth**, which rises up and contains the zinc sulphide
The earthly impurities are **wetted** by water and **sink** to the bottom
The froth is **skimmed** off and an acid added to **break it down**. The concentrated ore is **filtered** and **dried**
The ore is **roasted** in air to **convert** it to **zinc oxide and sulphur dioxide.**

$$2ZnS(s) + 3O_2(g) \longrightarrow 2ZnO(s) + 2SO_2(g)$$

The zinc oxide is then **heated with coke** and **lime stone** in furnace.
Coke **reduces** zinc oxide to **zinc vapour**

$$ZnO(s) + C(s) \longrightarrow Zn(g) + CO(g)$$

The zinc vapour is **condensed** by a **spray of molten lead**, and the zinc is **purified by re-distillation**

(b) (i) Electronic configuration of;
$Zn - 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$, $Zn^{2+} - 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$
Both zinc atom and zinc ion have their last electrons in the **d-sub-energy level,** thus making zinc a d-block element. However, zinc and zinc ion have completely filled 3-d sub-energy levels, and therefore not qualifying to be transition, since a transition element has incompletely filled 3-d sub-energy level.

(ii) Zinc ions **undergo hydrolysis** to form an **acidic** solution

$$Zn(H_2O)_4^{2+}(aq) + H_2O(l) \longrightarrow [Zn(H_2O)_3OH]^+(aq) + H_3O^+(aq)$$

(c) Both metals react with oxygen when **heated** to form oxides

$$2Zn(s) + O_2(g) \longrightarrow 2ZnO(s)$$
$$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$$

Both metals burn when **heated** in **steam** to form an **oxide** and **hydrogen gas**

$$Zn(s) + H_2O(g) \longrightarrow ZnO(s) + H_2(g)$$
$$Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$$

Both metals react with **dilute acids** to form a **salt** and **hydrogen gas** ie

$$Zn(s) + 2H^+(aq) \longrightarrow Zn^{2+}(aq) + H_2(g)$$
$$Mg(s) + 2H^+(aq) \longrightarrow Mg^{2+}(aq) + H_2(g)$$

Both metals form carbonates which decompose on heating to form an **oxide** and **carbon dioxide**

$$ZnCO_3(s) \longrightarrow ZnO(s) + CO_2(g)$$
$$MgCO_3(s) \longrightarrow MgO(s) + CO_2(g)$$

Both metals form nitrates which decompose on heating to form **an oxide, nitrogen dioxide** and oxygen

$$2Zn(NO_3)_2(s) \longrightarrow 2ZnO(s) + 4NO_2(g) + O_2(g)$$
$$2Mg(NO_3)_2(s) \longrightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$

(d) **White precipitate, dissolved** in excess ammonium hydroxide solution to form a **colourless solution.**

$$Zn^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Zn(OH)_2(s)$$
$$Zn(OH)_2(s) + 4NH_3(aq) \longrightarrow Zn(NH_3)_4^{2+}(aq) + 2\bar{O}H(aq)$$

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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2008

1. Complete the following equations.
   (a) $^{27}_{13}Al + {}^{1}_{0}n \longrightarrow$ ..... $+ {}^{4}_{2}He$
   (b) ..... $\longrightarrow {}^{235}_{90}Th + {}^{4}_{2}He$
   (c) ${}^{4}_{2}He + {}^{14}_{7}N \longrightarrow {}^{1}_{1}H +$ .....
   (d) ${}^{23}_{11}Na + {}^{2}_{1}D \longrightarrow$ ..... $+ {}^{1}_{1}H$

2. Name one reagent that can be used to distinguish between each of the following pairs of compounds. In each case, state what is observed if the reagent is separately treated with each member of the pair.
   (a) $CH_3CH_2CH_2OH$ and CH_3CH_2OH
   (b) $CH_3CH_2CH_2CH_2OH$ and $(CH_3)_3OH$ (3 marks)

3. (a) (i) Write the equation for the hydrolysis of sodium ethanoate in aqueous solution.
   (ii) Write an expression for the hydrolysis constant, K_h, of sodium ethanoate. (3 marks)
   (b) The pH of a 0.1M aqueous sodium ethanoate solution is 8.9. Calculate the hydrolysis constant of the solution. ($K_w = 1 \times 10^{-14}\ mol^2dm^{-6}$) (1 mark)

4. State what would be observed and write equation (s) for the reaction(s) that would take place when a solution of manganese (II) chloride was added to: (3 marks)
   (a) Aqueous ammonia dropwise until in excess.
   (b) Dilute nitric acid followed by lead (IV) oxide and the mixture warmed.

5. The empirical formula of a fluoride of sulphur, Y, is SF_4 0.1g of Y occupied 22.10cm^3 when vapourised at 20°C and 766 mmHg.
   (a) Determine the molecular formula of Y. (3½ marks)
   (b) Draw the structure of Y and name the shape. (1½ marks)

6. Complete the following equations and in each case outline a mechanism for the reaction.
   (a) $CH_3\overset{Br}{\overset{|}{C}}H\overset{Br}{\overset{|}{C}}HCH_3 \xrightarrow[\text{heat}]{CH_3CH_2\bar{O}/CH_3CH_2OH}$ (3 marks)
   (b) $(CH_3)_2\overset{Cl}{\overset{|}{C}}CH_2CH_3 \xrightarrow[\text{heat}]{NaOH(aq)}$ (3 marks)

7. State the properties of the following compounds in which boron resembles silicon, but differs from aluminium.

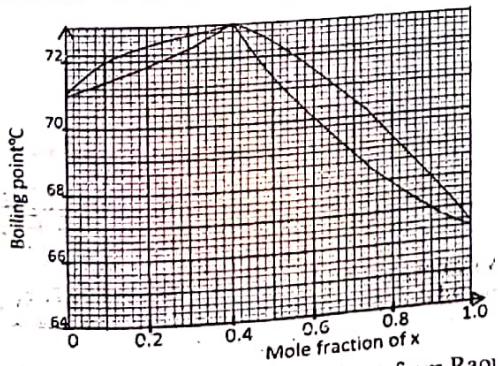
	Compound	Boron-silicon	Aluminium
(a)	Oxides		
(b)	Hydrides		

8. (a) (i) State the conditions for steam distillation (1½ marks)
   (ii) State one advantage of steam distillation over fractional distillation. (½ mark)
   (b) Substance, A, distils with steam at 98.3°C under pressure of 753mmHg. Calculate the percentage by mass of A in the distillate. (The vapour pressure of water at 98.3C is 715mmHg; A = 128) (3 marks)

9. Compound P is a blue green solid. P dissolved in water to give a pale blue solution. The solution of P formed a brown precipitate when reacted with potassium hexacyanoferrate (II) solution and a reddish-brown solution when a few drops of iron (III) ethanoic acid was formed.
   (a) Identify P (1 mark)
   (b) Write equation for the reaction that took place when P was heated with concentrated sulphuric acid. (1½ marks)

   Write equation(s) for the reaction(s) that would take place when excess ammonia solution is added to a solution of P. (1½ marks)

10. The diagram below shows the boiling point-composition curve for two miscible liquids X and Y.



   (a) State how the mixture of X and Y deviates from Raoult's law (1 mark)
   (b) Explain your answer in (a) (3 marks)

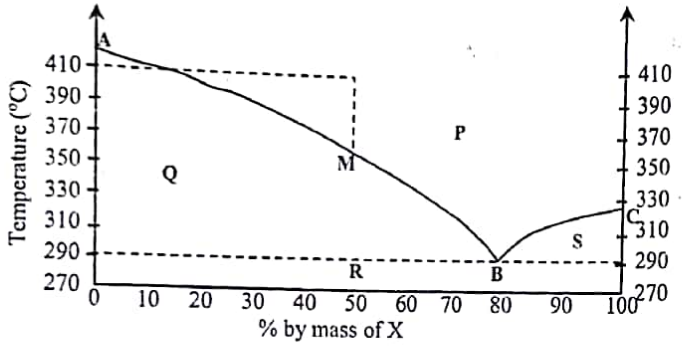
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(c) Determine the;
(i) boiling point of a mixture containing 0.3 mole fraction of Y. (1 mark)
(ii) composition of the vapour produced when a mixture containing 0.7 mole fraction of X is boiled.
(d) A mixture containing 0.5 mole fraction of X was fractionally distilled. State the composition of the:
(i) distillate. (1 mark) (ii) residue (1 mark)

11. (a) Write an equation for the reaction between water and the hydride of:
(i) Sodium (1½ marks) (ii) Silicon (1½ marks) (iii) Sulphur (1½ marks)
(b) Write an equation for the reaction between sodium hydroxide solution and:
aluminium oxide (ii) phosphorous pentoxide (iii) sulphur dioxide. (1½ marks each)

12. A compound Q contains 62.1% carbon, 10.3 hydrogen and the rest being oxygen.
(The vapour density of Q is 2.59×10^{-3} g/cm^3 at s.t.p)
(a) Determine the:
(i) Empirical formula of Q. (2 marks) (ii) Molecular formula of Q. (2 marks)
(b) Write the structural formulae of all the possible isomers of Q. (1½ marks)
(c) Q reacts with sodium, metal with effervescence identify (½ mark)
(d) Write an equation for the reaction between Q and:
(i) bromine (1½ marks) (ii) alkaline potassium manganate (VII) solution (1½ marks)

13. The phase diagram of mixture of metals X and Y is shown below.

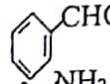
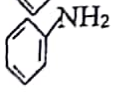


(a) State how the above curve was obtained. (2 marks)
(b) Identify the regions P, Q, R and S. (2 marks)
(c) State what point B represents (1 mark)
(d) Using the diagram, estimate the melting point of (1 mark)
(e) Describe what would happen if a mixture containing 50% by mass of X and Y is cooled from 410°C to 270°C. (3 marks)

14. The ionic radii and enthalpies of hydration of Na^+, Mg^{2+} and Al^{3+} are given in the table below.

Ion	Na^+	Mg^{2+}	Al^{3+}
Ionic radius/nm	0.095	0.065	0.050
ΔH^{θ} hydration/kJmol^{-1}	-390	-1891	-4613

(a) Briefly explain the variation in trends of:
(i) Ionic radii of the ions (2 marks) (ii) Enthalpy of hydration of the ions (2 marks)
(b) Calculate the change/radius ratio for:
(i) Na^+ (ii) Mg^{2+} (iii) Al^{3+}
(c) Which of the ions has:
(i) the least polarizing power? (½ mark) (ii) the greatest polarizing power? (½ mark)
(d) Give reasons for your answers in (c)(i) and (c)(i) above. (1 mark)

15. Write equations to show how the following compounds can be synthesized.
(a) $CH_3\overset{O}{\overset{\|}{C}}CH_3$ from $CH_3CH_2CH_2OH$ (4 ½ marks)
(b)  from  (2 marks)
(c)  from  (2 marks)

16. (a) Write the equation and state the conditions for the reaction leading to the formation of:
(i) tin (II) chloride. (2½ marks) (ii) tin (IV) chloride.
(b) Tin (II) chloride and tin (IV) chloride were separately exposed to air: (2½ marks)
(i) state what was observed in each case. (1 mark)
(ii) write the equation(s) for any reaction(s) that took place. (1½ marks)
(c) Write the equation for the reaction between tin (II) chloride and iron (III) sulphate solution. (1½ marks)

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17. Give reasons for each of the following procedures used in analytical chemistry. Illustrate your answers with equations.
(a) Sodium hydroxide solutions should be prepared using freshly boiled distilled water. (3 marks)
(b) Titrations involving thiosulphate solutions should be carried out in acidic medium. (3 marks)
(c) Phenolphthalein indicator is more suitable than methyl orange indicator for the titration of ethanoic acid with sodium hydroxide. (3 marks)

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2008

1. (a) $^{27}_{13}Al + {}^{1}_{0}n \longrightarrow {}^{24}_{11}Na + {}^{4}_{2}He$

(b) $^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He$

(c) $^{4}_{2}He + {}^{14}_{7}N \longrightarrow {}^{1}_{1}H + {}^{17}_{8}O$

(d) $^{23}_{11}Na + {}^{2}_{1}D \longrightarrow {}^{24}_{11}Na + {}^{1}_{1}H$

(a) **Reagent;** Aqueous iodine and sodium hydroxide solution
Observation; $CH_3CH_2CH_2OH$ – Shows **no observable change**
CH_3CH_2OH – forms a **pale yellow precipitate**

(b) **Reagent;** Solution of concentrated hydrochloric acid and anhydrous zinc chloride.
Observation; $CH_3CH_2CH_2CH_2OH$ – gives **no observable change** at **room temperature.**
$(CH_3)_3COH$ – gives a **cloudy** or **turbid solution** immediately or forms **two layers** immediately.

(a)(i) $CH_3COONa(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + NaOH(aq)$
or; $CH_3CO\bar{O}(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + \bar{O}H(aq)$

(ii) $Kh = \frac{[CH_3COOH][NaOH]}{[CH_3COONa]}$ or $Kh = \frac{[CH_3COOH][\bar{O}H]}{[CH3CO\bar{O}]}$

(b) Using; $Kh = \frac{[CH_3COOH][\bar{O}H]}{[CCH_2CO\bar{O}]}$

Assumptions; $[CH_3CO\bar{O}] = [CH_3COONa] = 0.1M$
$[CH_3COOH] = [\bar{O}H]$

But; $[\bar{O}H] = \frac{Kw}{[H^+]} = \frac{1\times10^{-14}}{[H^+]}$

However; $[H^+] = 10^{-pH}$ (since $pH = -\log_{10}[H^+]$)

And so; $[H^+] = 10^{-8.9}$

Thus; $[\bar{O}H] = \frac{1\times10^{-14}}{10^{-8.9}}$
$= 10^{-5.1} = \mathbf{7.94\times10^{-6}moldm^{-3}}$

Therefore; $Kh = \frac{[\bar{O}H]^2}{[CH3CO\bar{O}]}$
$= \frac{(7.94\times10^{-6})^2}{0.1} = \mathbf{6.30\times10^{-10}\ moldm^{-3}}$

(a) Observation; **White precipitate, insoluble** in excess ammonia solution but **turns brown** on standing.
Equation (s): $Mn^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Mn(OH)_2(s)$;
Then, $2Mn(OH)_2(s) + O_2(g) \longrightarrow 2MnO_2 \cdot H_2O(s)$
Or, $2Mn(OH)_2(s) + \frac{1}{2}O_2(g) \longrightarrow Mn_2O_3 \cdot 2H_2O(s)$

(b) Observation; **colourless** solution of manganese (II) chloride turns **purple.**
Equation: $2Mn^{2+}(aq) + 5PbO_2(s) + 4H^+(aq) \longrightarrow 2MnO_4^-(aq) + 5Pb^{2+}(aq) + 2H_2O(l)$

(a) Using; $Pv = \frac{mRT}{mr}$

Molecular mass; $mr = \frac{mRT}{Pv}$
$= \frac{0.1\times8.31\times(20+273)}{\left(\frac{766}{760}\times101325\right)\times(22.10\times10^{-6})} = 107.88g$

$n = \frac{107.88}{108} = 1$
∴molecular formula of *Y is SF_4*.

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$Therefore; (SF_4)_n = 107.88$

$and\ so;\ (1 \times 32)n + (4 \times 19)n = 107.88$

Alternatively;

Using; $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Volume of Y at stp; $V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{766 \times 22.10 \times 273}{(20+273) \times 760} = 20.754\ cm^3$

$Thus; 20.754cm^3\ of\ Y\ weigh\ 0.1g$

And so; $22400cm^3\ of\ Y\ weigh\ \frac{22400 \times 0.1}{20.754}$ g

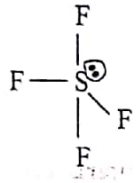
Hence; molecular mass of $Y = 107.93$g

Therefore; $(SF_4)_n = 107.93$

$32n + (4 \times 19)n = 107.93$

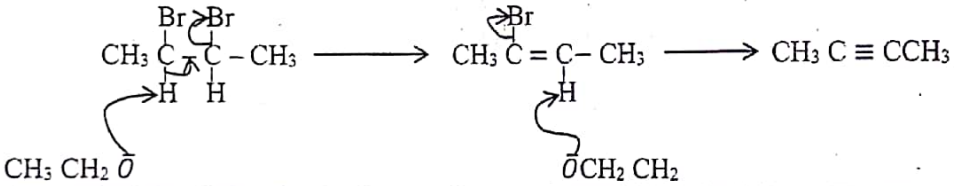
$n = \frac{107.93}{108} = 1$

$and\ so, the\ molecular\ formula\ of\ Y\ is\ SF_4$

(b)  irregular tetrahedral shape

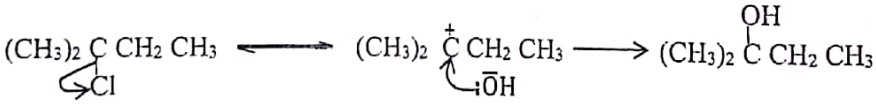
6. (a) $CH_3\,CH(Br)\,CH(Br)\,CH_3 \xrightarrow[\text{heat}]{CH_3CH_2\bar{O}/CH_3CH_2OH} CH_3\,C \equiv CCH_3$

Mechanism;



(b) $(CH_3)_2\,C(Cl)\,CH_2\,CH_3 \xrightarrow[\text{heat}]{NaOH(aq)} (CH_3)_2\,C(OH)\,CH_2\,CH_3$

Mechanism;



7.

Compound	Boron- silicon	Aluminium
Oxides	Oxides are acidic	Oxide is amphoteric
Hydrides	- Simple molecular structure - Ignite in air or highly flammable	- Polymeric - Does not ignite in air

8. (a) (i) -Substance to be steam distilled must be **immiscible with water**.
-Must have a **higher relative molecular mass**
-Should **exert a higher vapour pressure near the boiling point of water.**

(ii) Steam distillation can be used to purify substances which decompose at their boiling points

(b) Vapour pressure of $A = 753 - 7.5 = 38mmHg.$

Let; the percentage of A in distillate $= x$

Hence; the percentage of H_2O in distillate $= (100 - x)$

Thus; $\frac{\%\ of\ water\ in\ distillate}{\%\ of\ A\ in\ distillate} = \frac{Vapour\ pressure\ of\ H_2O \times Rmm\ of\ H_2O}{Vapour\ pressure\ of\ A \times Rmm\ of\ A}$

So;

$\frac{100 - x}{x} = \frac{715 \times 18}{38 \times 128}$

$x = 27.43\%$

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9. (a) $(CH_3COO)_2Cu$ or copper (II) ethanoate.

(b) $(CH_3COO)_2Cu(s) + H_2SO_4(aq) \longrightarrow 2CH_3COOH(aq) + CuSO_4(aq)$

(c) $Cu^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Cu(OH)_2(s)$

$Cu(OH)_2(s) + 4NH_3(aq) \longrightarrow Cu(NH_3)_4^{2+}(aq) + 2\bar{O}H(aq)$

10. (a) The mixture deviates **negatively** from Raoult's law.

(b) The intermolecular forces between molecules of X and Y (X – Y) are **greater in strength** than the intermolecular forces between the pure liquid molecules (X – X) or (Y –Y) This **reduces the escaping tendency** of the pure liquid molecules in solution into vapour phase, and consequently the **vapour pressure of the solution is lower than** expected from Raoult's law

(c) (i) **Hint**: In the boiling point-composition diagram shown, the upper curve respresnts the variation of the composition of the vapour with the composition of solution while the lower curve shows the variation of the boiling point of the solution with composition of mixture. Thus; to get the boiling point of amixture containing 0.3 mole fraction of Y, a vertical line is drawn from the horizontal axis at 0.3mole fraction of Y until it touches the liquid curve (lower curve), and then at that point a horizontal line is drawn to the boiling point axis to read off the boiling point.
Thus; The mixture containing 0.3 mole fraction of Y has a boiling point of **69.2°C.**

(ii) Composition of the vapour = 0.84 mole fraction of X and 0.16 mole fraction of X.
or, The vapour contains 84% X and 16% Y

(iii) Composition of the vapour = 0.6 mole fraction of Y and 0.4 mole fraction of X.
or, The vapour contains 60% Y and 40% X.

(d) (i) 100% X

(ii) 40% or 0.4 mole fraction of X and 60% or 0.6mole fraction of Y.

(a) (i) $NaH(s) + H_2O(l) \longrightarrow NaOH(aq) + H_2(g)$

(ii) $SiH_4(g) + 3H_2O(l) \longrightarrow H_2SiO_3(aq) + 4H_2(g)$

or $SiH_4(g) + H_2O(l) + 2\bar{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + 4H_2(g)$

(iii) $H_2S(g) + 2H_2O(l) \rightleftharpoons S^{2-}(aq) + 2H_3O^+(aq)$

or $H_2S(g) + H_2O(l) \rightleftharpoons HS^-(aq) + H_3O^+(aq)$

(b) (i) $Al_2O_3(s) + 6NaOH(aq) + 3H_2O(l) \longrightarrow 2Na_3Al(OH)_6(aq)$

or $Al_2O_3(s) + 6\bar{O}H(aq) + 3H_3O(l) \longrightarrow 2Al(OH)_6^{3-}$

or $Al_2O_3(s) + 2NaOH(aq) \longrightarrow 2NaAlO_2(aq) + H_2O(l)$

or $Al_2O_3(s) + 2\bar{O}H(aq) \longrightarrow 2AlO_2^-(aq) + H_2O(l)$

(ii) $P_2O_5(s) + 4NaOH(aq) \longrightarrow 2Na_2HPO_4(aq) + H_2O(l)$

or $P_2O_5(s) + 6\bar{O}H(aq) \longrightarrow 2PO_4^{3-}(aq) + 3H_2O(l)$

(iii) $SO_2(g) + 2NaOH(aq) \longrightarrow Na_2SO_3(aq) + H_2O(l)$

or $SO_2(g) + 2\bar{O}H(aq) \longrightarrow SO_3^{2-}(aq) + H_2O(l)$

or $SO_2(g) + NaOH(aq) \longrightarrow NaHSO_3(s)$

or $SO_2(g) + \bar{O}H(aq) \longrightarrow H\bar{S}O_3(aq)$

(a) (i) % of oxygen in Q $= 100 - (62.1 + 10.3) = 27.6\%$

	C	H	O
Composition of Q;	62.1	10.3	27.6
Moles;	$\frac{62.1}{12}$	$\frac{10.3}{1}$	$\frac{27.6}{16}$
	5.175	10.3	1.725
Mole ratio:	$\frac{5.175}{1.725}$	$\frac{10.3}{1.725}$	$\frac{1.725}{1.725}$
	3 :	6 :	1

Emperical formula of Q is C_3H_6O

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(ii) $1cm^3$ of Q weighs $2.59 \times 10^{-3} g$ at s.t.p

$\therefore 22400cm^3$ of Q weigh $\frac{22400 \times 2.59 \times 10^{-3}}{1}$ g at s.t.p

Hence; molecular mass of $Q = 58g$.

Thus; $(C_3H_6O)_n = 58$

$(3\times 12)n + (6 \times 1)n + (1 \times 16)n = 58$

$n = \frac{58}{58} = 1$

Hence; molecular formula of Q is C_3H_6O.

Note:

Normally, molecular mass is always obtained by multiplying the vapour density by 2. But this applies only when the vapour density is given without units. In this question the vapour density was given with units, hence the candidates had to calculate molecular mass through first principles as I did

(b) CH_3CH_2CHO, $CH_3\overset{O}{\overset{\|}{C}}-CH_3$, $CH_2{=}CH\,CH_2\,OH$, $CH_2{=}\overset{OH}{\overset{|}{C}}-CH_3$

(c) $CH_2=CH\,CH_2OH$ or $CH_2=\overset{OH}{\overset{|}{C}}-CH_3$

(d) (i) $CH_2=CH\,CH_2\,OH(l) + Br_2(l) \longrightarrow Br\,CH_2\overset{Br}{\overset{|}{C}}H\,CH_2\,OH(l)$

(ii) $CH_2=CH\,CH_2OH \xrightarrow{MnO_4^-/\bar{O}H} HO\,CH_2\overset{OH}{\overset{|}{C}}H\,CH_2\,OH$

13. (a) The curve was obtained by plotting the cooling curves of various compositions of the molten mixture of X and Y.

(b) (i) P – liquid mixture
(ii) Q – liquid mixture and solid Y
(iii) R – solid X and solid Y
(iv) S – liquid mixture and solid X

(c) Eutectic point

(d) (i) 323°C
(ii) 418°C

(e) The liquid mixture **cools without change in phase** up to a temperature of 360°C (point M) where **solid Y begins to crystallize out**. The composition of X in the mixture increases causing **a further decreasing in freezing point of Y along MB.**
At B (290°C) **solid X also begins to crystallize together with solid Y.** the freezing temperature **remains constant** until all the liquid mixture **freezes** (solidifies) and there after the **solid mixture cools to 270°C.**

14. (a) (i) Ionic radius decreases from Na^+ to Mg^{2+} to Al^{3+}; From Na^+ to Mg^{2+} to Al^{3+}, the **nuclear charge increases** while the **number of electrons remains constant.**
Effective nuclear charge becomes greater and outer energy level electrons are **strongly attracted** towards the nucleus, hence a decrease in ionic radius.

(ii) Enthalpy of hydration increases from Na^+ to Mg^{2+} to Al^{3+}. From Na^+ to Mg^{2+} to Al^{3+}, ionic radius decreases and ionic charge increases which result into **increase** in the **charge density** of the ion hence leading to **strong attraction** of many water molecules by the ion and thus **increase in hydration energy.**

(b) (i) $\frac{+1}{0.095} = 10.53$
(ii) $\frac{+2}{0.065} = 30.77$
(iii) $\frac{+3}{0.050} = 60.00$

(c) (i) Na^+
(ii) Al^{3+}

(d) Na^+ has the lowest polarizing power because it has the **smallest charge** and the **largest ionic radius** compared to Mg^{2+} and Al^{3+}. Al^{3+} has the greatest polarizing power because it has the **highest charge** and **smallest ionic radius.**

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15. (a) $CH_3CH_2CH_2OH \xrightarrow[\text{heat}]{\text{conc. } H_2SO_4} CH_3CH=CH_2 \xrightarrow[\text{2. } H_2O\text{ / warm}]{\text{1.conc. } H_2SO_4} CH_3\underset{\displaystyle OH}{\underset{|}{C}}HCH_3$

$CH_3\underset{\displaystyle O}{\underset{\|}{C}}-CH_3$ ← ($Cr_2O_7^{2-}/H^+$ or CrO_3/H^+ or MnO_4^-/conc.H_2SO_4, heat)

or; $CH_3CH_2CH_2OH \xrightarrow[\text{heat}]{\text{conc. } H_2SO_4} CH_3CH=CH_2 \xrightarrow[\text{or}(Al_2O_3/300^\circ C)]{Br_2/CCl_4} CH_3\underset{\displaystyle Br}{\underset{|}{C}}H\underset{\displaystyle Br}{\underset{|}{C}}H_2$

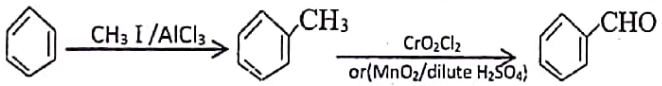
$CH_3\underset{\displaystyle O}{\underset{\|}{C}}-CH_3 \xleftarrow[HgSO_4/60^\circ C]{H_2O,\text{ dilute } H_2SO_4} CH_3C\equiv CH$ ← (KOH/ethanol, heat)

Alternatively;

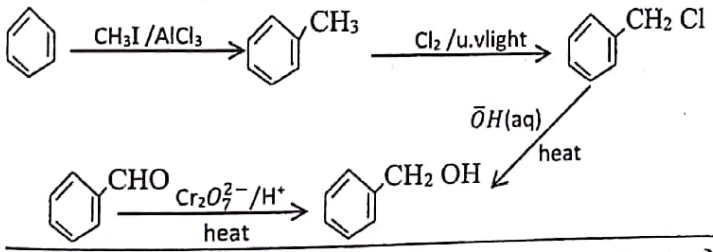
$CH_3CH_2CH_2OH$ to $CH_3\underset{\displaystyle O}{\underset{\|}{C}}-CH_3$

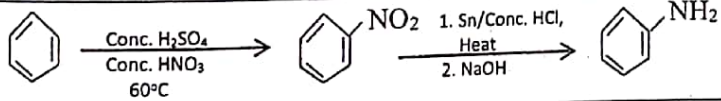
$CH_3CH_2CH_2OH \xrightarrow[\text{heat}]{\text{conc. } H_2SO_4} CH_3CH=CH_2 \xrightarrow{HBr} CH_3\underset{\displaystyle Br}{\underset{|}{C}}HCH_3 \xrightarrow[\text{heat}]{NaOH(aq)} CH_3\underset{\displaystyle OH}{\underset{|}{C}}H-CH_3$

($Cr_2O_7^{2-}/H^+$ or CrO_3/H^+ or MnO_4^-/conc.H_2SO_4, heat)

(b) 

Alternatively;



(c) 

16. (a) Equation; $Sn(s) + 2HCl(g) \longrightarrow SnCl_2(s) + H_2(g)$
Conditions – **heat** and **dry** hydrogen chloride.
(ii) Equation $Sn(s) + 2Cl_2(g) \longrightarrow SnCl_4(l)$
Conditions **heat.**
(b) (i) Tin (II) chloride gives **no observable change**
Tin (IV) chloride forms **misty fumes** in most air
(ii) $SnCl_4(l) + 2H_2O(l) \longrightarrow SnO_2(s) + 4HCl(g)$
or, $SnCl_4(l) + 4H_2O(l) \longrightarrow SnO_2 \cdot 2H_2O(s) + 4HCl(g)$
(c) $Sn^{2+}(aq) + 2Fe^{3+}(aq) \longrightarrow Sn^{4+}(aq) + 2Fe^{2+}(aq)$

17. (a) Freshly prepared distilled water **does not contain carbon dioxide or carbonic acid** which would otherwise react with the **alkaline** sodium hydroxide to **form sodium carbonate** and this would **reduce the concentration or the purity** of the sodium hydroxide.
ie $2NaOH(aq) + CO_2(g) \longrightarrow Na_2CO_3(aq) + H_2O(l)$
or, $2NaOH(aq) + H_2CO_3(aq) \longrightarrow Na_2CO_3(aq) + 2H_2O(l)$

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(b) The thiosulphate ions **would react** with the acid solution to form **sulphur, sulphur dioxide and water** and this would **reduce the concentration of the thiosulphate.**

$S_2O_3^{2-}(aq) + 2H^+(aq) \longrightarrow S(s) + SO_2(g) + H_2O(l)$

(c) Titration of ethanoic acid and sodium hydroxide solution results into formation of **sodium ethanoate** salt which at end point under goes **hydrolysis** to produce **hydroxide ions**, hence making the solution at end point **alkaline** .

$CH_3CO\bar{O}(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + \bar{O}H(aq)$.

Thus the pH at end point is greater than seven which is within the working range of phenolphthalein indicator that is a weak organic acid. This pH howecer is outside the working range of methyl orange indicator which is a weak organic base

QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2 (P525/2), 2008

1. (a) Ethanol reacts with ethanoic acid to form ethyl ethanoate according to the following equation. ΔH is negative.

$CH_3CO_2H(l) + CH_3CH_2OH(l) \rightleftharpoons CH_3CO_2CH_2CH_3(l) + H_2O(l)$

(i) State the conditions for the reaction (01 mark)

(ii) Describe how the equilibrium constant, K_c for the reaction can be determined by a titrimetric method. (08 marks)

(b) Explain what would happen to the equilibrium constant if; (03 marks)

(i) a catalyst was added (03 marks)

(ii) the temperature was increased.

(d) A mixture of 0.69g of ethanol and 0.9g of ethanoic acid were allowed to react at 90°C until equilibrium was reached. Calculate the mass of ethyl ethanoate formed at equilibrium. ($K_c = 3.6$). (05 marks)

2. (a) State four properties in which fluorine differs from iodine. (04 marks)

(b) State the conditions and write equations for the reaction between sodium hydroxide and; (05 marks)

(i) Fluorine (05 marks)

(ii) iodine

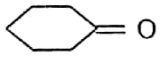
(c) Compare the oxidizing powers of fluorine and iodine using their reactions with water. (06 marks)

3. Write equations to show how each of the following compounds can be synthesized. In each case, indicate the reagents and conditions for the reaction.

(a)  from benzoic acid (5½ marks)

(b) $CH_3C \equiv CH$ from ethene. (5½ marks)

(c) $CH_3 - \underset{\displaystyle CH_3}{\overset{\displaystyle |}{C}} = NOH$ from ethanol (5 marks)

(d)  from cyclohexene (04 marks)

4. (a) (i) Describe an experiment which can be carried out to determine the solubility product of calcium iodate, $Ca(IO_3)_2$. (7½ marks)

(ii) The solubility product of calcium iodate is $1.69 \times 10^{-9} mol^3 l^{-3}$ at 25°C. Calculate the concentration of iodate ions in a saturated solution of calcium iodate at 25°C (3½ mrks)

(iii) State **three** factors that can affect the value of solubility product. (1½marks)

(b) (i) 0.1 mole of calcium nitrate was added to a litre of a saturated solution of calcium iodate and the mixture stirred. Calculate the mass of calcium iodate which was precipitated. State any assumptions you have made. (4½ marks)

(ii) Triphosphate ions form a soluble complex with calcium ions. State what would happen when triphosphate ions are added to a saturated solution of calcium iodate and give a reason for your answer. (02 marks)

(c) State **two** applications of solubility product. (01 mark)

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5. Complete the following equations and in each ease outline a mechanism for the reaction

(a)  + $CH_3CO\,Br \xrightarrow{FeCl_3}$ ..... (4 marks)

(b) $CH_3\overset{O}{\overset{\|}{C}}-CH_3 + H_2N-NH-CONH_3 \xrightarrow{H^+}$ ..... (5 marks)

(c) $CH_3CH_2CHO + HSO_3^-\,Na^+ \longrightarrow$ ..... (2½ marks)

(d) $(CH_3)_3CBr + CH_3CH_2O^-Na^+ \xrightarrow[heat]{CH_3CH_2OH}$ ..... (3 marks)

(e) $CH_3CH_2OH + conc.H_2SO_4 \xrightarrow{140^o}$ ..... (2 marks)

6. Explain the following observations:

(a) Ammonia forms a white precipitate with aqueous manganese (II) ions, but in the presence of ammonium chloride no precipitate is formed (05 marks)

(b) Methanoic acid forms a grey precipitate with ammoniacal silver nitrate whereas ethanoic acid does not. (04 marks)

(c) When sodium hydroxide solution is added drop wise until in excess to potassium chromium (III) sulphate solution, a green precipitate is formed that dissolves to form a deep green solution. On addition of hydrogen peroxide, the solution turns from green to yellowish-brown. (06 marks)

(d) The polarizing power of group II elements are much hiher than those of the group I elements.

7. (a) Define the following terms

(i) colligative property, (02 marks)

(ii) eutectic point, (02 marks)

(iii) eutectic mixture (02 marks)

(b) A solution contains 1.80g of naphthalene in 3.0g of camphor.

(i) Calculate the melting point of the solution

[The relative molecular mass of naphthalene = 128 melting point of pure camphor = 177°C The freezing point constant, kf for camphor = 40°C per mol per 100g] (04 marks)

(ii) State whether your answer in (b)(i) would be significantly affected if the pressure of the system was lowered. Give a reason for your answer. (02 marks)

(c) Naphthalene – biphenyl system forms a eutectic mixture at 41°C. The eutectic mixture contains 0.47 mole fraction of naphthalene. The melting points of various compositions of naphthalene – biphenyl system are shown in the table below.

Mole fraction naphthalene	0.125	0.275	0.625	0.800
Melting point (°C)	63.0	53.0	54.0	69.0

(i) Draw an accurate phase diagram for the naphthalene – biphenyl system and label all the regions of the diagram. [The melting points of naphthalene and biphenyl are 86°C and 71°C respectively.] (04 marks)

(ii) Explain what would happen if a liquid mixture containing 80% naphthalene at 60°C was gradually cooled. (02 marks)

(d) State **two** similarities between a eutectic mixture and a pure substance. (02 marks)

8. (a) Describe how;

(i) impure copper can be obtained from copper pyrites (09 marks)
(Your answer should include equations)

(ii) the percentage purity of copper can be determined in the laboratory by titrimetric method. (06 marks)

(b) Outline how an impure sample of copper can be purified (05 marks)

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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2008

Question. One.

(a) (i) -Warm or heat
-Concentrated sulphuric acid

(ii) A **known** amount of ethanoic acid (a **moles**) is mixed with a **known amount** of ethanol (b **moles**) and kept in a **sealed** tube for **one week** (for some time) at a **constant temperature** The amount of ethanoic acid remaining (x ***moles***) is found by breaking the tube in water and titrating with a **standard solution** of **sodium hydroxide** using **phenolphthalein indicator**

Treatment of results;
Moles of ethanoic acid present at equilibrium = $x\ moles$
Moles of ethanoic acid which reacted = $(a-x) moles$
Since, the mole ratio of ethanol; ethanoic acid = 1:1
Therefore moles of ethanol which reacted = $(a-x) moles$
Moles of ethanol present at equilibrium = $(b-(a-x) moles$
Moles of ester formed = moles of water = $(a-x) moles$
Let the volume of the tube = $x dm^3$

Equation of reaction between ethanoic acid and ethanol

$$CH_3CO_2H(l) + CH_3CH_2OH(l) \rightleftharpoons CH_3CO_2CH_2CH_3(l) + H_2O(l)$$

	$CH_3CO_2H(l)$	$CH_3CH_2OH(l)$	$CH_3CO_2CH_2CH_3(l)$	$H_2O(l)$
Moles initially;	a moles	b moles	0	0
Moles at Equilibrium;	x	$b-(a-x)$	$(a-x)$	$a-x$
Molar concentration at Equilibrium	$\frac{x}{v}$	$\frac{b-(a-x)}{v}$	$\frac{a-x}{v}$	$\frac{a-x}{v}$

Hence; $Kc = \frac{[CH_3CO_2CH_2CH_3][H_2O]}{[CH_3CO_2H][CH_3CH_2OH]}$

$$Kc = \frac{\left(\frac{a-x}{v}\right) \times \left(\frac{a-x}{v}\right)}{\left(\frac{x}{v}\right) \times \frac{b-(a-x)}{v}}$$

$$Kc = \frac{(a-x)^2}{x(b-a+x)}$$

(b) (i) The value of the equilibrium constant **remains the same** because a catalyst **equally changes** the rate of the forward and back ward reaction and the composition of the **equilibrium mixture remains unchanged**

(ii) - The value of the equilibrium constant **would decrease**
- Temperature change affects both the composition of the equilibrium mixture and the value of the equilibrium constant
- The back ward reaction is **endothermic** hence favoured by increase in temperature according to Le- Chatelier's principle.

Since, $Kc = \frac{[CH_3CO_2CH_2CH_3][H_2O]}{[CH_3COOH][CH_3CH_2OH]}$

The composition of the equilibrium mixture will have a **higher concentration** of reactants and a **lower concentration** of products and hence equilibrium constant decreases.

(c) Molecular mass of $CH_3COOH = (12\times2) + (4\times1) + (2\times16) = 60$
Molecular mass of $CH_3CH_2OH = (12\times2) + (6\times1) + 16 = 46$
Moles of CH_3COOH in $0.9g = \frac{0.9}{60} = 0.015 moles$

Moles of CH_3CH_2OH in $0.69g = \frac{0.69}{46} = 0.015 moles.$

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Let; x = moles of ethanoic acid that reacted at equilibrium;

	$CH_3CO_2H(l)$	+	$CH_3CH_2OH(l)$	⇌	$CH_3CO_2CH_2CH_3(l)$	+	$H_2O(l)$
Moles initially;	0.015		0.015		0		0
Moles at equilibrium;	$(0.015 - x)$		$(0.015 - x)$		x		x

$$Kc = \frac{x^2}{(0.015-x)^2}$$

$$\therefore x = 0.0098229$$

Number of moles of ethylethanoate $(CH_3CO_2CH_2CH_3)_n$ at equilibrium = 0.0098229
Molecular mass of $CH_3CO_2CH_2CH_3 = (4 \times 12) + (8 \times 1) + (2 \times 16) = 88$
Hence; mass of ethyl ethanoate at equilibrium = $0.0098229 \times 88 = \underline{0.8644}$ g

Question. Two.

(a) - Fluorine **oxidizes** water to form **oxygen** and **hydrogen fluoride** whereas iodine **does not** react with water
- Fluorine reacts with carbon or nitrogen to form carbon tetrafluoride or nitrogen trifluoride respectively. Iodine **does not** react with carbon or nitrogen
- Fluorine reacts with cold dilute sodium hydroxide solution to form sodium fluoride, oxygen difluoride and water while iodine reacts with the same alkali under similar conditions to form sodium iodide, sodium iodate (I) and water
- The solubility of fluoride salts differs from the solubility of iodine salts of the same element
- Fluorine has only one oxidation state of (-1) whereas iodine has several oxidation sates
- Hydrogen fluoride is a liquid whereas hydrogen iodide acid is a gas
- Hydrofluoric acid is a weak acid whereas hydroiodic acid is a strong acid
- Elements show their maximum oxidation states with fluorine but not with iodine
- Hydrofluoric acid reacts with silicon (IV) oxide but hydro iodic acid does not.

(b) (i) With **cold dilute** sodium hydroxide solution

$$2NaOH(aq) + 2F_2(g) \longrightarrow 2NaF(aq) + OF_2(g) + H_2O(l)$$

or, $$2\overline{O}H(aq) + 2F_2(g) \longrightarrow 2F^-(aq) + OF_2(g) + H_2O(l)$$

Warm (hot) **concentrated** sodium hydroxide solution

$$4NaOH(aq) + 2F_2(g) \longrightarrow 4NaF(aq) + O_2(g) + 2H_2O(l)$$

or, $$4\overline{O}H(aq) + 2F_2(g) \longrightarrow 4F^-(aq) + O_2(g) + 2H_2O(l)$$

(ii) **Cold dilute** sodium hydroxide

$$2NaOH(aq) + I_2(aq) \longrightarrow NaI(aq) + NaIO(aq) + H_2O(l)$$

or, $$2\overline{O}H(aq) + I_2(aq) \longrightarrow I^-(aq) + I\overline{O}(aq) + H_2O(l)$$

Hot concentrated sodium hydroxide

$$6NaOH(aq) + 3I_2(aq) \longrightarrow 5NaI(aq) + NaIO_3(aq) + 3H_2O(l)$$

or $$6\overline{O}H(aq) + 3I_2(aq) \longrightarrow 5I^-(aq) + IO_3^-(aq) + 3H_2O(l)$$

(c) Fluorine is a **stronger oxidizing agent** than iodine. Fluorine oxidizes water to produce hydrofluoric acid and oxygen gas

$$2F_2(g) + 2H_2O(l) \longrightarrow 4HF(aq) + O_2(g)$$

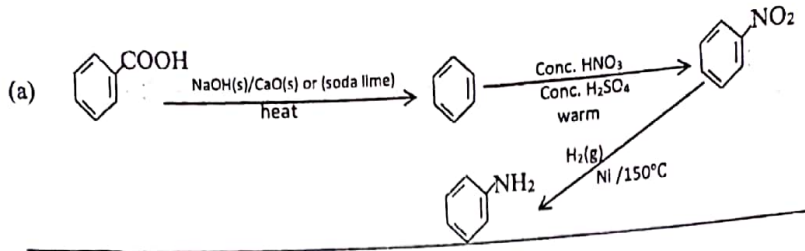
or, $$3F_2(g) + 3H_2O(l) \longrightarrow 6HF(aq) + O_3(g)$$

Iodine **does not** react with water

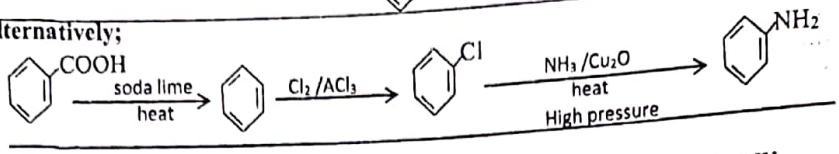
Question. Three.

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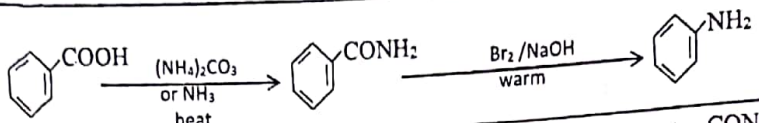
(a)



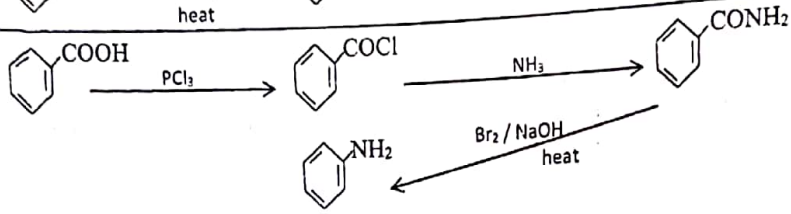
Alternatively;



or



or



(b) $CH_2 = CH_2 \xrightarrow{Cl_2/CCl_4} CH_2Cl\,CH_2Cl \xrightarrow[heat]{KOH/Ethanol} HC \equiv CH$

$HC \equiv CH \xrightarrow[Liquid\ NH_3]{Na\ or\ NaNH_2} Na^+\bar{C} \equiv CH \xrightarrow{CH_3Cl} CH_3C \equiv CH$

or,

$CH_2 = CH_2 \xrightarrow{HCl} CH_3CH_2Cl \xrightarrow[Ethanol,\ heat]{KCN} CH_3CH_2CN \xrightarrow[heat]{H_2O/H^+} CH_3CH_2COOH$

$CH_3CH_2COOH \xrightarrow[Dryether]{LiAlH_4} CH_3CH_2CH_2OH \xrightarrow[heat]{Conc.\ H_2SO_4} CH_3CH = CH_2$

$CH_3CH = CH_2 \xrightarrow[CCl_4]{Cl_2} CH_3\underset{Cl}{CH}CH_2Cl \xrightarrow[Ethanol,\ heat]{KOH} CH_3C \equiv CH$

or,

$CH_2 = CH_2 \xrightarrow[2.\ H_2O/warm]{1.\ Conc.\ H_2SO_4} CH_3CH_2OH \xrightarrow[heat]{Mn\bar{O}_4/conc.\ H_2SO_4} CH_3COOH \xrightarrow{CaCO_3} (CH_3COO)_2Ca$

$(CH_3COO)_2Ca \xrightarrow{heat} CH_3\overset{O}{\overset{\|}{C}}-CH_3 \xrightarrow{PCl_5} CH_3\overset{Cl}{\underset{Cl}{C}}-CH_3 \xrightarrow[Ethanol,\ heat]{KOH} CH_3C \equiv CH$

or, $CH_2=CH_2 \xrightarrow{HCl} CH_3CH_2Cl \xrightarrow[dryether,\ reflux]{Mg} CH_3CH_2MgCl \xrightarrow{CO_2} CH_3CH_2COOMgCl \xrightarrow{H_2O} CH_3CH_2COOH$

$CH_3CH_2COOH \xrightarrow[Dryether]{LiAlH_4} CH_3CH_2CH_2OH \xrightarrow[heat]{Conc.\ H_2SO_4} CH_3CH=CH_2$

$CH_3CH=CH_2 \xrightarrow[CCl_4]{Cl_2/} CH_3\underset{Cl}{CH}CH_2Cl \xrightarrow[heat]{KOH/Ethanol} CH_3C \equiv CH$

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or $CH_2 = CH_2 \xrightarrow{HCl} CH_3CH_2Cl \xrightarrow[\text{dryether, reflux}]{Mg} CH_3CH_2MgCl$

$CH_3CH_2MgCl \xrightarrow[2.H_2O/H^+]{1.\ H-\overset{O}{\overset{\|}{C}}-H} CH_3CH_2CH_2OH \xrightarrow[heat]{Conc.\ H_2SO_4} CH_3CH=CH_2 \xrightarrow[CCl_4]{Cl_2} CH_3CH(Cl)CH_2Cl \xrightarrow[heat]{KOH/Ethanol} CH_3C\equiv CH$

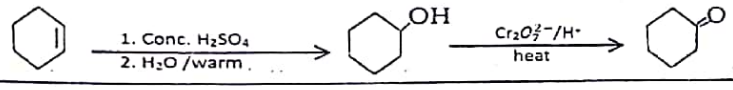
(c) $CH_3CH_2OH \xrightarrow[170°C]{Conc.\ H_2SO_4} CH_2=CH_2 \xrightarrow[CCl_4]{Cl_2} CH_2ClCH_2Cl \xrightarrow[heat]{KOH,\ Ethanol} HC\equiv CH \xrightarrow[Liquid\ NH_3]{Na} HC\equiv C^-Na^+ \xrightarrow{CH_3Cl} CH_3C\equiv CH$

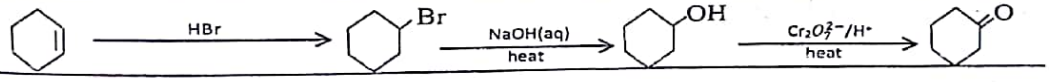
$CH_3C\equiv CH \xrightarrow[Dilute\ H_2SO_4,\ HgSO_4/60°C]{H_2O} CH_3-\overset{O}{\overset{\|}{C}}-CH_3 \xrightarrow[H^+]{NH_2OH} CH_3\overset{NOH}{\overset{\|}{C}}CH_3$

or, $CH_3CH_2OH \xrightarrow{PCl_5} CH_3CH_2Cl \xrightarrow[dryether,\ reflux]{Mg} CH_3CH_2MgCl \xrightarrow[warm]{CO_2,\ H_2O} CH_3CH_2COOH \xrightarrow[dryether]{LiAlH_4} CH_3CH_2CH_2OH \xrightarrow[heat]{Conc.\ H_2SO_4} CH_3CH=CH_2$

$CH_3CH=CH_2 \xrightarrow[2.\ H_2O/warm]{1.\ Conc.\ H_2SO_4} CH_3CH(OH)CH_3 \xrightarrow[heat]{Cr_2O_7^{2-}/H^+} CH_3\overset{O}{\overset{\|}{C}}CH_3 \xrightarrow[H^+]{NH_2OH} CH_3\overset{NOH}{\overset{\|}{C}}CH_3$

or, $CH_3CH_2OH \xrightarrow[heat]{Cr_2O_7^{2-}/H^+} CH_3COOH \xrightarrow{CaCO_3} (CH_3COO)_2Ca \xrightarrow{heat} CH_3\overset{O}{\overset{\|}{C}}CH_3 \xrightarrow[H^+]{NH_2OH} CH_3C(=NOH)CH_3$

(d) 

or 

Question. Four.

(a) (i) **Excess** of solid calcium iodate is added to a **given volume of distilled water** and the mixture is **shaken** for some time in a clean beaker.

The mixture is allowed to settle at a **constant temperature** and then **filtered**

- The **electrolytic conductivity of the filtrate is measured using a conductivity meter.**

The molar conductivity at infinite dilution of calcium ions and iodate ions are obtained from tables and are used to find the molar conductivity of calcium iodate at infinite dilution.

The concentration of calcium iodate (x moldm^3) in the saturated solution is calculated using the formula

$$x = \frac{Electrolytic\ conductivity\ of\ calcium\ iodate}{molar\ conductivity\ of\ calcium\ iodate\ at\ infinite\ dilution}$$

Equation of solubility of calcium iodate is;

$Ca(IO_3)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2IO_3^-(aq)$

From the equation of solubility; Concentration of calcium iodate = concentration of calcium ions = x

concentration of iodate (V) ions = $2x$

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Hence; The solubility product; Ksp of calcium iodate is calculated using the expression;

$Ksp = [Ca^{2+}][IO_3^-]^2 = x \times (2x)^2 = 4x^3$

Alternatively;

-Excess of solid calcium iodate is added to a given volume of **distilled** water and the mixture **shaken for some time** in clean beaker

-The mixture is allowed to settle at a **constant temperature** and then **filtered**

-**A known volume** of the saturated solution of the filtrate is pipetted and **excess potassium iodide** solution added followed by ethanoic acid. Iodate ions react with iodide ions to liberate iodine according to the equation

$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \longrightarrow 3I_2(aq) + 3H_2O(l)$

-The iodine liberated is titrated with a standard solution of sodium thiosulphate using **starch indicator** Iodine reacts with thiosulphate ion according to the equation

$2S_2O_3^-(aq) + I_2(aq) \longrightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$

Using the equations, the concentration of calcium iodate in the saturated solution is calculated ie $ymoldm^{-3}$

Hence; concentration of calcium ions $= y$ and concentration of iodate ions $= 2y$

Therefore, the solubility product; Ksp of calcium iodate is calculated using the expression;

$Ksp = [Ca^{2+}][IO_3]^2$

$= x(2x)^2 = 4x^3$

(ii) Equation of solubility of $Ca(IO_3)_2$ is;

$Ca(IO_3)_2(s) + (aq) \rightleftharpoons Ca^{2+}(aq) + 2IO_3^-(aq)$

$Ksp = [Ca^{2+}][IO_3^-]^2$; if; s = solubility $Ca(IO_3)_2$;

Then; $[Ca^{2+}] = s$ and $[IO_3^-] = 2s$

Therefore; $Ksp = s \times (2s)^2 = 1.69 \times 10^{-9}$

Hence; $4s^3 = 1.69 \times 10^{-9}$

$\therefore s = \sqrt[3]{\left(\frac{1.69\times10^{-9}}{4}\right)} = \underline{7.50 \times 10^{-4} moll^{-1}}$

$[IO_3^-] = 2 \times 7.50 \times 10^{-4} = \underline{1.50 \times 10^{-3} moll^{-1}}$

(iii) Temperature;

Note; The question called for three factors that can affect the value of solubility product, but the value of solubility product is **only affected by temperature**

(b) (i) Let; the solubility of $Ca(IO_3)_2$ on addition of 0.1M calcium nitrate $= xmoldm^{-3}$

Hence; $[Ca^{2+}] = x + 0.1 \simeq 0.1moldm^{-3}$ (since x is very small)

$[IO_3^-] = 2x$

since; $[Ca^{2+}][IO_3^-]^2 = Ksp$

Therefore; $0.1(2x)^2 = 1.69 \times 10^{-9}$

$x = \sqrt{\frac{1.69\times10^{-9}}{0.4}} = 6.5 \times 10^{-5}$

Hence; $[Ca(IO_3)_2] = 6.5 \times 10^{-5} moldm^{-3}$

Moles of calcium iodate precipitated $= 7.5 \times 10^{-4} - 6.5 \times 10^{-5}$

$= 6.85 \times 10^{-4} moles$

Formula mass of $Ca(IO_3)_2 = (1 \times 40) + (2 \times 127) + (6 \times 16) = 390$

Mass of $Ca(IO_3)_2$ precipitated $= (6.85 \times 10^{-4}) \times 390 = \mathbf{0.267g}$

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Assumptions

No change in temperature occured

$[Ca^{2+}] = 0.1moldm^{-3}$, since concentration of calcium ions from calcium iodate is very small, hence ignored

There is no change in total volume of solution

(ii) Solid calcium iodate **dissolves** or solubility of calcium iodate **increases.**

Formation of a complex reduces the concentration of calcium ions in solution and as a result **more calcium iodate dissolves** to keep the solubility product; Ksp, constant, and according to Le-chatelier's principle it has to dissolve to replace the calcium ions

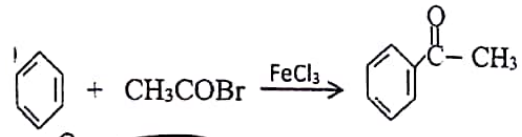
(c) Purification of common salt

Salting out of soap

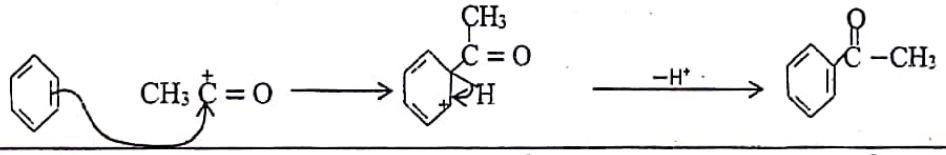
Identification of ions during qualitative analysis

Question. Five.

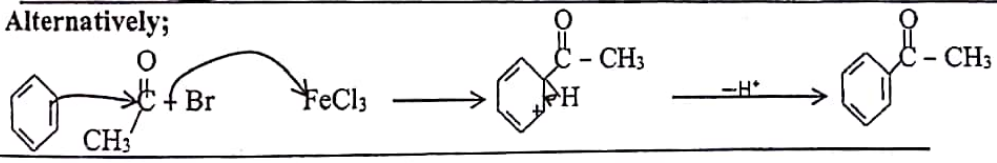
(a)



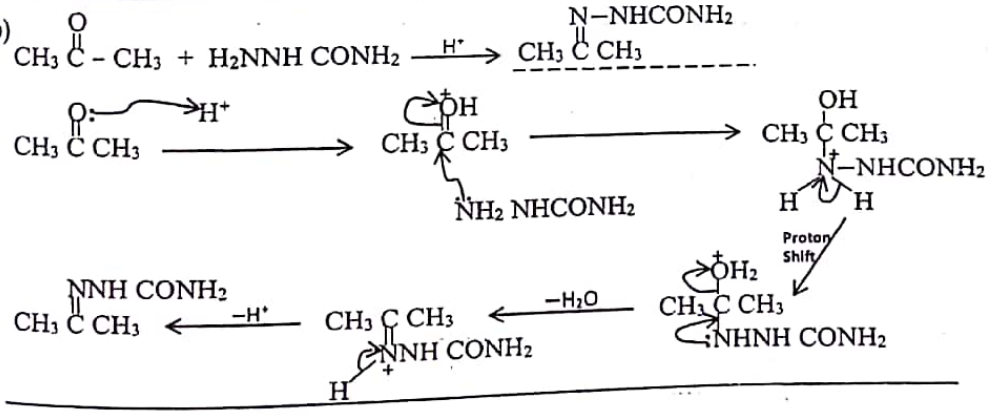




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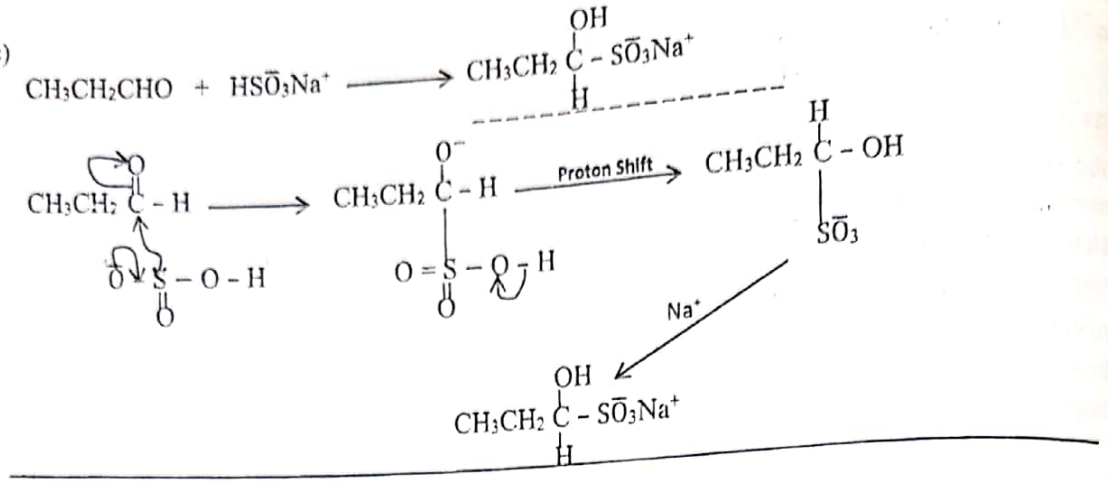


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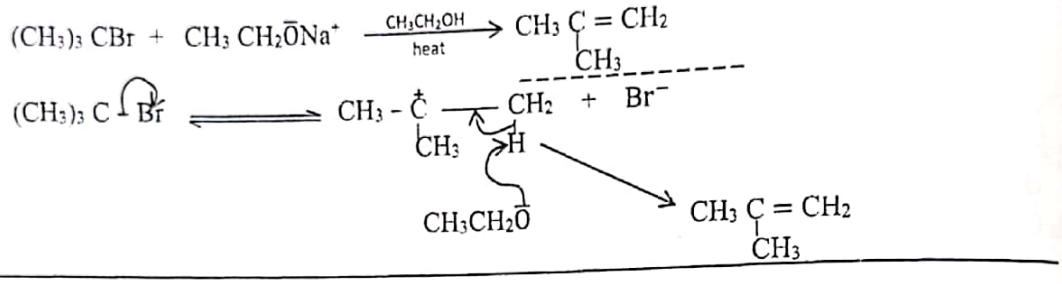


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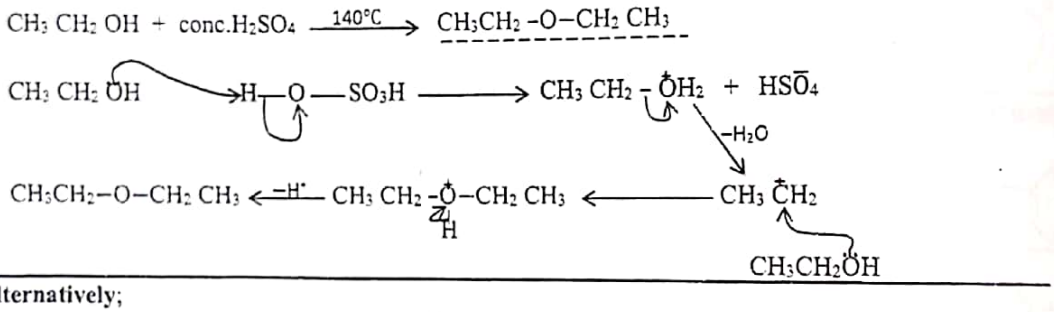
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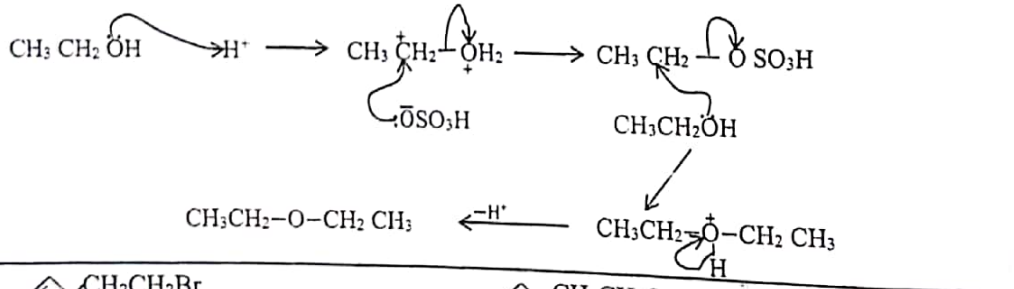
(d)



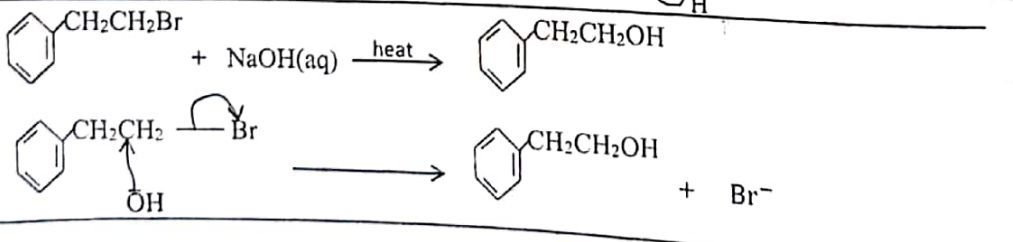
(e)



Alternatively;



(f)



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Question. Six.

(a) Ammonia is a **weak base** and therefore reversibly ionizes in water to form ammonium ions and **hydroxide ions.**

$NH_3(aq) + H_2O(l) \rightleftharpoons \overset{+}{N}H_4(aq) + \overline{O}H(aq)$

The product of the molar concentration of manganese (II) ions and hydroxide ions **exceeds** the solubility product of manganese (II) hydroxide hence causing **precipitation** of manganese (II) hydroxide

$Mn^{2+}(aq) + 2OH(aq) \longrightarrow Mn(OH)_2(s)$

However, in presence of ammonium chloride which is a **strong electrolyte** that increases the concentration of ammonium ions in solution **suppress the ionization of ammonia molecules.** This therefore **reduces the concentration of hydroxide ions** and as a result the solubility product of manganese (II) hydroxide is not exceeded and hence **no precipitation** occurs

(b) Methanoic acid has an **alkanal group** or **aldehyde group** (lacks an alkyl group). It is easily **oxidized** by ammoniacal silver nitrate to form **silver** atoms

$$H-\overset{\overset{O}{\|}}{C}-O-H(aq) + 2Ag(NH_3)_2^+(aq) \longrightarrow 2Ag(s) + CO_2(g) + 2\overset{+}{N}H_4(aq) + 2NH_3(aq)$$

Ethanoic acid **does not have an alkanal group** (contains an alkyl group) and so it **cannot be easily oxidized**

(c) Chromium (III) ions in potassium chromium (III) sulphate solution react with hydroxide ions of sodium hydroxide solution to form **insoluble chromium (III) hydroxide**

$Cr^{3+}(aq) + 3\overline{O}H(aq) \longrightarrow Cr(OH)_3(s)$

The chromium (III) hydroxide formed is **amphoteric** and hence reacts with excess sodium hydroxide which is **alkaline** to form a **soluble complex** of tetra hydroxo chromate (III) ions (or hexahydroxo chromate (III) ions)

$Cr(OH)_3(s) + \overline{O}H(aq) \longrightarrow Cr(OH)_4^-(aq)$

or $Cr(OH)_3(s) + 3\overline{O}H(aq) \longrightarrow Cr(OH)_6^{3-}(aq)$

Hydrogen peroxide then **oxidizes** the chromate (III) compound to form **chromate (VI) ions** in alkaline conditions

$2Cr(OH)_4^-(aq) + 3H_2O_2(aq) + 2\overline{O}H(aq) \longrightarrow 2CrO_4^{2-}(aq) + 8H_2O(l)$

or, $2Cr(OH)_3(s) + 3H_2O_2(aq) + 4\overline{O}H(aq) \longrightarrow 2CrO_4^{2-}(aq) + 8H_2O(l)$

or, $2Cr^{3+}(aq) + 3H_2O_2(aq) + 10\overline{O}H(aq) \longrightarrow 2CrO_4^{2-}(aq) + 8H_2O(l)$

(d) Group (II) elements form cations with a **larger positive charge** and **smaller cationic radius** and hence have a higher charge density than group (I) elements.

Question. Seven.

(a) (i) Physical property of a **dilute** solution that depends on the number of the **non volatile** solute particles present in a **fixed** volume of a solution

(ii) A point when a solution of a given composition solidifies **without change in composition** at **a constant temperature**

or; Lowest temperature reached before the whole system solidifies

or; A constant temperature at which the solid mixture is in equilibrium with the liquid mixture

(iii) A solution which solidifies without change in composition at a constant temperature

(b) (i) 3g of camphor dissolved 1.8g of naphthalene

$\therefore$ 100g of camphor dissolved $\left(\frac{100\times1.8}{3}\right)$ **= 60g naphthalene**

128g of naphthalene cause a freezing point depression of 40°C

$\therefore$ 60g of naphthalene cause a freezing point depression of $\left(\frac{60\times40}{128}\right)$ °C

$= 18.75$°C

Hence; melting point of solution $= 177 - 18.75 = 158.25$°C

(ii) The melting point of the solution **would be affected or lowered** because **increase in pressure increases the melting point of solution**

(c) (i) See graph next page

(ii) The mixture cools without change in phase upto point X, at a temperature

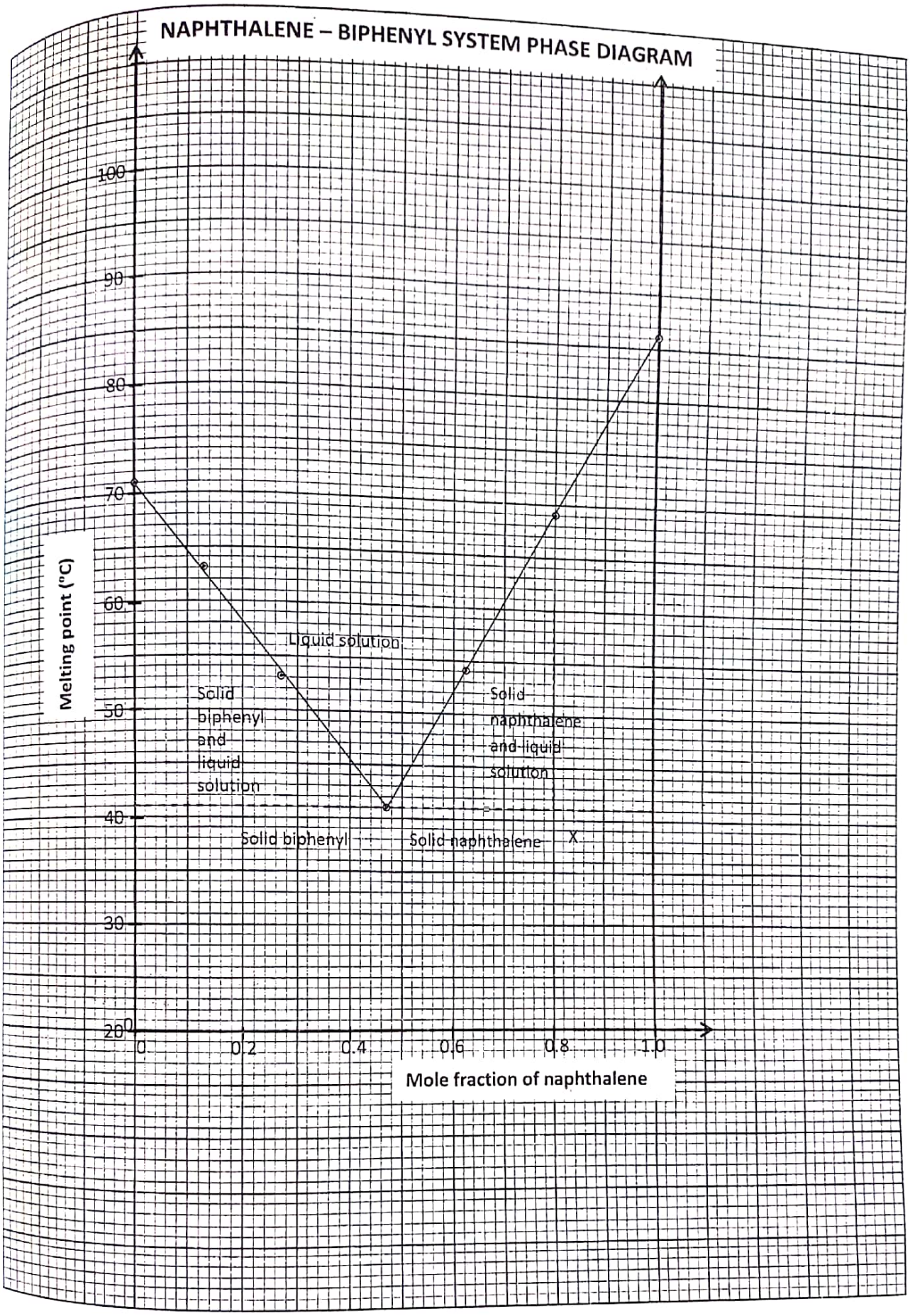
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of 41°C, (see graph). This temperature remains constant until all the mixture freezes. Thereafter the solid mixture cools without change in phase

(d) They both have a constant freezing point or melting point at a given pressure
They both have a constant composition at a given pressure.

(c) (i)

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Question. Eight.

(a) (i) Copper pyrites is **pulverized** (crushed)
It is then **agitated with water** and a frothing agent.
Air is blown through the mixture and a **froth** forms. The ore **rises to the surface** in a froth while earthly materials are wetted by water and **sink** to the bottom.
The froth is **skimmed off** and an **acid** is added to break it down
The froth is **filtered** and the ore is **dried**
The ore is **roasted** in air to obtain **iron (II) oxide, copper (I) sulphide** and **sulphur dioxide**

$$2CuFeS_2(s) + 4O_2(g) \longrightarrow Cu_2S(s) + 2FeO(s) + 3SO_2(g)$$

The ore is **heated** with **silicon (IV) oxide** in absence of air to form **Iron (II) silicate liquid** which is poured away

$$FeO(s) + SiO_2(s) \longrightarrow FeSiO_3(l)$$

The ore is heated in a controlled amount of air to convert it into **impure copper** and sulphur dioxide

$$Cu_2S(s) + O_2(g) \longrightarrow 2Cu(s) + SO_2(g)$$

or

$$\left.\begin{array}{l} 2Cu_2S(s) + 3O_2(g) \longrightarrow 2Cu_2O(s) + 2SO_2(g) \\ Cu_2S(s) + 2Cu_2O(s) \longrightarrow 6Cu(s) + SO_2(g) \end{array}\right\}$$

(ii) A **known** mass of impure copper is dissolved in a **known volume** of **excess standard** acidified potassium dichromate (VI) solution
The mixture is **warmed** and then cooled

$$3Cu(s) + Cr_2O_7^{2-}(aq) + 14H^+(aq) \longrightarrow 3Cu^{2+}(aq) + 2Cr^{3+}(aq) + 7H_2O(l)$$

The resultant solution (which contains excess dichromate (VI) ions) is titrated against a standard solution of ammonium ion (II) sulphate using redox indicator (Diphenyl amine)

$$6Fe^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14H^+(aq) \longrightarrow 6Fe^{3+}(aq) + 2Cr^{3+}(aq) + 7H_2O(l)$$

The results are used to calculate the mass of copper and hence the

$$\text{Percentage purity of copper} = \frac{\text{mass of copper}}{\text{mass of impure sample}} \times 100\%$$

Alternatively;
A **known** mass of impure copper is dissolved in **excess** warm concentrated **sulphuric acid** (or nitric acid)
The resultant solution is neutralized with **sodium carbonate** and ethanoic acid
The mixture is then reacted with **excess potassium iodide** to liberate iodine

$$2Cu^{2+}(aq) + 4I^-(aq) \longrightarrow Cu_2I_2(s) + I_2(aq)$$

The iodine solution is titrated against **standard** sodium **thiosulphate** solution using **starch indicator**

$$I_2(aq) + 2S_2O_3^{2-}(aq) \longrightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

The results are used to calculate the **mass of copper** and hence the

$$\text{Percentage of copper} = \frac{mass\ of\ copper}{mass\ of\ impure\ copper\ sample} \times 100\%$$

(b) **Impure copper** is used as the **anode** and **pure copper** as the cathode. An **electric current** is passed through acidified **copper (II) sulphate solution electrolyte** containing these electrodes. Copper anode **dissolves** to give copper (II) ions

$$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e$$

Copper (II) ions are discharged at the cathode to form a deposit of **pure copper.**

$$Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$$

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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2007

1. Equations for the half-life cell reactions are given below:

$SO_4^{2-}(aq) + H_2O(l) + 2e^- \longrightarrow SO_3^{2-}(aq) + 2OH^-(aq)$ E^θ/V -0.90

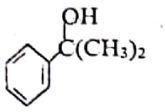
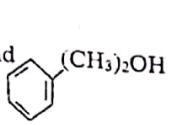
$Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$ $+0.34$

(a) Write equation for the overall reaction that would take place if the half cells are combined. (1½ marks)

(b) Calculate the e.m.f of the cell in (a) (1½ marks)

(c) State whether the cell reaction would be feasible or not. Give a reason for your answer. (1½ marks)

2. Name one reagent that can be used to distinguish between each of the following pairs compounds and state what would be observed in each case if each member of the pair is separately treated with the reagent you have named.

(a)  and  (3 marks)

(b) CH_3CHO and CH_3CH_2CHO (3 marks)

3. The first four ionization energies of some elements are shown in the table below.

Element	Ionization Energies			
	1st	2nd	3rd	4th
A	500	4600	6900	9500
B	740	1500	7700	10500
C	630	1600	3000	4800
D	900	1800	14800	21000
E	580	1800	2700	11600

(a) What is meant by the term ionization energy? (1 mark)

(b) (i) State the element that is not likely to form an ion with a unit positive charge. Give a reason for your answer. (2 marks)

(ii) Identify two elements that are in the same group of the Periodic Table. (1 mark)

4. (a) State three conditions which can enable components of a liquid mixture to be separated by steam distillation. (1½ marks)

(b) when a mixture of liquids A and B was steam distilled at 96°C and 774 mmHg pressure, the distillate contained 55% by mass of A. calculate the molecular mass of A.

(The vapour pressure of water is 634 mmHg at 96°C) (3 marks)

5. Draw the structure and name the shape of the following anions. In each case state the oxidation state of the chlorine atom. (4½ marks)

Anion	Structure	Shape	Oxidation state of chlorine.
ClO_2^-			
ClO_3^-			
ClO_4^-			

6. The Kinetic data for the reaction between X and Y are shown in the table below.

Experiment	[X]/mol dm^{-3}	[Y]/ mol dm^{-3}	Rate/mol $dm^{-3}s^{-1}$
1	0.30	0.15	1.5×10^{-2}
2	0.30	0.30	3.0×10^{-2}
3	0.60	0.30	6.0×10^{-2}
4	0.60	0.60	12.0×10^{-2}

(a) Determine the order of reaction with respect to X and Y (2 marks)

(b) Determine the overall order of the reaction. (½ mark)

(c) Calculate the rate constant for the reaction and indicate its units. (2½ marks)

7. State what would be observed and write equation for the reaction for the reaction that would take place if dilute sodium hydroxide was added drop-wise until in excess to solutions containing the following cations. (3 marks)

(i) Iron (II) ions (3½ marks)

(ii) Chromium (III) ions

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8. The vapour pressure of a solution containing 1 mole of liquid A and 4moles of liquid B is 0.750 atmospheres at a certain temperature.
The vapour pressure of pure A and B are 0.674 and 0.453 atmospheres respectively at the same temperature.
(a) Calculate the vapour pressure of the solution if it behaved as an ideal solution. (3 marks)
(b) State how the solution deviates from Raoult's Law. Give a reason for your answer. (1½ marks)

9. (a) 50cm^3 of an amine Q, $C_nH_{2n+1}NH_2$, diffused through a small hole in 126s. under the same conditions, the same volume of hydrogen diffused through the hole in 26.57s.
(i) Calculate the molecular mass of Q. (1½ marks)
(ii) Determine the molecular formula of Q. (1½ marks)
(b) (i) Write the structural formulae and IUPAC names of all the possible Isomers of Q. (2 marks)
(ii) Q reacts with nitrous acid to form a clear solution with evolution of a colourless gas. Identify Q. (1 mark)

10. The cooling curves of a solution containing 1.2g of sulphur in 20.0g of carbon disulphide and that of pure carbon disulphide are shown in figure 1 below.

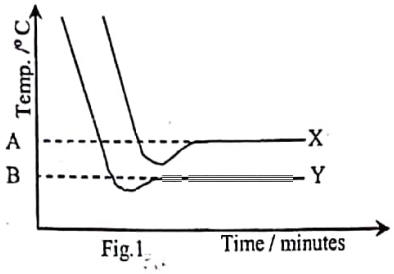
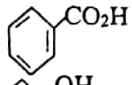
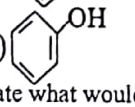


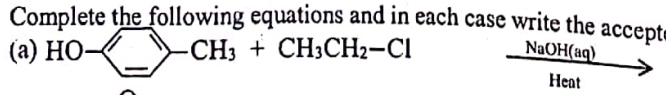
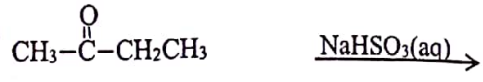
Fig.1

(a) (i) Identify the curves X and Y. (1 mark)
(ii) State what is represented by the points A and B (1 mark)
(b) Calculate the relative molecular mass of sulphur in carbon disulphide.
(The freezing point depression constant for carbon disulphide is 6.10°C mol^{-1}kg^{-1} and freezing point depression of carbon disulphide was 1.43°C). (3½ marks)
(c) (i) Comment on your result in (b) above (1 mark)
(ii) Deduce and draw the molecular structure of sulphur in carbon (2½ marks)

11. Write the equation to show the following compounds can be synthesized and in each case, indicate the conditions for the reaction.
(a) $CH_3\underset{\underset{OH}{|}}{C}HCH_2CH_3$ from butan-1-ol (3 marks)
(b)  from benzene (3 marks)
(c)  from benzene and sulphuric acid (3 marks)

12. State what would be observed and write equation for the reaction that would take place when
(a) Copper is added to a solution of concentrated nitric acid (2½ marks)
(b) Potassium iodide is added to acidified solution of hydrogen peroxide. (2 marks)
(c) Sodium sulphite is added to a solution of acidified potassium dichromate (VI). (2½ marks)
(d) Aqueous iron (II) sulphate is added to acidified potassium manganate (VII) solution. (2 marks)

13. (a) 25.0cm^3 of 0.30M sodium hydroxide was added to 22.5cm^3 of water. Calculate the pH of the resultant solution. (2 marks)
(b) Calculate the mass of sodium ethanoate that should be added to 1dm^3 of a 0.1M ethanoic acid at 25°C to give a solution whose pH is 5.5. State any assumptions made.
(The acid dissociation constant for ethanoic acid, $Ka = 1.8 \times 10^{-5}$mol dm^{-3} at 25°C) (5 marks)
(c) Few drops of dilute hydrochloric acid were added to the solution in (b).
(i) State what happened to the pH of the solution. (1 mark)
(ii) Give a reason for your answer in (c) (i) (1 mark)

14. Complete the following equations and in each case write the accepted mechanism for the reaction
(a)  (3 marks)
(b)  (3 marks)

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(c) $(CH_3)_3C-I \xrightarrow[\text{Heat}]{EtO^-/EtOH}$ (3 marks)

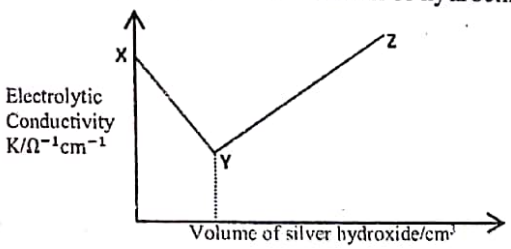
15. Compound R contains cobalt 24.8%, chrorine 29.8% and water 45.4%.
(a) (i) Calculate the empiriacal formula of R. (1 mark)
(ii) Determine the molecula formula of R (RFM of R = 237.9) (1 mark)
(b) To a solution of R in water was added concentrated hydrochloric acid drop wise until in excess.
(i) State what was observed (1 mark)
(ii) Write the equation for the reaction that took place. (1½ marks)
(c) The resultant solution in (b) was diluted
(i) State what was observed (1mark)
(ii) Write the equation for the reaction that took place (1½ marks)
(d) State what would be observed when aqueous ammonia is added drop-wise until in excess to a solution of R in water. (1 mark)

16. During the manufacture of sulphuric acid by the contact process, sulphur dioxide is catalytically oxidized to sulphur trioxide according to the following equation:

$2SO_2(g) + O_2 \rightleftharpoons 2SO_3(g), \Delta H^{\theta}_{298k} = -197kJ\,mol^{-1}$

The sulphur trioxide formed is then aborbed in 98% sulphuric acid.
(a) Name two major sources of sulphur dioxide used in the contact process. (1 mark)
(b) State the industrial conditions used to obtain maxium yield of sulphur trioxide. (1½ marks)
(c) State the conditions under which sulphuric acid reacts with carbon and copper. (1 mark)
(d) Write the equation for the reaction between sulphuric acid and
(i) Carbon (1½ marks) (ii) Copper (1½ marks)
(e) Sulphuric acid is used in the manufacture of calcium dihydrogen phosphate from calcium phosphate. (1½ marks)

17. (a) The conduct metric curve for the titration of hydrochloric acid and silver hydroxide is given below.

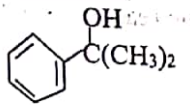


Explain the shape of the curve (XYZ) (4 marks)
(b) The molar conductivities of silver nitrate, potassium nitrate and potassium chloride are 134.0, 143.2 and 140.8$\Omega^{-1}cm^2mol^{-1}$ respectively at infinite dilution at 25°C.
Calculate the:
(i) Molar conductivity of silver chloride at infinite dilution at 25°C (1½ marks)
(ii) Solubility product, K_{sp} of silver chloride at 25°C.
(The electrolytic conductivity of water and that of a saturated solution of silver chloride are 5.5×10^{-8} and 1.9×10^{-6} $\Omega^{-1}cm^{-1}$ respectively,) (3½ marks)

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2007

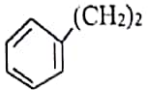
1. (a) $Cu^{2+}(aq) + SO_3^{2-} + 2\bar{O}H(aq) \longrightarrow Cu(s) + SO_4^{2-}(aq) + H_2O(l)$
(b) $Emf_{cell} = E^{\theta}_{Right} - E^{\theta}_{Left}$
$= 0.34 - (-0.90)$
$= +1.24volts$
(c) Cell reaction is **feasible** because the Emf of cell is **positive**

2. (a) **Reagent** – Anhydrous Zinc chloride and concentrated hydrochloric acid
Observation



– **Two layers** form immediately
or – Forms a **cloudy solution** immediately
or – Solution **turns turbid** immediately.

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– gives **no observable change at room temperature**
or – **cloudy solution** forms on **heating.**

(b) **Reagent** – Aqueous Iodine and sodium hydroxide solution
Observation;
CH_2CHO – forms a **yellow precipitate**
CH_3CH_2CHO – **No observable change**

3. (a) Energy required to remove completely one mole of electrons from one mole of **gaseous** atoms or one mole or **gaseous** ions
or Energy required to remove an electron from a **gaseous** atom or **gaseous** ion

(b) (i) Element A
The difference between the 1st and 2nd Ionization energy is **very large** compared to the difference between the 2nd and 3rd , 3rd and 4th Ionization energies.

(ii) B and D

4. (a) Component should have a **high relative molecular mass**
Component to be steam distilled must be **immiscible with water**
Component should have a **high vapour pressure near the boiling point of water**

(b) percentage by mass of water in distilate = 100 − 55 = 45%

$$vapour\ pressure\ of\ liquid\ A = 774 - 634 = 140mmHg$$

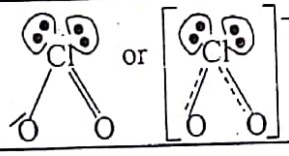
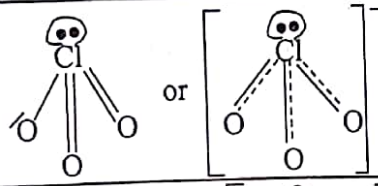
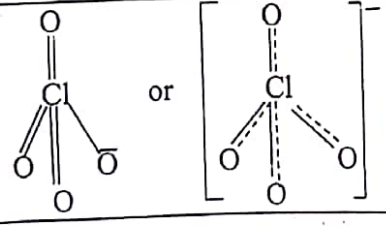
$$\frac{\%\ of\ water\ in\ distillate}{\%\ of\ A\ in\ distillate} = \frac{v.pressure\ of\ water \times Rmm\ of\ H_2O}{v.pressure\ of\ A \times Rmm\ of\ A}$$

$$\frac{45}{55} = \frac{634 \times 18}{140 \times Rmm\ of\ A}$$

$$Rmm\ of\ A = \frac{18 \times 55 \times 634}{140 \times 45}$$

$$= 99.63g$$

5.

Anion	Structure	Shape	Oxidation state of chlorine
ClO_2^-		V- shaped or Bent shape	+3
ClO_3^-		Trigonal pyramidal	+5
ClO_4^-		Tetrahedral	+7

6. (a) (i) Doubling the $[X]$ with the $[Y]$ constant, doubles the rate of reaction hence the reaction is **first order** with respect to X.

(ii) Doubling $[Y]$ maintaining $[X]$ constant, doubles the rate of reaction hence the reaction is **first order** with respect to Y.

(b) Overall order of reaction = 1 + 1 = 2

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(c) Rate $= K[X][Y]$

$K = \frac{Rate}{[X][Y]}$ (K = rate constant)

$= \frac{1.5\times10^{-2}}{0.3\times0.15}$ (substitution using values of experiment 1)

$K = 0.33 mol^{-1} dm^3 s^{-1}$

7. (i) **Green precipitate, insoluble** in excess sodium hydroxide solution **turns brown** on standing

$Fe^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Fe(OH)_2(s)$

$4\,Fe(OH)_2(aq) + 2H_2O(l) + O_2(g) \longrightarrow 4Fe(OH)_3(s)$

(ii) **Green precipitate, dissolves** in excess to give a **green solution**

$Cr^{3+}(aq) + 3\bar{O}H(aq) \longrightarrow Cr(OH)_3(s)$

Then; $Cr(OH)_3(aq) + \bar{O}H(aq) \longrightarrow Cr(OH)_4^-(aq)$

or; $Cr(OH)_3(aq) + 3\bar{O}H(aq) \longrightarrow Cr(OH)_6^{3-}(aq)$

or; $Cr(OH)_3(aq) + \bar{O}H(aq) \longrightarrow CrO_2^-(aq) + 2H_2O(l)$

8. (a) $P_A = X_A P_A^O$ (P = partial vapour pressure, x = mole fraction, P° = vapour pressure of pure component)

$P_A = ⅕ \times 0.674$

$= 0.1348\ atm$

$P_B = X_B P_B^O$

$= ⅘ \times 0.453 \quad = 0.3624\ atm$

Total vapour pressure; $P_T = P_A + P_B$

$= 0.1348 + 0.3624$

$= 0.4972 atm$

(b) Positive deviation

This is because the vapour pressure of the solution is **higher** than that of an ideal solution.

9. (a) (i) $\frac{tH_2}{tQ} = \sqrt{\frac{Rmm\ of\ H_2}{Rmm\ of\ Q}}$

$\frac{26.57}{126} = \sqrt{\frac{2}{Rmm\ of\ Q}}$

$Rmm\ of\ Q = \frac{(126)^2\times2}{(26.57)^2}$

$molecular\ mass\ of\ Q = 44.98g$

(ii) $Cn\ H_{2n+1}NH_2 = 44.98$

$12n + 2n + 1 + 14 + 2 = 44.98$

$14n = 27.98$

$n = \frac{27.98}{14}, \qquad n = 2$

Thus; molecular formula of Q is C_2H_7N

Note – Candidates should not give the molecular formula as $C_2H_5NH_2$

(b) (i) $CH_3\ CH_2NH_2$ – Amino ethane or ethyl amine

$CH_3 - N - H$ Dimethyl amine

$\quad\quad\ |$

$\quad\quad CH_3$

(ii) Ethyl amine or Amino ethane or $CH_3\ CH_2NH_2$

10. (a) (i) X – cooling curve for pure carbon disulphide (solvent)

Y – cooling curve for the solution

(ii) A – freezing point of pure carbon disulphide

B – freezing point of solution

(b) 20g of CS_2 dissolved 1.2g of sulphur

∴ 1000g CS_2 dissolved $\frac{1000\times1.2}{20}$ g of sulphur

$= 60g\ of\ sulphur.$

1.43°C is depression in freezing point caused by 60g of sulphur.

∴ 6.10°C *is depression* in freezing point *caused by* $\frac{6.10\times60}{1.43}\ g\ of\ sulphur$

Hence; *relative molecular mass of sulphur* $= 256$

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(c) (i) The relative molecular mass of sulphur in carbon disulphide is **eight times greater** than the actual relative atomic mass of sulphur. This is because sulphur associates in carbon disulphide.

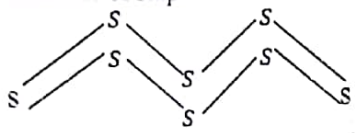
(ii) $Sn = 256$ (but S = 32)

$32n = 256$

$n = \frac{256}{32} = 8$

∴ Molecular formula of sulphur is S_8

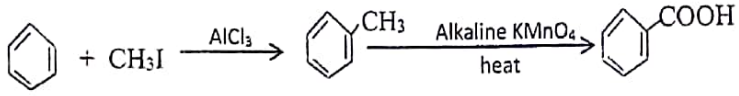
Molecular structure of sulphur is

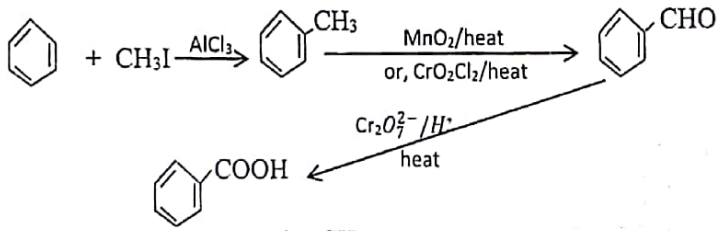


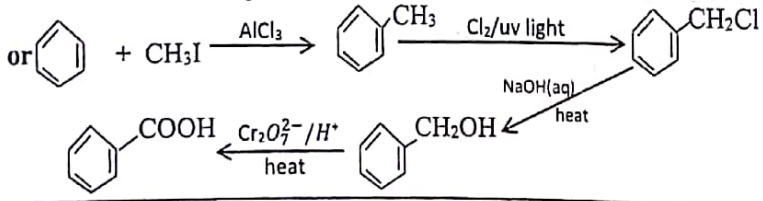
11. (a) $CH_3CH_2CH_2CH_2OH \xrightarrow[\text{heat}]{\text{Conc. } H_2SO_4} CH_3CH{=}CHCH_3 \xrightarrow{HCl} CH_3CH_2\underset{Cl}{CH}CH_3 \xrightarrow{NaOH(aq)} CH_3\underset{OH}{CH}CH_2CH_3$

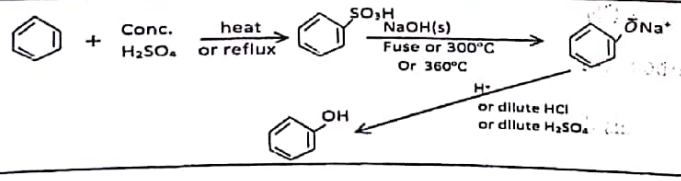
Alternatively

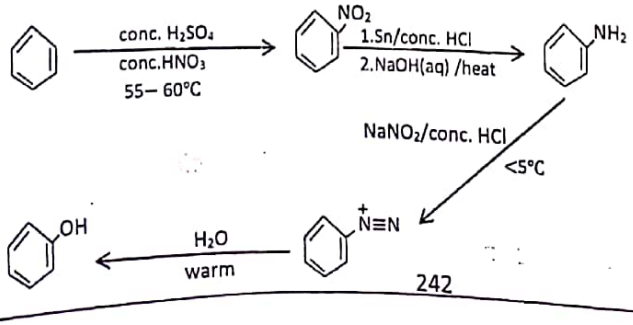
$CH_3CH_2CH_2CH_2OH \xrightarrow[170°C]{\text{Conc. } H_2SO_4} CH_3CH{=}CHCH_3 \xrightarrow[2.H_2O/warm]{1.\text{ Conc. } H_2SO_4} CH_3\underset{OH}{CH}CH_2CH_3$

(b) 

or 

or 

(c) 

or 

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12. (a) **Equation;** $Cu(s) + 4HNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$
Observation; Copper **dissolves** giving a **blue solution** and **brown fumes** of a gas.

(b) **Equation;** $2I^-(aq) + 2H^+(aq) + H_2O_2(aq) \longrightarrow I_2(aq) + 2H_2O(l)$
Observation; The **colourless** solution turns **brown**

(c) **Equation;** $Cr_2O_7^{2-} + 3SO_3^{2-}(aq) + 8H^+(aq) \longrightarrow 3SO_4^{2-}(aq) + 2Cr^{3+}(aq) + 4H_2O(l)$
Observation; Solution of potassium dichromate (VI) changes from **orange** to **green**

(d) **Equation;** $5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \longrightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$
Observation; Solution of potassium manganate (VII) changes from **purple** to **colourless**

13. (a) Total volume of resultant solution $= 225 + 25 = 250cm^3$

$moles\ of\ NaOH\ in\ 25.0cm^3 = \frac{25}{1000} \times 0.30mole. \quad = 7.5 \times 10^{-3} moles$

$Hence; 250cm^3\ of\ solution\ contain\ 7.5 \times 10^{-3} moles$ of NaOH

$Thus; 1000cm^3\ of\ solution\ contain\ \frac{1000 \times 7.5 \times 10^{-3}}{250} moles$ of NaOH

$= 0.03$M NaOH

$[\bar{O}H]$ in resultant solution $= 0.03$M

$[H^+]\ in\ resultant\ solution = \frac{Kw}{[\bar{O}H]}$

$= \frac{1 \times 10^{-14}}{0.03} = 3.33 \times 10^{-3} M$

$pH = -\log_{10}[H^+]$

$= -\log 3.33 \times 10^{-13} = \mathbf{12.48}$

(b) $Ka = \frac{[CH_3CO\bar{O}][H^+]}{[CH_3COOH]}$

Assumptions;

$[CH_3CO\bar{O}] = [CH_3COONa]$

$[CH_3COOH] = 0.1M$

$Ka = \frac{[CH_3COONa][H^+]}{[CH_3COOH]}$

$But; \quad [H^+] = 10^{-5.5} (since\ pH = -\log_{10}[H^+]$

$[H^+] = 3.16 \times 10^{-6} M$

Hence; $[CH_3COONa] = \frac{Ka[CH_3COOH]}{[H^+]}$

$= \frac{1.8 \times 10^{-5} \times 0.1}{3.16 \times 10^{-6}} = \mathbf{0.57M}$

$RFM\ of\ CH_3COONa = 12 + 3 + 12 + 32 + 23 = 82$

$\therefore mass\ of\ CH_3COONa = 82 \times 0.57 \quad = 46.74g$

Alternatively; $pH = PKa + \log_{10}\frac{[salt]}{[acid]}$

$5.5 = -\log_{10} 1.8 \times 10^{-5} + \log_{10}\frac{[salt]}{0.1}$

$5.5 = 4.745 + \log\frac{[salt]}{0.1}$

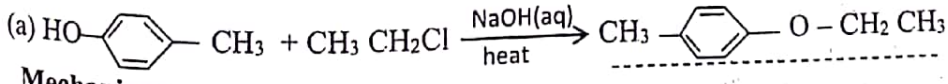
$[salt] = 10^{-0.75} \times 0.1 \quad = \mathbf{0.5689M}$

RFM of $CH_3COONa = 82$

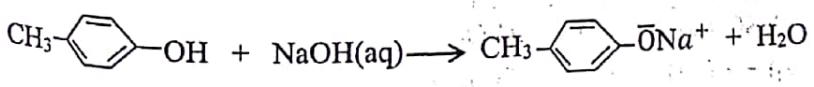
mass of $CH_3COONa = 82 \times 0.5689 \quad = 46.65g$

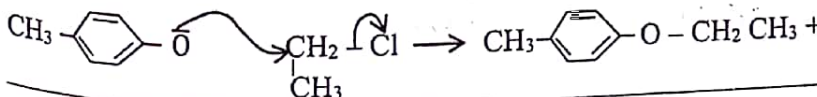
(c) (i) pH remained constant

(ii) Ethanoate ions **from sodium ethanoate** react with hydrogen ions from the hydrochloric acid added to form ethanoic acid molecules, thus keeping the pH constant.

14. (a) 

Mechanism;



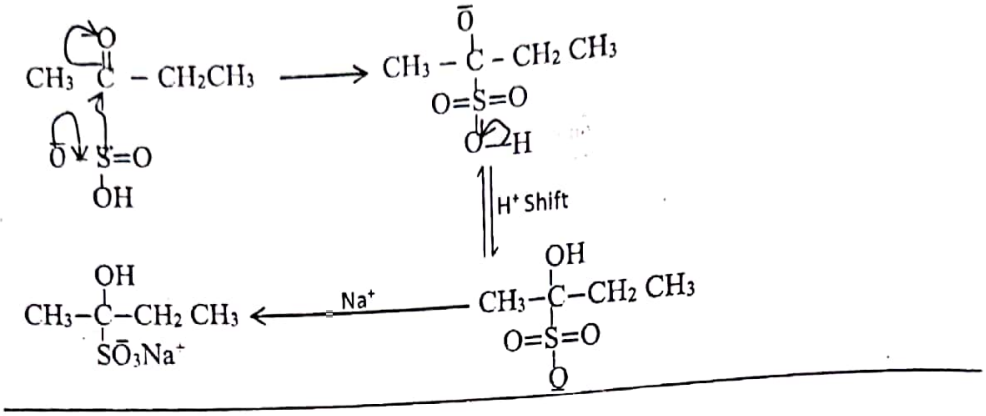


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(b) $CH_3\overset{O}{\overset{\|}{C}}-CH_2CH_3 \xrightarrow{NaHSO_3} CH_3\overset{OH}{\overset{|}{C}}-CH_2CH_3$ (with $SO_3^-Na^+$)

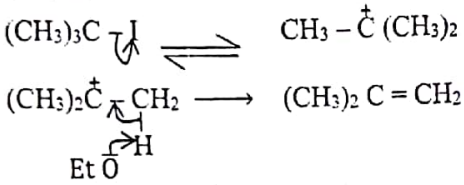
Mechanism;

$NaHSO_3 \longrightarrow Na^+ + HSO_3^-$



(c) $(CH_3)_3C-I \xrightarrow[\text{heat}]{Et\,O^-/EtOH} (CH_3)_2C=CH_2$

Mechanism



15. (a) (i) Composition of R;

	Co	Cl	H_2O
Moles;	$\frac{24.8}{58.9}$	$\frac{29.8}{35.5}$	$\frac{45.4}{18}$
	0.421	0.839	2.52
Mole ratio;	$\frac{0.421}{0.421}$	$\frac{0.839}{0.421}$	$\frac{2.52}{0.421}$
	1 :	2 :	6

Emperical formula of R is $CoCl_2.6H_2O$

(ii) $(CoCl_2 . 6H_2O)_n = 237.9$

$58.9n + 71n + 108n = 237.9$

$n = \frac{237.9}{237.9} = 1$

Hence; molecular formula of R is **$CoCl_2 .6H_2O$**

(b) (i) The **pink** solution turned **blue**

(ii) $Co(H_2O)_6^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons CoCl_4^{2-}(aq) + 6H_2O(l)$

(c) (i) The **blue** solution turned **pink**

(ii) $CoCl_4^{2-}(aq) + 6H_2O(l) \rightleftharpoons Co(H_2O)_6^{2+}(aq) + 4Cl^-(aq)$

(d) **Blue precipitate, insoluble** in excess aqueous ammonia and **turns brown** on standing

16. (a) Sulphur, Iron pyrites, Copper pyrites, Zinc sulphide, Lead (II) sulphide

(b) - Temperature of $400 - 500°C$
- Use of vanadium (V) oxide catalyst
- Pressure of $150 - 250\ atm$
- Plenty of oxygen or air

(c) Sulphuric acid should be **hot** and **concentrated**

(d) (i) $C(s) + 2H_2SO_4(aq)$ or $(l) \longrightarrow CO_2(g) + 2SO_2(g) + 2H_2O(l)$

(ii) $Cu(s) + 2H_2SO_4(aq) \longrightarrow CuSO_4(aq) + SO_2(g) + 2H_2O(l)$

(e) (i) $Ca_3(PO_4)_2(s) + 2H_2SO_4(aq) \longrightarrow Ca(H_2PO_4)_2(s) + 2CaSO_4(s)$

or $Ca_3(PO_4)_2(s) + 2H_2SO_4(aq) + 5H_2O(l) \longrightarrow Ca(H_2PO_4)_2 \cdot H_2O(s) + 2CaSO_4 \cdot 2H_2O(s)$

(ii) Used as a fertilizer

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17. (a) Initially, conductivity is **high** due to **high conductivity of hydrogen ions** from the strong acid. Along XY, conductivity **decreases** because the fast moving hydrogen ions are **replaced** by the slow moving silver ions

At Y, conductivity is due to **silver ions** and **chloride ions** after complete neutralization (end point)

Along YZ, conductivity **increases** due to **excess hydroxide ions** and **silver ions.**

(b) (i) $\Lambda_o(AgCl) = \Lambda_o(Ag^+) + \Lambda_o(Cl^-)$

or $\Lambda_o(AgCl) = \Lambda_o(AgNO_3) + \Lambda_o(KCl) - \Lambda_o(KNO_3)$

$= 134.0 + 140.8 - 143.2$

$= 131.6\Omega^{-1}cm^2mol^{-1}$

(ii) Let the solubility of $AgCl = x moldm^{-3}$

$$x = \frac{1000K}{\Lambda_o(AgCl)}$$

But; $K\ solute\ (AgCl) = Ksolution - Kwater$ (solvent)

$= 1.934 \times 10^{-6} - 0.055 \times 10^{-8} = 1.879 \times 10^{-6}\Omega^{-1}cm^{-1}$

Thus; $x = \frac{1000 \times 1.879 \times 10^{-6}}{131.6} = 1.428 \times 10^{-5} moldm^{-3}$

But; $Ksp\ of\ AgCl = [Ag^+][Cl^-] = (x) \times (x) = x^2$

$= (1.428 \times 10^{-5})^2$

$\boldsymbol{Ksp\ of\ AgCl = 2.039 \times 10^{-10} mol^2 dm^{-6}}$

QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2007

1. (a) Define the term isotopes. (1 mark)

(b) Descreibe the main steps involved in the operation of a mass spectrometer
(Diagram not required) (5 marks)

(c) The table below shows the information from a mass spectrum of a lead sample.

Isotope	Detector current /mA
204	0.16
206	2.72
207	2.50
208	5.92

Calculate:

(i) the relative abundance of the different isotopes of lead in the sample used. (5 marks)

(ii) the relative atomic mass of lead (5 marks)

(d) State two advantages of using a mass spectrometer over the depression of freezing point method of determining relative atomic masses. (2 marks)

(e) The initial count of a radioactive nucleus was 680 per second. After 350 seconds, the count rate was 125 per second.

Calculate the:

(i) decay constant (2 marks) (ii) half life of the nucleus (2 marks)

2. The melting points and atomic numbers of magnesium , aluminium, phosphorus and chlorine, members of Period 3 of the Periodic Table are given in the table below.

Element	Mg	Al	P (white)	Cl
Melting point /°C	649	661	44	-101
Atomic number	12	13	15	17

(a) Explain the trend in melting points of the elements (6 marks)

(b) Compare the reactions of the elements with

(i) water (7½ marks)

(ii) sodium hydroxide solution (6½ marks)

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3. Complete the following equations and in each cases outline the mechanism for the reaction. (4 marks)

(a) $CH_3CH = CHCH_3 \xrightarrow{Br_2/H_2O}$ (4 marks)

(b)  $+ CH_3I \xrightarrow{AlCl_3}$ (5½ marks)

(c) $RCHO + H_2N - OH \xrightarrow{H^+}$ (3 marks)

(d) $CH_3CHBrCH_2Br \xrightarrow[\text{heat}]{CH_3CH_2O^-Na^+}$ (3½ marks)

(e)  $\xrightarrow[\text{heat}]{\text{Conc. } H_2SO_4}$

4. (a) Describe with the aid of a labelled diagram how the standard electrode potential of a zinc electrode can be determined. (8 marks)

(b) The electrode potential of some half-cell reactions are shown below.

		E^θ /volts
A.	$Fe^{3+}(aq) + e \rightleftharpoons Fe^{2+}(aq)$	+0.77
B.	$Zn^{2+}(aq) + 2e \rightleftharpoons Zn(s)$	- 0.76
C.	$MnO_4^-(aq) + 8H^+(aq) + 5e \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$	+1.51
D.	$MnO_4^-(aq) + e \rightleftharpoons MnO_4^{2-}(aq)$	+0.56
E.	$Cu^{2+}(aq) + 2e \rightleftharpoons Cu(s)$	+0.34
F.	$MnO_4^{2-}(aq) + 4H^+(aq) + 2e \rightleftharpoons MnO_2(s) + 2H_2O(l)$	+2.26

State the species that is the best:

(i) reducing agent (1 mark) (ii) oxidizing agent (1 mark)

(c) (i) Write the cell convention for the cell made by combining the electrodes of the half-cell reactions **A** and **B** in (b). (1 mark)

(ii) Write equation for the cell reaction. (1½ marks)

(ii) Determine the e.m.f of the cell. (1 mark)

(iii) State wether the reaction in (ii) is possible or not and give a reason for your answer. (2 marks)

(c) (i) Determine the oxidation states of manganese in MnO_4^-, MnO_4^{2-} and MnO_2. (1½ marks)

(ii) Write the equation for the spontaneous reaction between D and F from (b) above. (1½ marks)

(iii) State what would be observed if carbon dioxide gas was bubbled through a solution containing manganate (VI) ions. (1½ marks)

5. (a) Define the term **eutectic temperature**. (1 mark)

(b) The melting points of mixtures of different compositions of cadmium and zinc are shown in the table below.

Percentage of zinc	0	10	17	30	60	100
Melting point /°C	321	295	270	305	360	491

(i) Draw a well –labelled melting point-composition diagram for the cadmium-zinc mixture. (5½ mrks)

(ii) Explain the phase changes which would take place if a liquid mixture containing 5% zinc was colled to 250°C (5½ marks)

(iii) 200g of the liquid mixture of composition 5% zinc was cooled to 275°C and calulate the mass of cadmium in the remaining liquid mixture at this temperature. (5 marks)

(c) Mention three tests which can be carried out on a eutectic mixture to show that it is not a pure compound. (3 marks)

6. Write equation to show how the following compounds can be synthesized.

(a) $CH_3C \equiv CH$ from propan -2-ol. (4½ marks)

(b)  from benzene. (3½ marks)

(c) CH_3COCl from ethene. (4 marks)

(d)  from benzene. (4 marks)

(e) $CH_3CO_2CH_3$ from bromoethane. (4 marks)

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7. **Explain the following observations**
(a) Beryllium is in group (II) of the Periodic Table, but its properties resemble those of aluminium which is in group (III) of the Periodic Table. (4 marks)
(b) Aluminium trifluoride is ionic, while aluminium trichloride is convalent. (5 marks)
(c) Boron trichloride, BCl_3 is a non-polar molecule where as nitrogen trichloride, NCl_3 is polar. (4 marks)
(d) The elements of group (II) of the Periodic Table are harder and have higher melting and boiling points than group (I) elements. (2 marks)
(e) Lead (II) chloride is more soluble in concentrated hydrochloric acid than in dilute hydrochloric acid.

8. (a) (i) Briefly describe how a sample of soap can be prepared. (5 marks)
(ii) Write equation for the reaction leading to the formation of soap. (4 marks)
(b) Explain why soap cannot be used effectively in: (1 mark)
(i) hard water
(ii) strongly acidified medium
(c) Write equations to show how alkyl benzene sulphonate can be prepared from Octadecan-1-ol, $CH_3(CH_2)_{16}CH_2OH$. (5 marks)
(d) Explain why the following compounds are added to soap less detergents: (6 marks)
(i) polyphosphates, (2 marks)
(ii) disodium sulphate. (2 marks)

END

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2007

Question. One.

(a) Isotopes are **atoms** of the **same element** having the **same atomic number** but **different mass numbers** hence **different number of neutrons**

(b) The sample of the substance whose molecular mass is to be determined is **vapourised** and introduced into the ionization chamber.
The vapourised sample is **bombarded by fast moving electrons** to form **positive ions**
The ions are **accelerated** by an **electric field** to the **same velocity**
The ions are **deflected** by a **magnetic field** according to their **mass to charge ratio**
The magnetic field and electric field are **varied** so that ions of a given mass to charge ratio are received by the **detector.**

(c) (i) Total detector current $= 0.16 + 2.72 + 2.50 + 5.92 = 11.30MA$

$$\%\ abundance\ of\ isotope - 204 = \frac{0.16}{11.30} \times 100 = 1.42\%$$

$$\%\ abundance\ of\ isotope - 206 = \frac{2.72}{11.30} \times 100 = 24.07\%$$

$$\%\ abundance\ of\ isotope - 207 = \frac{2.50}{11.30} \times 100 = 22.12\%$$

$$\%\ abundance\ of\ isotope - 208 = \frac{5.92}{11.30} \times 100 = 52.40\%$$

(ii) Relative atomic mass of lead $= \frac{\sum(Isotopic\ mass \times relative\ abundance)}{\sum(relative\ abundance)}$

$$= \frac{(204 \times 1.42) + (206 \times 24.07) + (207 \times 22.12) + (208 \times 5.92)}{100}$$

$$= \frac{20726.4}{100} = 207.26$$

(d) The mass spectrometer produces very accurate relative atomic mass compared to freezing depression method
The mass spectrometer uses a very small amount of the sample

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(e) (i) Using $2.303 \log\left(\frac{No}{Nt}\right) = \lambda t$

$2.303 \log\left(\frac{680}{125}\right) = \lambda \times 350$

$Decay\ constant;\ \lambda = \frac{2.303 \log\left(\frac{680}{125}\right)}{350}$

$= 4.84 \times 10^{-3} second^{-1}$

(ii) Half life $t\frac{1}{2} = \frac{In2}{\lambda}$

$= \frac{0.693}{4.84 \times 10^{-3}}$

$= 143.2 seconds$

Question. Two.

(a) The melting point **increases from magnesium to aluminium** then **decreases from aluminium to chlorine**

Magnesium and aluminium are **metals** and have **giant metallic structures** whose atoms held together by **strong metallic bonds**. Aluminium has **a smaller atomic radius** than magnesium and therefore has **slightly stronger metallic bonds** which are **more difficult to break** and hence aluminium has a slightly higher melting point than magnesium.

Phosphorus and chlorine are **non metals** and have **simple molecular structures** and their molecules are held together by **weak vander waal's forces** whose strength depends on the molecular mass. Phosphorus exists as a **tetraatomic molecule** (P_4) and has a **larger molecular mass** than the **diatomic molecule** of chlorine (Cl_2). Phosphorus therefore has **stronger vander waal's forces** between its molecules than chlorine hence a **higher melting point** than chlorine.

(b) (i) Magnesium **reacts slowly** with **cold water** to form **magnesium hydroxide** and **hydrogen gas**

$Mg(s) + 2H_2O(l) \longrightarrow Mg(OH)_2(s)\ \text{or}\ (aq) + H_2(g)$

Heated magnesium reacts with **steam** to form **magnesium oxide** and **hydrogen gas**

$Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$

Aluminium **does not** react with water or steam because of the protective oxide film

However, if the oxide film is removed, aluminium reacts with **water** or **steam** to form **aluminium oxide** and **hydrogen**

$2Al(s) + 3H_2O(g) \longrightarrow Al_2O_3(s) + 3H_2(g)$

Phosphorus **does not** react with **coldwater**. **Heated** phosphorus **reduces steam** to **hydrogen** and the phosphorus is **oxidized** to **phosphorus acid**.

$P(s) + 3H_2O(g) \longrightarrow H_3PO_3(aq) + \frac{3}{2}H_2(g)$

Chlorine reacts with **cold water** reversibly to form **hypochlorous** acid (chloric (I) acid) and **hydrochloric** acid

$Cl_2(g) + H_2O(l) \rightleftharpoons HCl(aq) + HClO(aq)$

or, $Cl_2(g) + H_2O(l) \rightleftharpoons H^+(aq) + Cl^-(aq) + HClO(aq)$

(ii) Magnesium **does not react** with sodium hydroxide solution

Aluminium reacts with **warm concentrated** sodium hydroxide solution to form **sodium aluminate** and **hydrogen gas**

$Al(s) + \bar{O}H(aq) + 3H_2O(l) \longrightarrow Al(OH)_4^-(aq) + \frac{3}{2}H_2(g)$

or, $Al(s) + \bar{O}H(aq) + H_2O(l) \longrightarrow Al\bar{O}_2(aq) + \frac{3}{2}H_2(g)$

Phosphorus reacts with **hot concentrated** sodium hydroxide solution to form **phosphine** and **sodium dihydrogenphosphite**

$P_4(s) + 3NaOH(aq) + 3H_2O(l) \longrightarrow 3NaH_2PO_2(aq) + PH_3(g)$

Chlorine reacts with **cold dilute** sodium hydroxide solution to form **sodium chloride, sodium chlorate(I)** (or sodium hypo chlorite) and water.

$Cl_2(g) + 2\bar{O}H(aq) \longrightarrow Cl^-(aq) + \bar{O}Cl(aq) + H_2O(l)$

or, $Cl_2(g) + 2NaOH(aq) \longrightarrow NaCl(aq) + NaOCl(aq) + H_2O(l)$

Chlorine reacts with **hot concentrated** sodium hydroxide solution to form **sodium chloride, sodium chlorate (V)** and **water.**

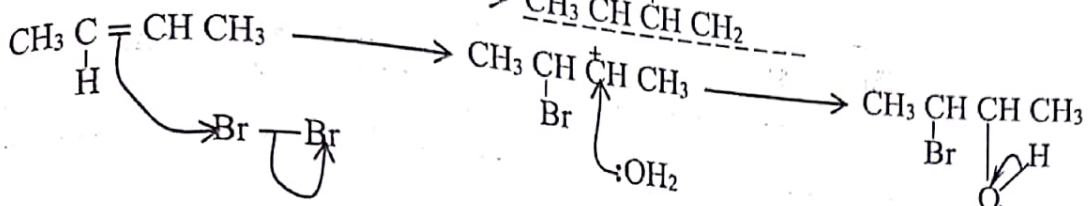
$3Cl_2(g) + 6\bar{O}H(aq) \longrightarrow 5Cl^-(aq) + Cl\bar{O}_3(aq) + 3H_2O(l)$

or, $3Cl_2(g) + 6NaOH(aq) \longrightarrow 5NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$

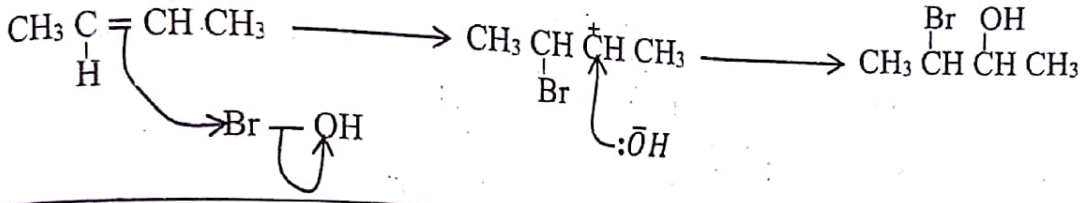
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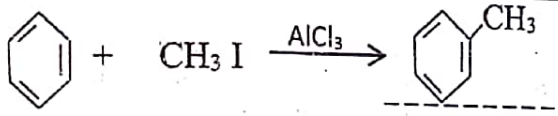
Question. Three.

(a) $CH_2CH=CHCH_3 \xrightarrow{Br_2/H_2O} CH_3CH(Br)CH_2(OH)$

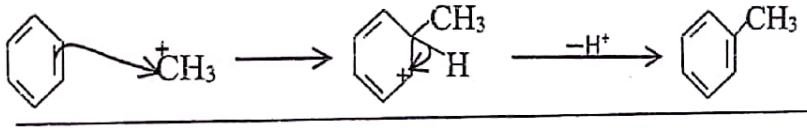


or, $Br_2(aq) + H_2O(l) \rightleftharpoons HBr(aq) + HOBr(aq)$

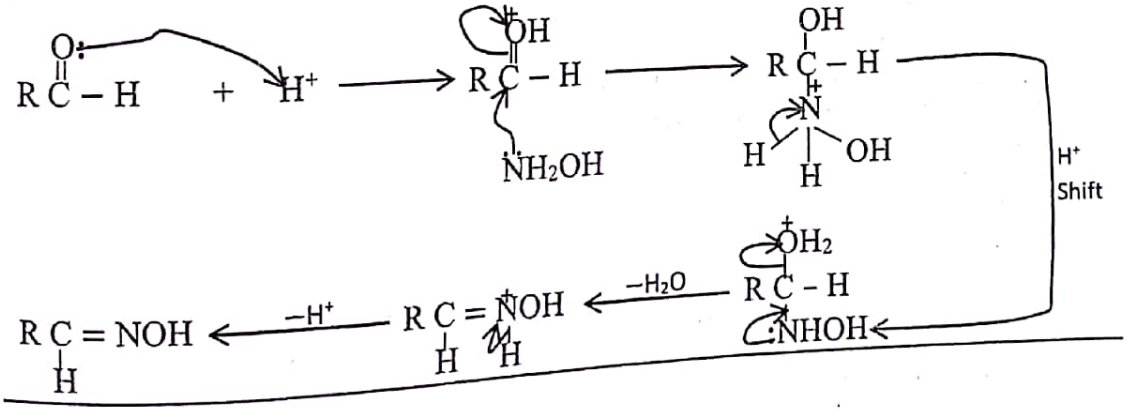


(b) 

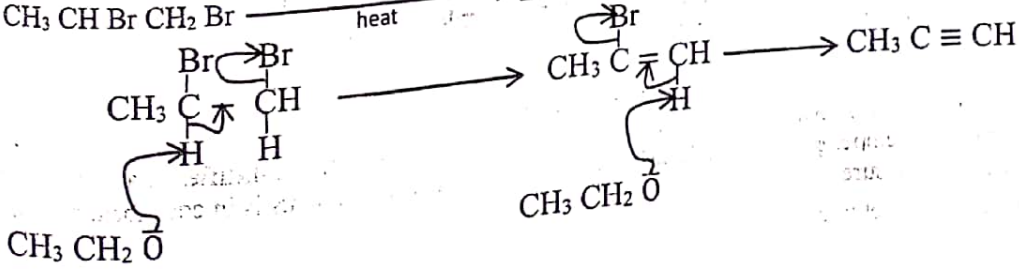




(c) $RCHO + H_2N-OH \xrightarrow{H^+} RC(H)=N-OH$

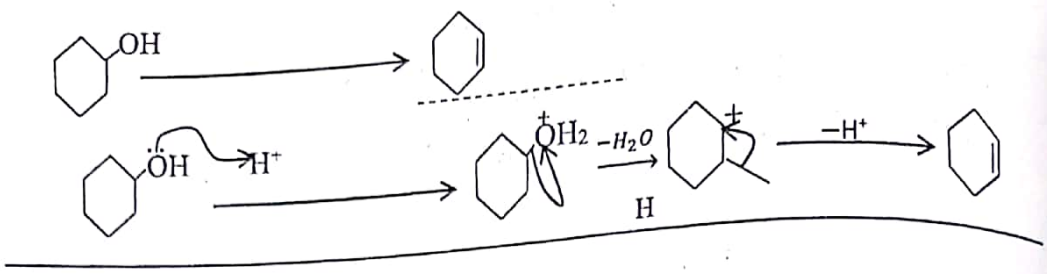


(d) $CH_3CHBrCH_2Br \xrightarrow[\text{heat}]{CH_3CH_2\bar{O}\,Na^+} CH_3C\equiv CH$



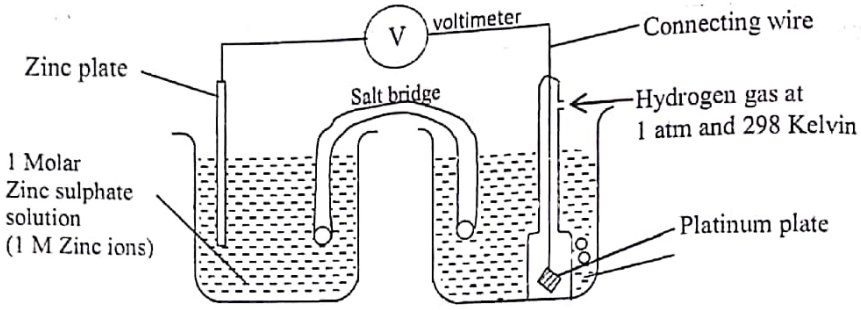
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(e)



Question. Four.

(a)



Zinc plate is dipped in a solution containing **1Molar zinc ions** making a zinc half cell.
The zinc half cell is connected by a **salt bridge** to the **standard hydrogen electrode.**
The electromotive force (Emf) of the cell is measured using a **voltmeter**
Since the standard hydrogen electrode has an electrode potential of **0.00volts**, then the **reading on the voltmeter is the standard electrode potential of the zinc electrode**. The temperature of the cell should be **298k or 25°C.**

(b) (i) Zinc or Zn(s)
(iii) Manganate (VI) ion or $MnO_4^{2-}(aq)$

(c) (i) $Zn(s) \mid Zn^{2+}(aq) \mid\mid Fe^{3+}(aq),\ Fe^{2+}(aq) \mid Pt(s)$
or $Zn(s) \mid Zn^{2+}(aq) \mid\mid Fe^{3+}(aq),\ Fe^{2+}(aq) \mid Pt(s)$
(ii) $Zn(s) + 2Fe^{3+}(aq) \rightarrow Zn^{2+}(aq) + 2Fe^{2+}(aq)$
(iii) Emf cell $= E_{right} - E_{left}$
$= +0.77 - (-0.76)$
$= +1.53 volts$
(iv) The reaction is **possible** because the Emf of the cell is **positive**

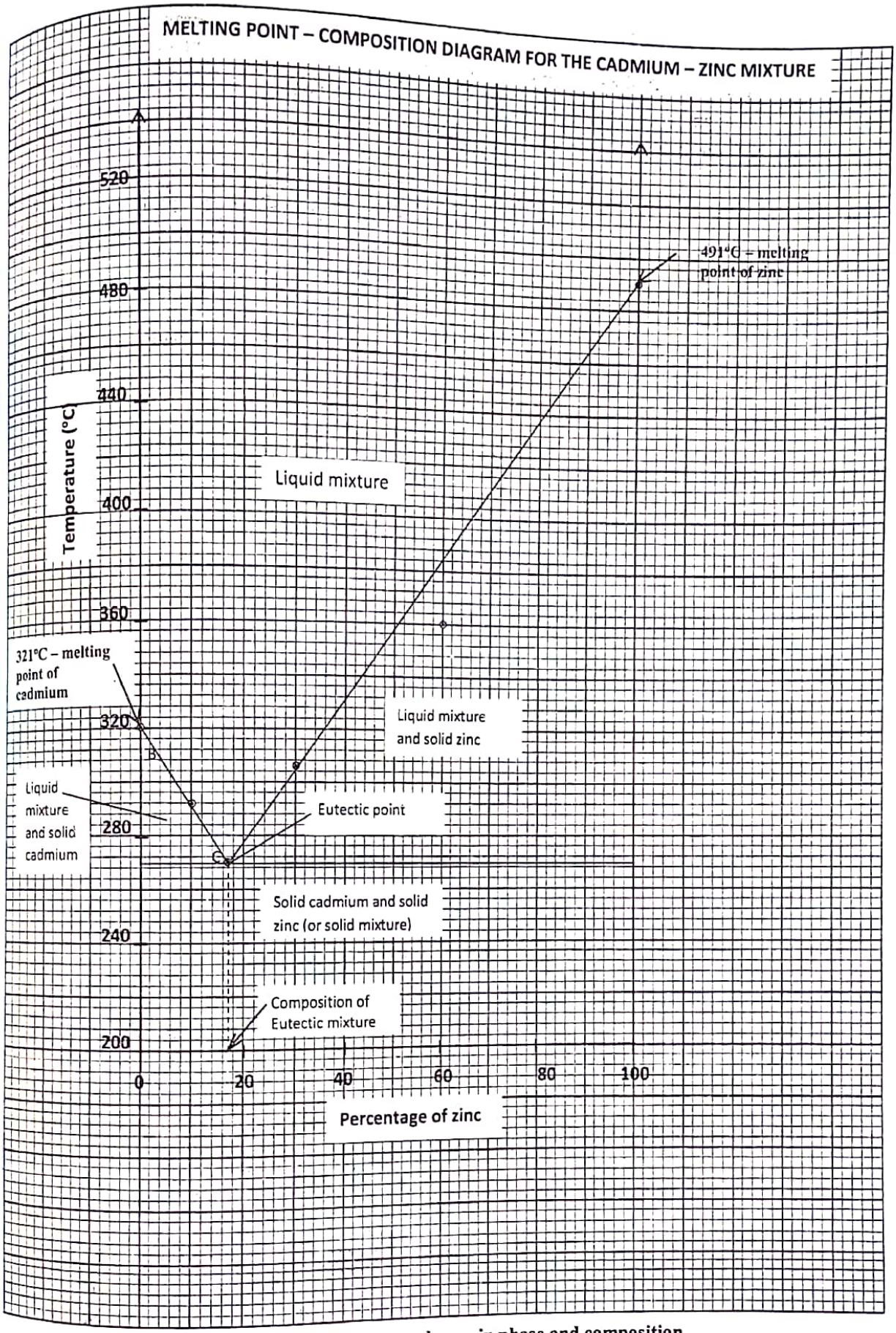
(d) (i) Let the oxidation state of Mn in $MnO_4^- = x$
Hence; $x + (-2 \times 4) = -1$
Therefore; $x = +7$
Let the oxidation state of Mn in $MnO_4^{2-} = y$
Hence; $y + (-2 \times 4) = -2$
Therefore; $y = +6$
Let the oxidation state of Mn in $MnO_2 = w$
Hence; $w + (-2 \times 2) = 0$
Therefore; $w = +4$
(ii) $3MnO_4^{2-}(aq) + 4H^+(aq) \rightarrow 2MnO_4^-(aq) + MnO_2(s) + 2H_2O(l)$
(iii) **Green solution** of manganate (VI) ions turns **purple** and a **brown** or (black) precipitate is formed.

Question. Five.

(a) The **lowest temperature** that can be reached before the whole system **solidifies** at a **constant pressure** **or;** constant temperature at which the liquid mixture of two components is in equilibrium with the solid at a given pressure

(b) (i) See graph net page

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(ii) The mixture **cools** up to 310°C **without a change in phase and composition**
At 310°C, **cadmium begins to crystallize**. The composition of zinc in the mixture **increases** causing a **further decrease** in freezing point of cadmium a long BC.

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At C; zinc also **begins to freeze**. The freezing temperature and composition remain constant until all the **liquid mixture freezes**. Thereafter, the solid mixture cools to 250°C **without a change in phase.**

(iii) From the graph composition of the liquid mixture at 275°C = 16% *zinc*

Mass of zinc in liquid mixture before freezing $= \frac{5}{100} \times 200$

$= 10g$

At 275°C, mass of zinc = 10g

Let; mass of cadmium be xg

Hence; $\frac{10}{(x+10)} \times 100 = 16$

Therefore; $x = 52.5$g

(c) - Microscopic examination which would show a heterogeneous mixture of individual crystals of two components

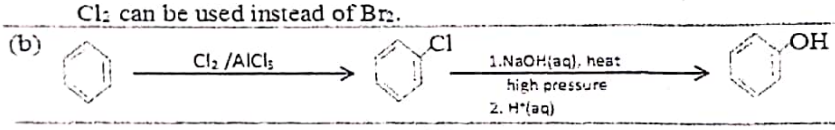
- By adding zinc or cadmium to the eutectic mixture which would increase the melting point of the eutectic mixture.
- By changing the pressure which would change the composition of the eutectic mixture

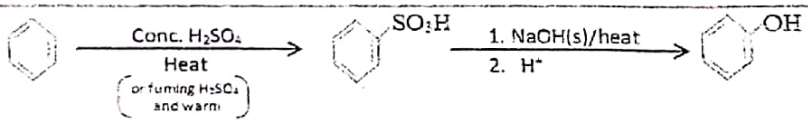
Question. Six.

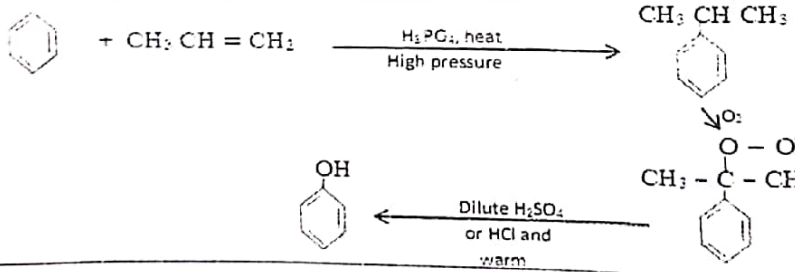
(a) $CH_3\,CH(OH)\,CH_3 \xrightarrow[\text{heat}]{\text{Conc. } H_2SO_4} CH_3\,CH = CH_2 \xrightarrow{Br_2/CCl_4} CH_3\,CH(Br)\,CH_2Br$

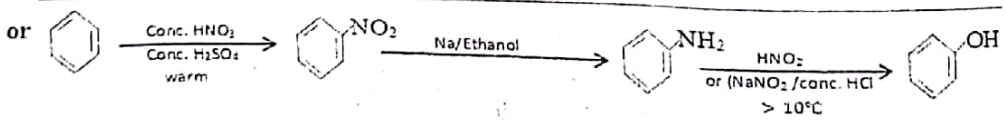
$CH_3\,CH(Br)\,CH_2Br \xrightarrow[\text{heat}]{\text{KOH/Ethanol}} CH_3\,C \equiv CH$

Note; In step (i) Al_2O_3 or (conc.H_3PO_4)can be used instead of (conc.H_2SO_4)and in step (ii) Cl_2 can be used instead of Br_2.

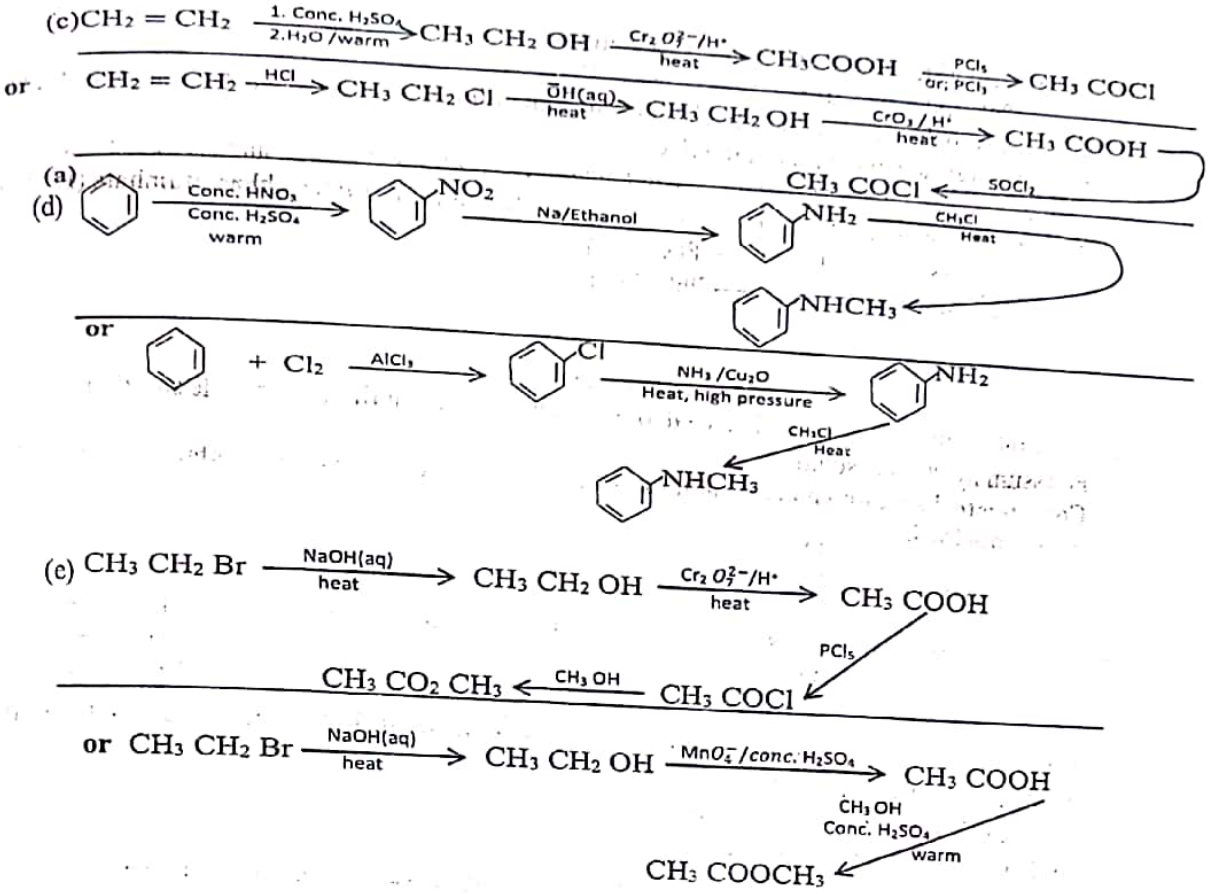
(b) 

or 

or 

or 

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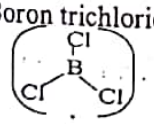


Question. Seven.

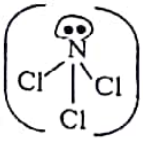
(a) Beryllium atom has a **smaller atomic radius** than all other group (II) elements
Beryllium and aluminium have the **same electro negativity value** (or electro positivity value) and **similar electrode potential;**
Also, the Beryllium ion and aluminium ion have the **same charge density** (similar polarizing power)

(b) The **ionic radius** of the fluoride ion is **much smaller** than that of the chloride ion, and therefore the valence electrons of fluoride ion are **more strongly attracted** to nucleus. The fluoride ions are therefore **not easily polarized** by the aluminium ion making aluminium fluoride **ionic**
The chloride ion on the other hand has a **big ionic radius** and hence its valence electrons are **less strongly attracted** to the nucleus. The chloride ion is therefore **easily polarized** by the aluminium ion hence making aluminium chloride **covalent**

(c) Boron trichloride; BCl_3 has a **trigonal planar structure**



Its bonds (Boron-chlorine bonds) are polar but the **polarities of the bonds cancel out** because the structure is **symmetrical** and hence it is a **non polar molecule.**



Nitrogen tri chloride, NCl_3 is a **pyramidal molecule,** because of the presence of the lone pair of electrons on the nitrogen atom.
It has **polar bonds** because the **polarity of the bonds in the presence of the lone pair of electrons doesnot cancel out** and hence it is a **polar molecule.**

(d) For group (II) elements, each atom **donates two electrons** to metallic bonding whereas each atom in group (I) **contributes one electron.** The **strength of the metallic bonds** in group (II) elements is **greater** than that of group (I) elements and hence more energy is needed to break the bonds in group (II) elements than group (I) elements

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(e) Lead (II) chloride is **sparingly soluble in water** ie

$PbCl_2(s) + (aq) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq)$

In dilute hydrochloric acid, the **chloride ion concentration is low** and hence the solubility of lead (II) chloride is **less** due to **common ion effect**

In concentrated hydrochloric acid, the **chloride ion concentration is high** and hence the lead (II) chloride reacts with the chloride ions to form a soluble **complex of tetra chloro plumbate (II) ion**

$PbCl_2(s) + 2Cl^-(aq) \longrightarrow PbCl_4^{2-}(aq)$

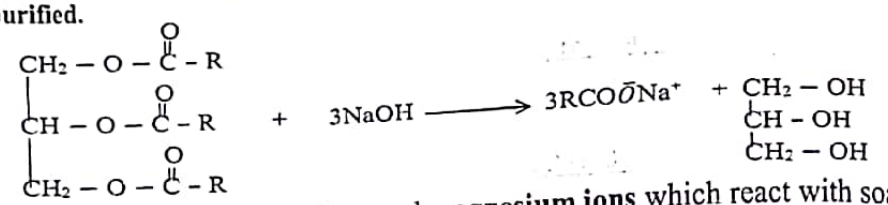
or $Pb^{2+}(aq) + 4Cl^-(aq) \longrightarrow PbCl_4^{2-}(aq)$

Question. Eight.

(a) (i) A **fat** or **oil** such as palm oil is **heated** with **concentrated sodium hydroxide solution** (or Potassium hydroxide solution)

Concentrated sodium chloride solution is added to the mixture, **soap precipitates**. It is then skimmed off and **purified.**

(ii)



(b) (i) Hard water contains **calcium ions** and **magnesium ions** which react with soap to form **insoluble salts** called scum

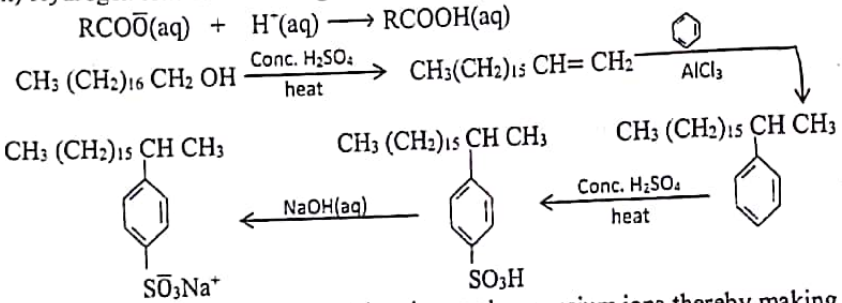
$2RCO\bar{O}(aq) + Ca^{2+}(aq) \longrightarrow (RCOO)_2\,Ca(s)$

or $2RCO\bar{O}(aq) + Mg^{2+}(aq) \longrightarrow (RCOO)_2\,Mg(s)$

(ii) Hydrogen ions form a strong acid medium **react with alkanoate** ions of soap to form a **weak acid**

$RCO\bar{O}(aq) + H^+(aq) \longrightarrow RCOOH(aq)$

(c)



(d) (i) -Polyphosphates react with calcium ions and magnesium ions thereby making Detergents effective with hard water

(ii)-Disodium sulphate increases the bulkness of the detergent

QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2006

1. The rate equation for a certain reaction is:

   Rate = $K[P][Q]^2[R]$

   (a) State what would happen to the rate of reaction if:

   (i) the concentration of P and Q are kept constant, but that of R doubled. (½ mark)

   (ii) the concentration of all the species are halved. (½ mark)

   (iii) concentration of all the species are doubled. (½ mark)

   (b) the following results were obtained in a study of the reaction between peroxodisulphate and iodide ions.

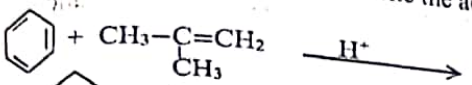
Experiment	$[S_2O_8^{2-}]$ mol dm^{-3}	$[I^-]$ mol dm^{-3}	Initial rate/ mol dm^{-3}s^{-1}
1	0.024	0.024	9.6×10^{-6}
2	0.048	0.024	1.92×10^{-5}
3	0.048	0.012	9.6×10^{-6}

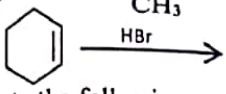
   (i) Write the rate equation. (1 mark)

   (ii) Calculate the rate constant for the reaction and state its units. (1½ marks)

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2. Complete the following equations and write the accepted mechanism for the reaction in each case.

(a)  $+ CH_3-\underset{CH_3}{\overset{|}{C}}=CH_2 \xrightarrow{H^+}$

(b)  $\xrightarrow{HBr}$

3. (a) complete the following equations for the nuclear reactions (3½ marks)

(i) $^{35}_{17}Cl + {}^{1}_{0}n \longrightarrow {}^{1}_{1}H +$ ..... (1 mark)

(ii) $^{214}_{83}Bi \longrightarrow 3\beta + 2\alpha +$ ..... (1 mark)

(iii) $^{2}_{1}H + {}^{10}_{5}B \longrightarrow {}^{1}_{0}n +$ ..... (1 mark)

(b) When a radioactive isotope was stored for 42 days, it retained $\frac{1}{8}^{th}$ of its original activity. Calculate the half-life of the isotope. (2 marks)

4. (a) State the co-ordination number and oxidation states of the central atoms/ions in the following complexes.

Complex	Co-ordination number	Oxidation state.
$(Cl(H_2O)_6Br_3)$		
$(CoCl_4)^{2-}$		
$(Ni(H_2O)_6)^{2+}$		

(b) Briefly explain why transition elements form complexes (2½ marks)

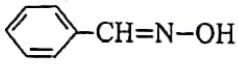
5. Compound Q C_7H_7Br burns with a sooty flame

(a) Write the structural formulae of all the possible isomers of Q. (2 marks)

(b) When Q was heated with aqueous sodium hydroxide, a primary alcohol, Z was formed.

(i) Identify Q (½ mark)

(ii) Write equation and outline a mechanism for the reaction between Q and sodium hydroxide. (1½ mrks)

(iii) Write an equation to show how Z can be converted into  $-CH=N-OH$

6. (a) Write the electronic configuration of copper. (1 mark)

(b) State two properties of copper as a transition element. (1 mark)

(c) Hydrated copper(II) sulphate was dissolved in water. Write equation(s) for the reaction(s) that took place. (3 marks)

7. 50.0g of substance Y was dissolved in water to make $1000cm^3$ of solution. If the partition coefficient of Y between water and ether is 0.2, calculate the mass of Y extracted by shaking the $1000cm^3$ of solution with:

(a) $500cm^3$ of ether (2 marks)

(b) Two successive portions of $250cm^3$ of ether. (3 marks)

8. Draw the structures and name the shapes of the following molecules /ions.

Molecule/ion	Structure	Shape
CO_3^{2-}		
SiF_4		
$(CH_3)_3N$		

9. (a) The standard enthalpy change of formation of silicon (IV) ethloride is -610kJ mol^{-1}. The standard enthalpy changes of atomization of silicon and chlorine are +338 and +122kJ mol^{-1} respectively. Use these values to construct a born-Harber cycle for the formation of silicon(IV) chloride from its elements and indicate the energy changes (2 marks)

(b) Calculate the average bond energy of the Si–Cl bond. (2 marks)

10. (a) Alkenes react with bromine according to the following equation:

$RCH=CH_2 + Br_2 \xrightarrow{CCl_4} RCH(Br)-CH_2Br$

2.8g of an alkene X reacted completely with 4.0g of bromine.

(i) Determine the number of moles of X that reacted with bromine. (1 mark)

(ii) Calculate the molecular mass of X (1 mark)

(iii) Determine the molecular formula of X (1 mark0

(iv) Write the structural formulae of all the possible isomers of X (1½ marks)

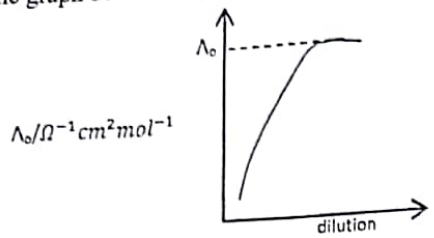
(b) Ozonolysis of X gave only one product. Identifly X. (1 mark)

(c) Write the mechanism of the reaction between X and water in the presence of sulphuric acid (3½ marks)

11. (a) State three factors that can affect molar conductivity of electrolytes. (1½ marks)

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(b) The graph below shows the variation of molar conductivity of a strong electrolyte with dilution.



Briefly explain the shape of the graph. (2½ marks)

(c) The molar conductivity of nitric acid, potassium nitrate and potassium fluoride are 421, 145 and 129$\Omega^{-1}cm^2mol^{-1}$ respectively at infinite dilution. Calculate the:

(i) Molar conductivity of hydrofluoric acid at infinite dilution. (2 marks)

(ii) Dissociation constant, Ka, of a 0.1M hydrofluoric acid solution
(The electrolytic conductivity of hydrofluoric acid is $3.15\times 10^{-5}\Omega^{-1}cm^{-1}$) (3 marks)

12. Carbon, silicon, germanium, tin and lead are in group (IV) of the Periodic Table.

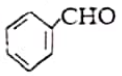
(a) (i) Write the general outermost electronic configuration of the elements. (1 mark)

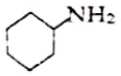
(ii) State the common oxidation states exhibited by the elements in their ions or compounds. (1 mark)

(b) State what would be observed and write equation for the reaction that would take place, if any, when the following compounds are treated with water.

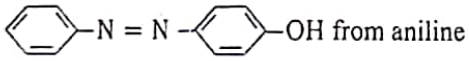
(i) CCl_4 (1 mark) (ii) $SiCl_4$ (3 marks) (iii) $SnCl_4$ (3 marks)

13. Write equations to show how the following compounds can be synthesized.

(a)  from benzene (2marks)

(b)  from cyclohexene. (1½ marks)

(c) CH_3CH_2 > $C=N-OH$ from but-1-ene (3 marks)
CH_3

(d)  from aniline (2½ marks)

14. (a) Name one of source of nitrogen and one source of hydrogen for use in the manufacture of ammonia. (1 mark)

(b) Nitrogen and hydrogen react to form ammonia according to the following equation:

$3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g)$, $\Delta H = -92kJ\ mol^{-1}$

State what would happen to the position of the equilibrium and in each case give a reason if:

(i) the pressure of the system is increased (1½ marks)

(ii) the temperature of the system is increased (1½ marks)

(iii) iron is added to the system (1½ marks)

(c) At a certain temperature, the equilibrium constant for the reaction between nitrogen and hydrogen k_p, was 4.82×10^{-5} atm^{-2} and the partial pressure of nitrogen and hydrogen are 30 and 120 atmospheres respectively.

(i) Write an expression for the equilibrium constant, k_p (½ mark)

(ii) Calculate the partial pressure of ammonia at equilibrium. (3 marks)

15. (a) A chloride of aluminium, X, contains 20% aluminum and 80% chloride.

(i) Calculate the empirical formula of X. (2 marks)

(ii) Determine the molecular formula of X. (The vapour density of X is 133.5) (1½ marks)

(iii) Write the structural formula of X. (1 mark)

(b) Write an equation to show how aluminium chloride can be prepared from aluminium. (1 mark)

(c) aluminium chloride was dissolved in water. Write the equation for the reaction that took place. (1½ marks)

(d) Sodium carbonate was added to an aqueous solution of aluminium chloride.

(i) State what was observed. (½ mark)

(ii) Write the equation for the reaction that took place. (1½ marks)

16. (a) The osmotic pressure of a solution containing 4g per litre of a polymer is $65Nm^{-5}$ at 298K. Calculate the approximate molecular mass of the polymer. (2 marks)

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(b) The structural formulae of some polymers are given in the table below. For each polymer, write the structural formula of the monomer(s), the name(s) of the monomer(s) the type of polymerization and use of the polymer. (7 marks)

Polymer	Structure of monomer(s)	Name of monomer(s)	Type of polymerization	Use of polymer
$\left\{CH_2-\underset{CH_3}{\overset{COOCH_3}{C}}-CH_2-\underset{CH_3}{\overset{COOCH_3}{C}}\right\}_n$				
$\left\{CH_2\underset{Cl}{C}=CHCH_2CH_2-\underset{Cl}{C}=CHCH_2\right\}_n$				
$\left\{\overset{H}{N}(CH_2)_6NHC(CH_2)_4\overset{O}{\overset{\|}{C}}\right\}_n$				

17. (a) What is meant by the term common ion effect? (1 mark)

(b) Calcium iodate, $Ca(IO_3)_2$ is sparingly soluble in water. Write:

(i) the equation for the solubility of calcium iodate in water. (1½ marks)

(ii) the expression for the solubility product, K_{sp} of calcium iodate.

(c) if the solubility product of calcium iodate at 25°C is 1.95×10^{-4} mol dm^3, calculate the solubility in moles per litre at 25°C of calcium iodate in

(i) water (1½ marks)

(ii) a 0.1M solution of sodium iodate (2 marks)

(d) Comment on your answers in (c) above. (2 marks)

END

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2006

1. (a) (i)The rate of reaction would **double** or **increases by two**

Explanation of the answer;

When the concentration of P and Q are **kept constant** but that of R doubled, the rate of reaction only depends on the concentration of R.

Hence. $Rate = k[R] \quad = k(2)$

$Rate = 2k$; *hence the rate doubles or* ***increases by two times.***

(ii) The rate of reaction **decreases by 16 times** the original value or the rate becomes $\frac{1}{16}$ times the orginal value.

Explanation of the answer;

When the concentration of all the species are halved, the rate of reaction depends on the concentration of all the species, hence;

$Rate = k[P][Q]^2[R]$

$= k(½) \times (½)^2 \times (½)$

$Rate = \frac{1}{16}k$, hence the rate changes by $\frac{1}{16}$ times

(iii) The rate of reaction **increases by 16 times** the original value

Explanation of the answer

When the concentrations of all the species are doubled, the rate of reaction depends on the concentrations of all the species, hence;

$Rate = k[P][Q]^2[R]$

$= k(2) \times (2)^2 \times (2)$

$Rate = 16k$, hence the **rate increases by 16 times.**

(b) (i) Rate $= k[S_2O_8^{2-}][I^-]$

Explanation of the answer;

By inspection method, in experiments 1 and 2, when the $[I^-]$ is **constant**, and the

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$[S_2O_8^{2-}]$ doubled, the rate of reaction also doubled, indicating that the reaction is first **order** with respect to $S_2O_8^{2-}$. Similarly in experiments 2 and 3 when the $[S_2O_8^{2-}]$ is constant and the $[I^-]$ halved, the rate of reaction **decreases by half**, indicating that the reaction is also **first order** with respect to I^-.

Alternatively; deducing order of reaction by calculation method;

Considering experiments 1 and 2

$$\left(\frac{0.048}{0.024}\right)^x = \left(\frac{1.92 \times 10^{-5}}{9.6 \times 10^{-6}}\right)$$

$$2^x = 2^1$$

Therefore; $x = 1$, *indicating that the reaction is* ***first order*** *with respect to* $S_2O_8^{2-}$

Considering experiments 2 and 3

$$\left(\frac{0.012}{0.024}\right)^y = \left(\frac{9.6\times10^{-6}}{1.92\times10^{-5}}\right)$$

$$(0.5)^y = (0.5)^1$$

Hence; $y = 1$, *indication that the reaction is* ***first order*** *with respect to* I^-

(ii) From Rate = $k[S_2O_8^{2-}][I^-]$

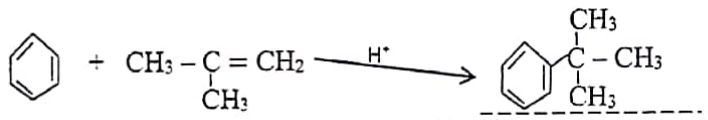
Rate constant; k $\frac{Rate}{[S_2O_8^{2-}][I^-]}$

(Considering experiment 1)

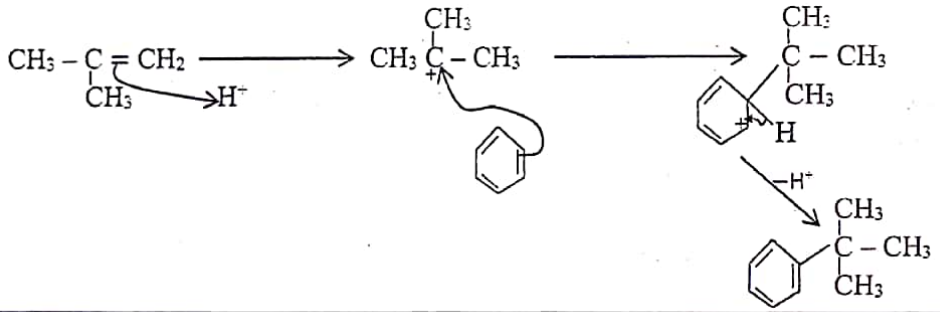
$$K = \frac{9.6\times10^{-6}}{0.024\times0.024}$$

$$= 1.67 \times 10^{-2} mol^{-1} dm^3 S^{-1}$$

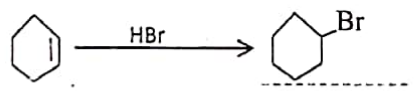
2. (a)



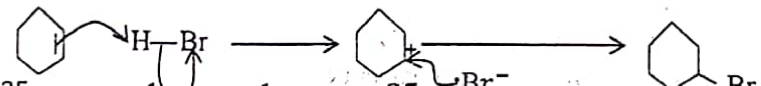
Mechanism



(b)



Mechanism



3. (a) (i) $^{35}_{17}Cl + {}^{1}_{0}n \longrightarrow {}^{1}_{1}H + {}^{35}_{16}S$

(ii) $^{214}_{83}Bi \longrightarrow 3\beta + 2\alpha + {}^{206}_{82}Pb$

(iii) $^{2}_{1}H + {}^{10}_{5}B \longrightarrow {}^{1}_{0}n + {}^{11}_{6}C$

(b) Let the original activity of the isotope = 1 or $\left(\frac{8}{8}\right)$

Thus; using $2.303 \log_{10}\left(\frac{No}{Nt}\right) = \lambda t$

Taking; No = 1, Nt = $\frac{1}{8}$ and t = 42days

Therefore, $2.303 \log_{10}\left(\frac{1}{\frac{1}{8}}\right) = \lambda \times 42$

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$$\lambda = \frac{2.303 \log_{10} 8}{42} = 4.95 \times 10^{-2} \text{day}^{-1}$$

Hence; half life; $t_{½} = \frac{\ln 2}{\lambda}$

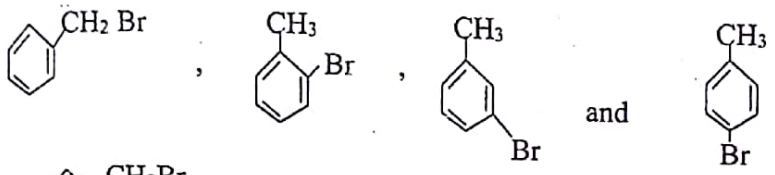
$$= \frac{0.693}{4.95 \times 10^{-2}} \quad = \mathbf{14 days}$$

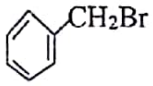
4. (a)

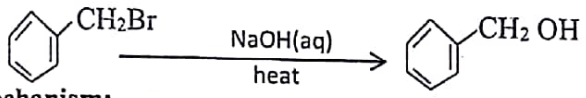
Complex	Coordination number	Oxidation state
$Cr(H_2O)_6\ Br_3$	6	+3
$[CoCl_4]^{2-}$	4	+2
$Ni(H_2O)_6^{2+}$	6	+2

(b) Transition metals have **accessible vacant 3d-orbitals** which can **accommodate lone pairs of electrons** from the liqands

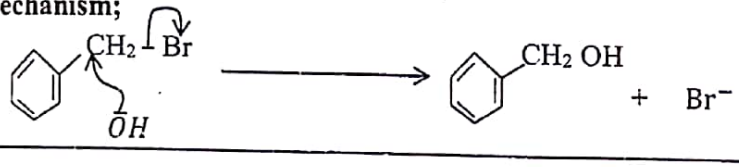
On addition to this, transition metals form ions with **small ionic radii** and **high charge** which gives them a **high charge density** that enables them to strongly attract the liqands.

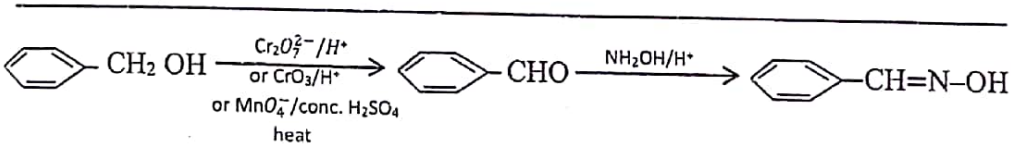
5. (a) 

(b) (i) 

(ii) 

Mechanism;



(iii) 

6. (a) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$ or $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$

(b) -Copper forms many complex compounds
-Copper has variable oxidation states
-Copper forms coloured compounds
-Copper can be used as a catalyst

(c) $Cu(H_2O)_4^{2+}(aq) + H_2O(l) \rightleftharpoons [Cu(H_2O)_3OH]^+(aq) + H_3O^+(aq)$

$[Cu(H_2O)_3OH]^+(aq) + H_2O(l) \rightleftharpoons [Cu(H_2O)_2\ 2OH](s) + H_3O^+(aq)$

7. (a) Let; mass of Y extracted by $500cm^3$ of ether $= xg$

Hence; mass of Y remaining in aqueous layer $= (50.0 - x)g$

$$\text{concentration of Y in ether} = \frac{x}{500}$$

$$\text{concentration of Y in aqueous layer} = \frac{50.0-x}{1000}$$

Thus; $K_D = \frac{\text{concentration of Y in aqueous layer}}{\text{concentration of Y in ether}}$

So; $0.2 = \left(\frac{50.0-x}{1000}\right) \times \left(\frac{500}{x}\right)$

$$x = \mathbf{35.71g}$$

(b) Let; mass of Y extracted by the 1st $250cm^3$ portion of ether $= wg$

Mass of Y remaining in aqueous layer $= (50.0 - w)g$

$$\text{concentration of Y in ether} = \left(\frac{w}{250}\right)$$

$$\text{concentration of Y in aqueous layer} = \left(\frac{50.0-w}{1000}\right)$$

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$K_D = \left(\frac{50.0-w}{1000}\right) \times \left(\frac{250}{w}\right) = 0.2$

$\therefore\ w = 27.78g,$

Hence;

mass of Y remaining in aqueous layer after the 1st *extraction* $= (50 - 27.78) = 22.22g$

Let; mass of Y extracted by 2nd 250cm^3 portion of ether $= kg$

Mass of Y remaining in aqueous layer after the 2nd extraction $= (22.22 - k)g$

Concentration of Y in ether $= \left(\frac{k}{250}\right)$

Concentration of Y in aqueous layer $= \left(\frac{22.22-k}{1000}\right)$

$K_D = \left(\frac{22.22-k}{1000}\right) \times \left(\frac{250}{k}\right) = 0.2$

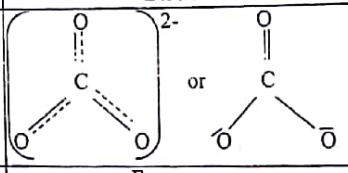
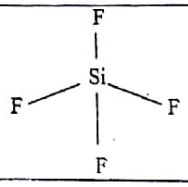
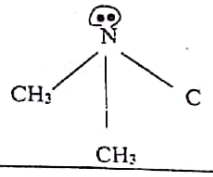
$0.8k = 22.22 - k$

$\therefore\ k = \frac{22.22}{1.8} = \mathbf{12.34}g,$

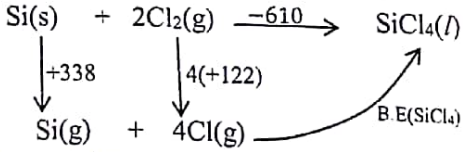
Total massof Y extracted $= (27.78 + 12.34)g$

$= \mathbf{40.12}g$

8.

Molecule/ion	Structure	Shape
CO_3^{2-}		Trigonal planar
SiF_4		Tetrahedral
$(CH_3)_3N$		Trigonal pyramidal

(a)



(b) From Hess's law;

$-610 = 338 + 4(122) + \text{B.E}(SiCl_4)$

$B.E(SiCl_4) = -610 - 826 = \mathbf{-1436}KJmol^{-1}$

Hence; 4(Si – Cl) bonds are formed with evolution of $-1436KJ$

$\therefore\ 1(Si - Cl)bond\ is\ formed\ with\ eveolution\ of\ \frac{-1436KJ}{4}$

Thus; average bond energy of the Si – Cl bond $= -359\text{KJmol}^{-1}$

9. (a) (i) **Number of moles of Br_2 that reacted with the alkene**

Rmm of bromine; $Br_2 = 2 \times 79.9 = 159.8$

$(moles\ of\ Br_2\ in\ 4.0g) = \frac{4.0}{159.8} = 0.025moles\ of\ Br_2$

According to the equation of reaction;

1mole of Br_2 reacts with 1mole of the alkene

$\therefore$ 0.025mole of Br_2 reacts with 1×0.025mole of alkene

Hence; moles of alkene X which reacted with $Br_2 = 0.025moles$

(ii) $0.025moles\ of\ X\ weigh$ 2.8g

$\therefore\ 1mole\ of\ X\ weighs\ \frac{2.8}{0.025} = 112\text{g}$

Hence, molecular mass of X = 112g

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(iii) Since the general molecular formula of alkenes is C_nH_{2n}

Thus; $C_nH_{2n} = 112$

So; $12n + 2n = 112$

Therefore; $n = \frac{112}{14} = 8$

Hence; the molecular of X is C_8H_{16}

(iv) $CH_3CH_2CH_2CH_2CH_2CH_2CH=CH_2$, $CH_3CH=CHCH_2CH_2CH_2CH_2CH_3$

$CH_3CH_2CH=CHCH_2CH_2CH_2CH_3$, $CH_3CH_2CH_2CH=CHCH_2CH_2CH_3$

(b) $CH_3CH_2CH_2CH=CHCH_2CH_2CH_3$

(c) $CH_3CH_2CH_2\underset{H}{C}=CHCH_2CH_2CH_3 \longrightarrow CH_3CH_2CH_2CH_2\underset{:OH_2}{CH}CH_2CH_2CH_3$ ($C=CH$ + H^+)

$CH_3CH_2CH_2CH_2\underset{OH}{CH}CH_2CH_2CH_3 \xleftarrow{-H^+} CH_3CH_2CH_2CH_2\underset{H}{\overset{+O}{\overset{|}{CH}}}CH_2CH_2CH_3$

10. (a) -Concentration of the electrolyte
-Ionic radius
-Ionic charge

(b) Molar conductivity of a strong electrolyte **increases with increase in dilution** until it **almost remains constant at infinite dilution.**

As dilution increases, the **conducting ions become far apart** which **reduces the ionic interfearence** (dragging effect).This **reduces the mobility of the conducting ions** hence a decrease in the molar conductivity. At infinite dilution there is **no ionic interfearance** and hence conductivity remains constant.

Equation of reaction leading to formation of hydrofluoric acid;

$KF(aq) + HNO_3(aq) \longrightarrow KNO_3(aq) + HF(aq)$

Then from Kohrasch's law;

(c) (i) From, Kohrausch's law;

$$\Lambda_o(HF) = \Lambda_o(KF) + \Lambda_o(HNO_3) - \Lambda_o(KNO_3)$$
$$= 129 + 421 - 145 = 405\Omega^{-1}cm^2mol^{-1}$$

(ii) Molar conductivity of 0.1M HF(aq); $\Lambda = \frac{1000K}{C}$

$$= \frac{1000\times3.15\times10^{-5}}{0.1} = \mathbf{3.15\times10^{-1}\Omega^{-1}cm^2mol^{-1}}$$

Degree of ionization; $\propto, of\ HF(aq) = \frac{molar\ conductivity\ of\ 0.1M\ HF(aq)}{molar\ conductivity\ of\ HF(aq) at\ infinity\ dilution}$

Hence; $\propto = \frac{3.15\times10^{-1}}{405} = 7.78\times10^{-4}$

But; $Ka = \frac{\propto^2 C}{1-\propto} = \frac{(7.78\times10^{-4})^2\times0.1}{1-7.78\times10^{-4}}$

$Ka = 6.06\times10^{-8} moldm^{-3}$

11. (a) (i) $ns^2\ np^2$

(ii) +2 and +4

(b) (i) No observable change

(ii) White precipitate and White fumes

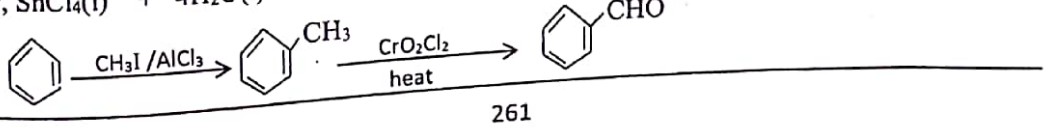
$SiCl_4(l) + 2H_2O(l) \longrightarrow SiO_2(s) + 4HCl(g)$

or, $SiCl_4(l) + 4H_2O(l) \longrightarrow Si(OH)_4(s) + 4HCl(g)$

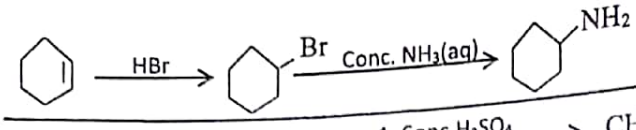
(iii) White precipitate and white fumes.

$SnCl_4(l) + 2H_2O(l) \longrightarrow SnO_2(s) + 4HCl(g)$

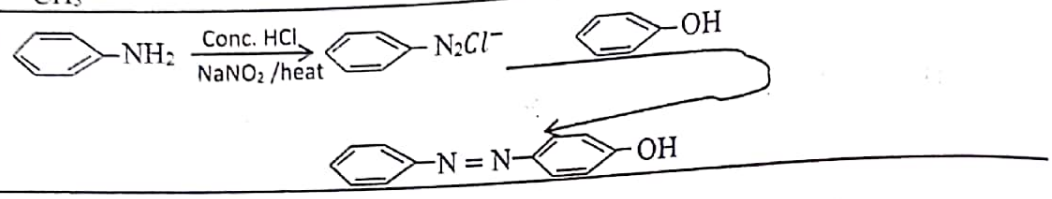
or, $SnCl_4(l) + 4H_2O(l) \longrightarrow Sn(OH)_4(s) + 4HCl(g)$

12. (a) 

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(b) 

(c) $CH_3CH_2CH=CH_2 \xrightarrow[2.\ H_2O/warm]{1.\ Conc.H_2SO_4} CH_3CH_2\underset{OH}{CH}CH_3 \xrightarrow[heat]{MnO_4^-/\ onc.H_2SO_4} CH_3CH_2\overset{O}{\overset{\|}{C}}CH_3 \xrightarrow{NH_2OH/H^+} CH_3CH_2(CH_3)C=N-OH$

(d) 

13. (a) Source of nitrogen is **air**
Source of hydrogen is **water, natural gas, coal** or **petroleum**

(b) (i) Equilibrium position **shift from left to right**.
This is because the forward reaction (formation of ammonia) is accompanied with a **decrease in volume**.

(ii) Equilibrium position shifts **from right to left**
This is because the forward reaction is **exothermic** or because the back ward reaction is **endothermic**

(iii) Equilibrium position **remains unchanged**
This is because iron acts as a **catalyst** in this reaction and therefore increases the rate of both the forward and back ward reaction in the same way.

(c) (i) $Kp = \frac{(P_{NH_3})^2}{(P_{H_2})^3 \cdot (P_{N_2})}$ or $Kp = \frac{P^2NH_3}{P^3H_2 \times P_{N_2}}$

(ii) Partial pressure of NH_3; $P_{NH_3} = \sqrt{KP \times (P_{H_2})^3 \times (P_{N_2})}$

$= \sqrt{4.82 \times 10^{-5} \times (120)^3 \times 30}$

$= \mathbf{49.99atm}$

14. (a) (i) Composition of X;

	Al	Cl
Moles;	$\frac{20}{27}$	$\frac{80}{35.5}$
	0.740	2.253
Mole ratio;	$\frac{0.740}{0.740}$	$\frac{2.253}{0.740}$
	1 :	3

Emperical formula of X is $AlCl_3$

(ii) Molecular mass of $X = 2 \times$ *vapour density*

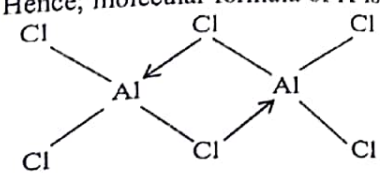
$= 2 \times 133.5 = \mathbf{267g}$

Thus; $(AlCl_3)n = 267$

$(1 \times 27)n + (3 \times 35.5)n = 267$

$Therefore; n = \frac{267}{133.5} = 2$

Hence; molecular formula of X is Al_2Cl_6

(iii) 

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(b) $2Al(s) + 6HCl(g) \longrightarrow 2AlCl_3(s) + 3H_2(g)$
$2Al(s) + 3Cl_2(g) \longrightarrow 2AlCl_3(s)$

(c) $2AlCl_3(s) + 6H_2O(l) \longrightarrow 2Al(OH)_3(s) + 6HCl(aq)$
or, $Al(H_2O)_6^{3+}(aq) + H_2O(l) \longrightarrow [Al(H_2O)_5OH]^{2+}(aq) + H_3O^+(aq)$

(d) (i) **White precipitate and effervescence of a colourless gas**

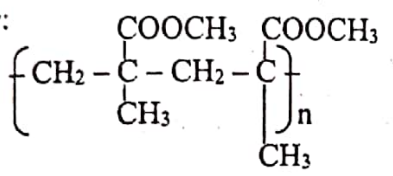
(ii) $2AlCl_3(s) + 3H_2O(l) + 3Na_2CO_3(aq) \longrightarrow 2Al(OH)_3(s) + 6NaCl(aq) + 3CO_2(g)$
or, $2Al^{3+}(aq) + 3H_2O(l) + 3CO_3^{2-}(aq) \longrightarrow 2Al(OH)_3(s) + 3CO_2(g)$

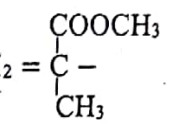
15. (a) using; $\pi v = \frac{m}{mr}RT$

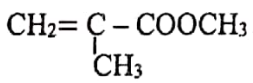
Thus; molecular mass of polymer, $mr = \frac{mRT}{\pi v}$

$= \frac{4\times8.31\times298}{65\times10^{-3}}$

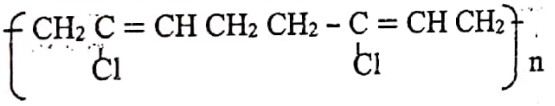
$= 152392.62g$

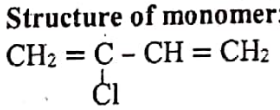
(b) **Polymer:** 

Structure of monomer: 

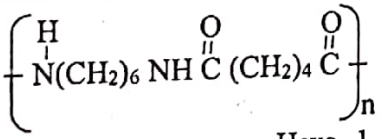
or 

Name of monomer(s); 2, 3-dimethyl Propanoate
Type of Polymerization; Addition Polymerization
Use of the Polymer; Making wind screens of air crafts

Polymer: 

Structure of monomer: 

Name of monomer; 2-chloro-buta-1, 3-diene
Type of Polymerization; addition Polymerization
Use of Polymer; making hose pipes and gaskets

Polymer: 

Structure of monomer: $HN_2(CH_2)_6NH_2$

Name of monomer; Hexa -1, 6 diamine
Type of Polymerization; Condensation Polymerization
Use of Polymer; making Fabrics and fish nets

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16. (a) The precipitation (or reduction in solubility) of a **sparingly soluble ionic compound** from its **saturated** solution by addition of a **soluble compound** containing a **similar ion**

(b) (i) $Ca(IO_3)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2IO_3^-(aq)$
or $Ca(IO_3)_2(s) + (aq) \rightleftharpoons Ca^{2+}(aq) + 2IO_3^-(aq)$
(ii) $Ksp = [Ca^{2+}][IO_3^-]^2$

(c) (i) Let the solubility of $Ca(IO_3)_2$ in water $= (S)moldm^{-3}$
Hence; $[Ca^{2+}] = (S)\ moldm^{-3}$
$[IO_3^-] = 2S\ moldm^{-3}$

Thus; $Ksp = S \times (2S)^2$
So; $Ksp = 4S^3 = 1.95 \times 10^{-4}$

Therefore; $S = \sqrt[3]{\frac{1.95\times10^{-4}}{4}} = 3.653 \times 10^{-2} moll^{-1}$

(ii) Let the solubility of $Ca(IO_3)_2$ in the 0.1M sodium iodate solution $= x\ moldm^{-3}$
Thus; $[Ca^{2+}] = xmoldm^{-3}$
$[IO_3^-] = 2x + 0.1 \simeq 0.1moldm^{-3}$ (since x is very small)

And so; $Ksp = [Ca^{2+}][IO_3^-]^2$

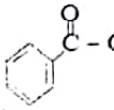
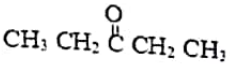
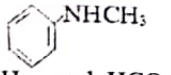
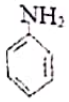
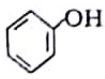
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$$Ksp = x \times (0.1)^2 = 1.95 \times 10^{-4}$$
$$\therefore x = \frac{1.95\times10^{-4}}{(0.1)^2} = 1.95 \times 10^{-2} \text{moldm}^{-3}$$

(d) Solubility of Calcium iodate in 0.1M sodium iodate solution is lower than that in water. and this is because in sodium iodate solution, the **concentration of iodate ions** is **high**, and so the excess iodate ions reacts with calcium ions in solution thus **precipitating calcium iodate** hence reducing the solubility of calcium iodate; i.e

$$Ca^{2+}(aq) + 2IO_3^-(aq) \longrightarrow Ca(IO_3)_2(s)$$

QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2006

1. (a) Write:
   (i) the electronic configuration of manganese atom (Atomic number = 25) (1 mark)
   (ii) the possible oxidation states of manganese. (2½ marks)
   (b) (i) Write the half equation for the reduction of potassium permanganate in acidic medium. (1½ marks)
   (ii) State the change in the oxidation state of the manganese in the reaction in (b) (i) above. (1 mark)
   (c) State **three** advantages of using potassium permanganate in volumetric analysis. (3 marks)
   (d) Briefly explain why hydrochloric acid and nitric acid are not used for acidifying potassium permanganate solution during volumetric analysis. (3 marks)
   (b) Explain what would be observed if aqueous sodium hydroxide solution was added drop-wise till in excess to a solution containing manganese(II) ions. (6 marks)
   (c) Name a reagent apart from aqueous ammonia and sodium hydroxide solution that can be used to distinguish manganese (II) ions, Mn^{2+} from Nickel ions, Ni^{2+}.
   State what would be observed if each of them is separately treated with the reagent you have named.(2mks
2. (a) Explain what is meant by the term **ideal solution.** (3 marks)
   (b) At Standard atmospheric pressure, hydrochloric acid and water form a **constant boiling ppoint mixture** having a boiling point of 110°C and composition 20% by mass of hydrochloric acid.
   (i) Define the term **constant boiling point mixture.** (2 marks)
   (ii) Sketch a labelled diagram of the boiling point –composition for hydrochloric acid and water system. [The boiling points of water and hydrochloric acid are 100°C and 85°C respectively.] (3 marks)
   (iii) Describe what would happen if a mixture of 10% hydrochloric acid is fractionally distilled. (3 marks)
   (c) A constant boiling point mixture of hydrochloric acid and water has a density of 1.18g cm^{-3}. Calculate the volume of the acid needed to prepare one litre of 2M hydrochloric acid solution. (3 marks)
   (d) The vapour pressure of ethanol at 20°C is 43.6mmHg while that of benzene at the same temperature is 75.2 mm Hg. The mole fraction of benzene is 0.09 for a mixture of benzene and ethanol at 20°C.
   Calculate:
   (i) the vapour pressure of the mixture. (4 marks)
   (ii) the mole fraction of benzene in the vapour phase. (2 marks)
3. For each of the following pairs of compounds:
   (i)  and 
   (ii)  and 
   (iii) CH_3CO_2H and HCO_2H.
   (iv)  and 

   Name **one** reagent which;
   (a) When reacted with each member of the pair will show similar observation.
   (b) Can be used to distinguish between the members of each pair. (8 marks)
   In each case state what would be observed when each member of the pair is reacted with the reagent you have named. (12 marks)

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4. (a) (i) Define the term **enthalpy of solution.** (1 marks)

(ii) State the energy terms that determine the magnitude and sign of the enthalpy of solution of an ionic salt. (2 marks)

(iii) Describe an experiment that can be used to determine the enthalpy of solution of an ionic salt. (9 marks)

Your answer should include treatment of results and any assumptions used in the experiment

(*Diagrams are not required*)

(b) Some thermo-chemical data of copper, copper (II) chloride and chlorine are given below.

Enthalpy of formation of $CuCl_2$	$= -220\ kJ\ mol^{-1}$
Enthalpy of sublimation of Cu	$= +338.3\ kJ\ mol^{-1}$
First ionization energy of Cu	$= +745\ kJ\ mol^{-1}$
Second ionization energy of Cu	$= +1958\ kJ\ mol^{-1}$
First electron affinity of chlorine	$= -364.0\ kJ\ mol^{-1}$
Bond dissociation energy of chlorine	$= +121.1\ kJ\ mol^{-1}$

(i) Draw an energy level diagram which can be used to determine the lattice energy of copper (II) chloride. (4 marks)

(ii) The hydration energy of copper (II) chloride is $-2883.9\ kJ\ mol^{-1}$. Determine the enthalpy of solution of copper (II) chloride. (3 marks)

(iii) Comment on the solubility of copper (II) chloride. (1 mark)

5. Nitrogen (II) oxide combines with oxygen at 80°C and 200 atmospheres to form nitrogen (IV) oxide according to the following equation:

$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g),\ \Delta H = -xkJmol^{-1}$

(a) (i) Write an expression for the equilibrium constant, kp, for the reaction. (1 mark)

(ii) Calculate kp, if the mixture contained 67% nitrogen (IV) oxide at equilibrium. (3½ marks)

(b) State how the value of kp will be affected if:

(i) temperature is increased (1 mark)

(ii) a catalyst is added (½ mark)

(c) The Kinetic data for the reaction in (a) is shown in the table below:

Initial rate/$Nm^{-2}s^{-1}$	6.8	27.2	61.2	108
P_{NO}^2/N^2m^{-4}	0.04	0.16	0.36	0.64

P_{NO} = the partial pressure of **NO**.

(i) Plot a graph of initial rate aginst P_{NO}^2 (3 marks)

(ii) Using the graph, determine the order of the reaction with respect to nitrogen (II) oxide. (1 mark)

(iii) Give a reason for your answer in (c) (ii) (1 mark)

(d) When the partial pressure of oxygen was doubled to a new constant value, the gradient of the graph in (c) (i) doubled.

(i) Determine the order of reaction with respect to oxygen.
Explain your answer. (2 marks)

(ii) Write the rate equation for the reaction in (b) (1 mark)

(iii) Calculate the rate constant when the initial rate = 170 $Nm^{-2}s^{-1}$
$P_{NO} = 0.1Nm^{-2}$ and $P_{O_2} = 1.36Nm^{-2}$ and state its units. (2 marks)

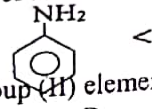
(e) State the effect of the following on the rate of this reaction.

(i) halving partial pressure of nitrogen (II) oxide while that of oxygen is kept constant. (2 marks)

(ii) doubling partial pressure of both nitrogen (II) oxide and oxygen. (2 marks)

6. Explain the following observations.

(a) The basic strengths of aminobenzene, ammonia and dimethylamine are in the order.



$< NH_3 < (CH_3)_2NH$. (4 marks)

(b) The tendency of group (II) elements to form complex ions is in the order: (4 marks)

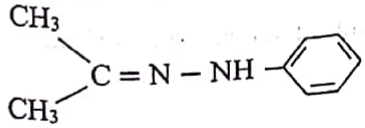
Be > Mg > Ca > Ba

(c) The bond angle in water molecule is 104° whereas that in a molecule of ammonia is 107° (4 marks)

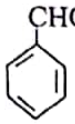
(d) The acid dissociation constant, k_a, of bromoethanoic acid is greater than that of ethanoic acid, at the same temperature. (4 marks)

(e) Ammonia boils at −33°C whereas phosphine, pH_3 boils at −88°C (4 marks)

7. Write equations to show how the following compounds can be synthesized. (5 marks)

(a)  from propene.

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(b)  From benzene. (2 marks)

(c) $CH_3CH_2C \equiv CH$ from ethanol. (7½ marks)

(d) $CH_3CH_2NH_2$ from ethanol. (3 marks)

(e) CH_3CO_2H from ethane. (2½ marks)

8. (a) Outline the reactions that take place in the blast furnace during the extraction of iron from Spathic iron, $FeCO_3$ (8 marks)

(b) Briefly describe how iron reacts with the following. (*Your answer should include equations*)

(i) water. (3½ marks)

(ii) chlorine, (2½ marks)

(iii) dilute sulphuric acid, (3 marks)

(iv) concentrated sulphuric acid. (3 marks)

END

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2006

Question. One.

(a) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$ or $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$

(ii) +1, +2, +3, +4, +5, +6, +7

(b) (i) $MnO_4^-(aq) + 5e + 8H^+(aq) \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$

or in mild acid

$MnO_4^-(aq) + 4H^+(aq) + 3e \longrightarrow MnO_2(s) + 2H_2O(l)$

(ii) +7 to +2 (or; in mild acid; +7 to +4)

(c) -Potassium permanganate acts as its own indicator
-It has a fairly high formula mass
-Can oxidize a wide range of substances
-Fairly soluble in water
-Not hygroscopic or deliquescent
-Its reactions are fast at room temperature

(d) Potassium manganate (VII) **oxidizes** hydrochloric acid to **chlorine**

$2KMnO_4(aq) + 16HCl(aq) \longrightarrow 2KCl(aq) + 2MnCl_2(aq) + 8H_2O(l) + 5Cl_2(g)$

Nitric acid is a **strong oxidizing agent** which can **compete** with potassium manganate (VII) **for the reducing agent.**

(e) **White precipitate** of **manganese (II) hydroxide** which is **insoluble** in excess sodium hydroxide solution and turns **brown** due to **oxidation** by air to form **hydrated manganese (IV) oxide** or hydrated manganese (III) oxide.

$Mn^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Mn(OH)_2(s)$

$2Mn(OH)_2(s) + O_2(g) \longrightarrow 2MnO_2 \cdot H_2O(s)$ **or;**

$4Mn(OH)_2(s) + O_2(g) \longrightarrow 2Mn_2O_3 \cdot 2H_2O(s)$

(f) Sodium bismuthate and nitric acid

Observation; Mn^{2+} - gives a **purple** (or pink) solution

Ni^{2+} - gives no observable change.

Alternatively;

Reagent – lead (IV) oxide and nitric acid and heat

Observation; Mn^{2+} - gives a purple (or pink) solution

Ni^{2+} - gives no observable change.

Alternatively;

Reagent – Ammonium peroxodisulphate solution (ammonium persulphate solution) and silver nitrate solution

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Observation; Mn^{2+} - gives a purple (pink solution)
Ni^{2+} - gives no observable change.

Alternatively;
Reagent – Dimethyl glyoxime in alkaline solution
Observation; Mn^{2+} - gives no observable change.
Ni^{2+} - gives a red precipitate

Alternatively;
Reagent; Hydrogen sulphide or ammonium sulphide solution or sodium sulphide solution or potassium suphide solution.
Observation; Mn^{2+} - gives a pink precipitate
Ni^{2+} - gives a black precipitate

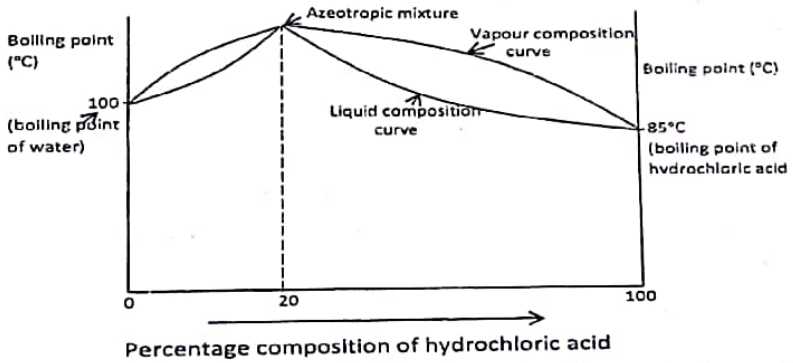
Alternatively;
Reagent – sodium carbonate solution
Observation; Mn^{2+} - gives a red precipitate
Ni^{2+} - gives a green precipitate

Question. Two.

(a) An ideal solution is a solution in which the inter molecular forces between the like molecules (A – A or B – B) and unlike molecules (A – B) are **equal** in strength ie.
(A – A and B – B ≈ A – B)
The solution is formed with **no change in total volume** and **no change in temperature.** The solution obeys **Raoult's law of vapour pressures.**

(b) (i) A mixture whose liquid and vapour states have the **same composition**
or A liquid mixture which boils at **constant temperature** at a **given pressure** to give vapour of the **same composition** as the liquid mixture

(ii)



(iii) The mixture would produce a **vapour** which is **richer in water than hydrochloric acid.** Continued heating and condensation of the vapour would eventually yield **pure water as the distillate** while the **azeotropic** mixture would be obtained as the residue.

(c) Moles of HCl in 1 litre of 2M hydrochloric acid solution = 2 moles
Relative molecular mass of HCl = 1 + 35.5 = 36.5
Mass of pure HCl needed = (2 × 36.5) = 73g
Note, The constant boiling mixture of HCl and water contains 20% HCl.
Let, the mass of the constant boiling mixture which contains 73g of HCl be (y)g
Hence; $\frac{73}{y} \times 100 = 20$

$$y = \frac{73 \times 100}{20} = \underline{365g}$$

Since density of the mixture = 1.18 gcm^{-3}
Hence; 1.18g of HCl is contained in 1cm^3 of HCl
Therefore; 365g of HCl is contained in $\frac{365}{1.18}$ cm^{-3} of HCl = 309.32 cm^{-3}
Thus volume of acid needed = 309.32 cm^{-3}

(d) (i) Mole fraction of ethanol in mixture = 1 – 0.09 = 0.91

$$\begin{pmatrix}\text{V. Pressure of} \\ \text{ethanol in mixture}\end{pmatrix} = \begin{pmatrix}\text{mole fraction} \\ \text{of ethanol}\end{pmatrix} \times \begin{pmatrix}\text{v. pressure of} \\ \text{pure ethanol}\end{pmatrix}$$

$$= 0.91 \times 43.6 \quad = 39.7 mmHg$$

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V.Pressure of benzene in mixture $= 0.09 \times 75.2 \quad = 6.8mmHg$

V. pressure of mixture $= 39.7 + 6.8 \quad = 46.5mmHg$

(ii) Mole fraction of benzene in vapour phase $= \frac{V.pressure\ of\ benzene\ in\ mixture}{Total\ vapour\ pressure\ of\ the\ mixture}$

$= \frac{6.8}{46.5} = 0.15$ **(or 15%)**

Question. Three.

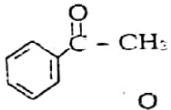
(a) (i) 2,4-dinitrophenyl hydrazine
Observation – yellow or orange precipitate
or,Reagent – Saturated sodium hydrogen sulphite solution
Observation – white precipitate

(ii) **Reagent** – Hydro chloric acid
Observation – both dissolve in hydrochloric acid
or, Reagent – sulphuric acid
Observation – white precipitate
or, Reagent – Bromine water
Observation - White precipitate

(iii) **Reagent** – Sodium carbonate (or Sodium hydrogen carbonate)
Observation – Bubbles of a colourless gas
or, Reagent – magnesium metal
Observation – Bubbles of a colourless gas

(iv) **Reagent** – Sodium metal
Observation – **Bubbles** of colourless gas

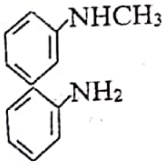
(b) (i) **Reagent** – Aqueous iodine and sodium hydroxide solution
Observation



– Gives a yellow precipitate

$CH_3CH_2\overset{O}{\overset{\|}{C}}CH_2CH_3$ shows no observable change

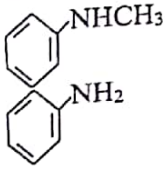
(ii) **Reagent** – sodium nitrite with concentrated hydrochloric acid at a temperature less than 10°C
Observation;



- forms a yellow oily liquid

- gives a colourless solution

or Reagent – Trichloromethane in alcoholic sodium hydroxide solution
Observation;



- does not give unpleasant smell

- Gives unpleasant smell

(iii) **Reagent** – Fehlings solution
Observation; CH_3COOH – gives no observable change
HCOOH – gives a red precipitate

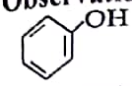
or, Reagent – Ammoniacal silver nitrate solution
Observation; CH_3COOH – gives no observable change
HCOOH – forms a sliver mirror

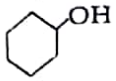
or, Reagent – Acidified potassium manganate (VII) solution
Observation; CH_3COOH – gives no observable change
HCOOH – **Purple** solution turns **colourless**

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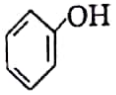
or, **Reagent** - Acidified potassium dichromate (VI) solution
Observation – **orange** solution turns **green**

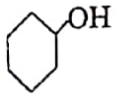
(iv) **Reagent** – **Neutral** iron (III) chloride solution
Observation;


- violent colouration or purple colouration

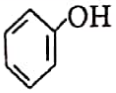

- gives no observable change

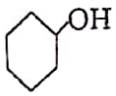
or, **Reagent** – bromine water
Observation;


- forms a white precipitate


- gives no observable change

or, **Reagent** – Benzene diazonium salt in an alkali
Observation;


- forms a yellow precipitate


- gives no observable change

Question. Four.

(a) (i) The **heat change** when **one mole** of a solute **dissolves** in a specified amount of **water** to form an **infinitely dilute solution** such that any further dilution causes no heat change.

(ii) Lattice energy
Hydration energy

(iii) A **known volume** (V) of water is put in an **insulated** container.
The temperature of water is measured and recorded (T_1°C)
A known mass (wg) of an ionic salt is added to the water in the insulated container
The mixture is stirred and the final steady temperature is measured and recorded (T_2°C)

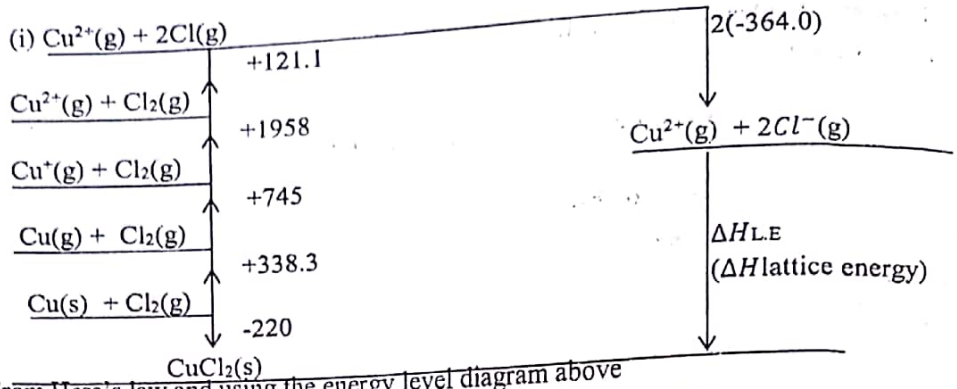
Assumptions;
Specific heat capacity of solution = $4.2Jg^{-1}°C^{-1}$
Density of solution/water = $1gcm^{-3}$
Heat capacity of the container is negligible and Formula mass of salt =M

Treatment of results
Mass of water = $(V \times 1) = Vgrams$
Temperature change; $\Delta T = (T_2 - T_1)°C$
Mass of solution mixture = $(w + V)grams$
Heat change = $mass\ of\ solution \times S.H.C \times temperature\ change$
$= (w + V) + 4.2 \times (T_2 - T_1)$

Hence; wg of salt liberate $(w + V) + 4.2 \times (T_2 - T_1)$
Therefore, $Mg\ of\ salt\ liberate\ \frac{M\times(w+V)+4.2\times(T_2-T_1)}{w}$
Thus; molar enthalpy of solution of the salt = $\left(\frac{M\times(w+V)\times4.2\times(T_2-T_1)}{w}\right) Jmol^{-1}$

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(b)



(ii) From Hess's law and using the energy level diagram above

$$-220 = 338.3 + 745 + 1958 + 121.1 + 2(-364.0) + \Delta HL.E$$

ΔHLattice energy $= -2654.4 KJmol^{-1}$

ΔHsolution of $CuCl_2 = \Delta H lattice\ energy + \Delta H hydration\ energy$

$= +2654.4 + (-2883.9) = \mathbf{-229.5 KJmol^{-1}}$

(iii) Copper (II) Chloride is **soluble** in water since its enthalpy of solution is **negative**

Question. Five.

(a) (i) $Kp = \frac{P^2NO_2}{P^2NO \times PO_2}$ or $Kp = \frac{(PNO_2)^2}{(PNO) \times PO_2}$; $P = partial\ pressure$

(ii) % of $(NO + O_2) = 100 - 67 = 33\%$

Total moles of NO and O_2 at equilibrium $= 2 + 1 = 3$ ($since\ mole\ ratio\ of\ NO:O_2 = 2:1$)

% of $NO = \frac{2}{3} \times 33 = 22\%$

% of $O_2 = \frac{1}{3} \times 33 = 11\%$

$PNO_2 = \frac{67}{100} \times 200$, $PNO = \frac{22}{100} \times 200$, $PO_2 = \frac{11}{100} \times 200$

Hence; $Kp = \frac{\left(\frac{67}{100} \times 200\right)^2}{\left(\frac{22}{100} \times 200\right)^2 \times \left(\frac{11}{100} \times 200\right)} = 0.4216\ atm^{-1}$

(b) (i) Kp value decreases (because the forward reaction is exothermic)

(ii) Kp value remains constant

(c) (i) **See graph next page**

(ii) Sceond order

(iii) The graph of initial rate against P^2NO is a **straight line** through the origin, indicationg that the rate of reaction is directly proportional to the square of the partial pressure of nitrogen monoxide

(d) (i) Partial pressure : Rate of reaction

doubled; $(2)^x$ 2(doubled)

Hence; x = 1;

Therefore; order of reaction with respect to oxygen is 1 or **first order**

(ii) The reaction is first order with respect to oxygen because the rate of reaction is directly propotional to the partial pressure of oxygen raised to the first power

(iii) Rate equation of reaction is given by;

$\text{Rate} = KP^2_{NO} \times P_{O_2}$

Rate constant; $K = \frac{Rate}{P^2NO \times PO_2}$

$= \frac{170}{(0.1)^2 \times (1.36)}$

$= 12500 N^{-2} m^4 S^{-1}$

(e) (i) The rate of reaction **reduces by four times**

Note

When the partial pressure of nitrogen (II) oxide is halved while that of oxygen is kept constant, then the reaction rate depends only on the partial pressure of nitrogen (II) oxide;

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Hence; Rate of reaction = $K \times P^2_{NO}$

$= K \times (½)^2 = ¼K$

Hence rate decreases by four times

(ii) The rate **increases by eight times**

Note; when the partial pressure of both nitrogen (II) oxide and oxgen are doubled, the rate of reaction then depends on the partial pressure of nitrogen (II) oxide and oxygen hence;

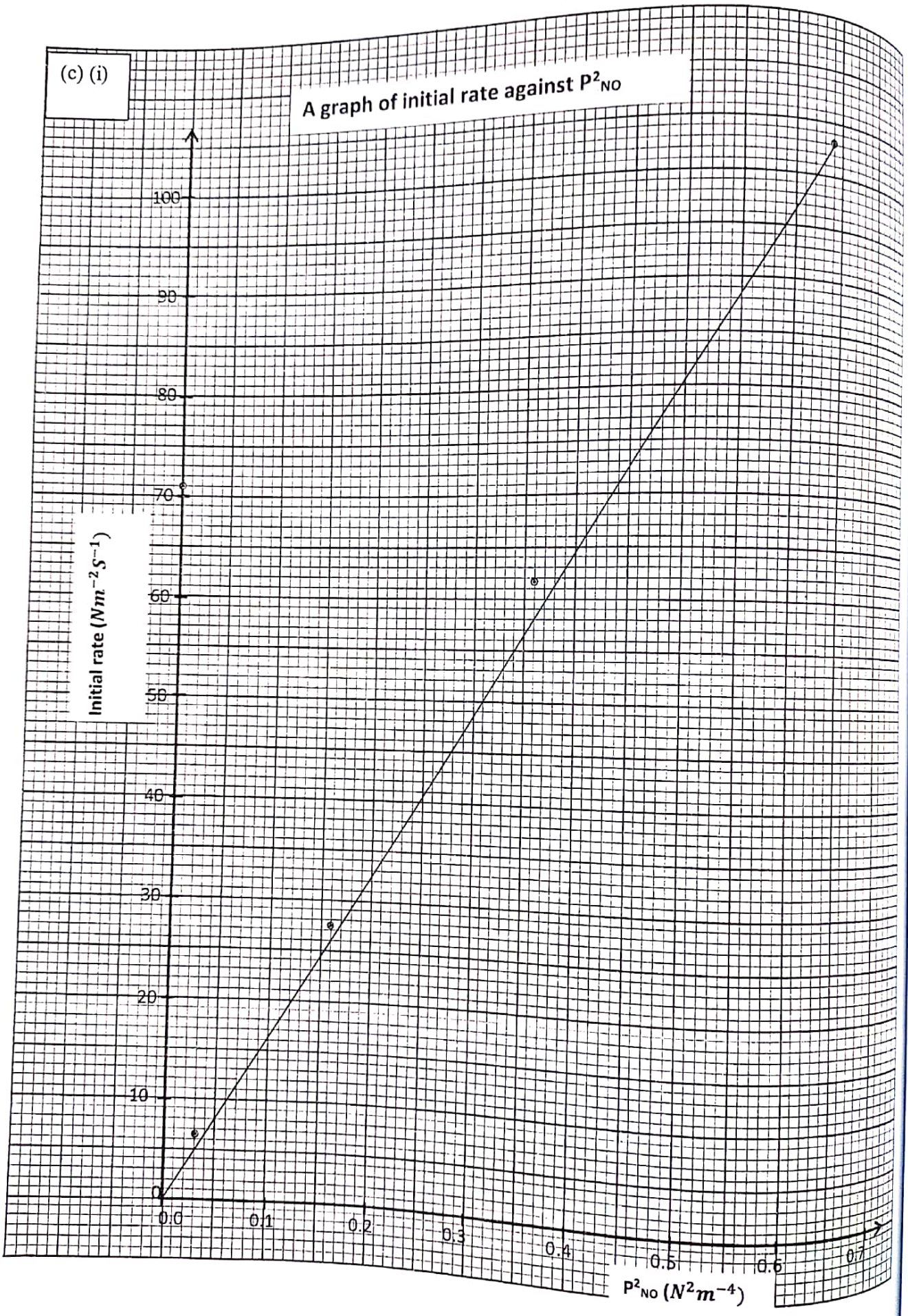
Rate of reaction $= K \times P^2_{NO} \times P_{O_2}$

$= K \times (2)^2 \times (2)$

$= 8K$; *hence rate increases by eight times*

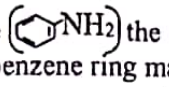
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(c) (i)

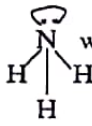
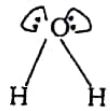


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Question. Six.

(a) The basic strength of an amine depends on the **availability of the lone pair of electrons** on the nitrogen atom.
In amino benzene  the lone pair of electrons on the nitrogen **interacts** with the **delocalized pie electrons** of the benzene ring making the lone pair of electrons on the nitrogen **not easily available.**
Ammonia has three hydrogen atoms bonded to the nitrogen atom and these hydrogen atoms have **no inductive effect** and hence have **no effect on the availability of the lone pair of electrons** on the nitrogen atom and therefore ammonia is a stronger base than amino benzene
Dimethyl amine has two methyl groups and these methyl groups have a **positive inductive effect** (release electrons to the nitrogen atom). These methyl groups therefore **increase** the **availability of the lone pair of electrons on the** nitrogen atom making dimethyl amine a stronger base than ammonia

(b) Formation of complex ions is favoured by **high charge** and **small ionic radius**, and from Beryllium to barium **cationic radius increases** white the **charge remains** the **same, charge density density decreases** and hence **attraction** of the ligand molecules by the cation to form the complex ion **decreases.**

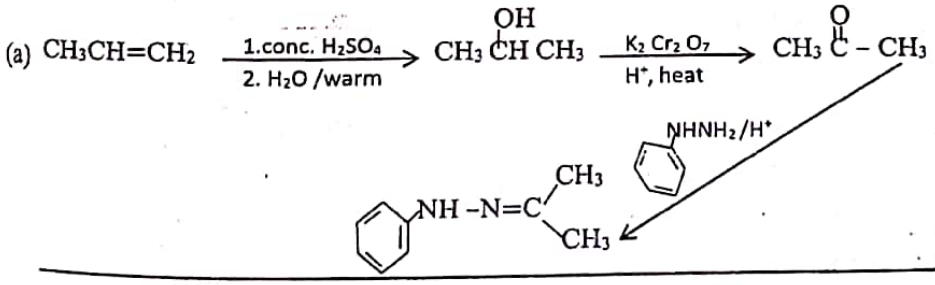
(c) Structure ammonia is  while that of water is 

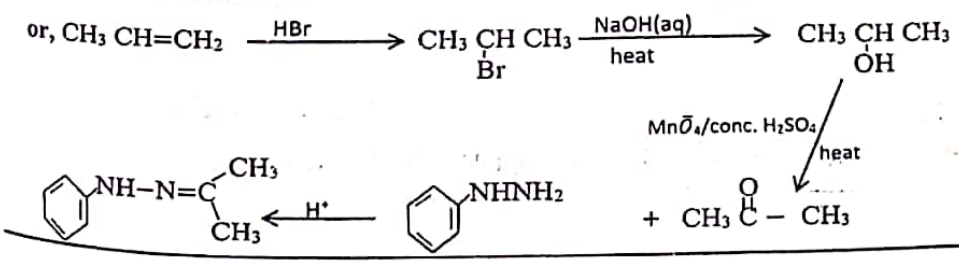
Both molecules have **four electron pairs** around their central atoms.
In water, there are **two lone pairs** of electrons while ammonia has one **lone pair** of electrons
The two lone pairs exert **greater repulsion on the bond pairs** of electrons in water than the one lone pair in ammonia thus making the bond angle in ammonia to be larger than water.

(d) In bromo ethanoic acid, the **bromine atom** is **more electronegative** than the carbon atom. The bromine atom therefore **withdraws** bonding electrons away from the carbon atom. This effect results into **weakening of the oxygen-hydrogen bond** resulting into **easy release of protons**
In ethanoic acid, the **methyl group releases electrons** to the carboxyl group resulting into **strengthening of the oxygen –hydrogen bond** and hence making it **difficult to release protons**

(e) The nitrogen atom in ammonia is **more electronegative** than the phosphorus atom in phosphine. This makes the nitrogen-hydrogen bond in ammonia to be more polar than the phosphorus-hydrogen bond in phosphine. Hence the molecules of ammonia associate through **intermolecular hydrogen bonds** while in between phosphine molecules are **vander waal's bonds or forces** However, the **hydrogen bonds are stronger than the vander waal's bonds or forces** and therefore more energy is required to break hydrogen bonds in ammonia than the vander waal's forces in phosphine.

Question. Seven.

(a) 

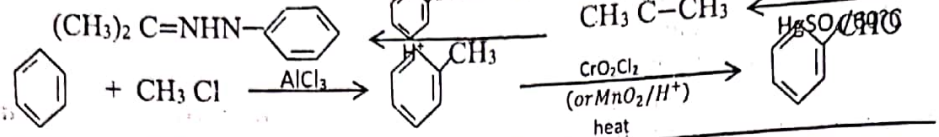
or, 

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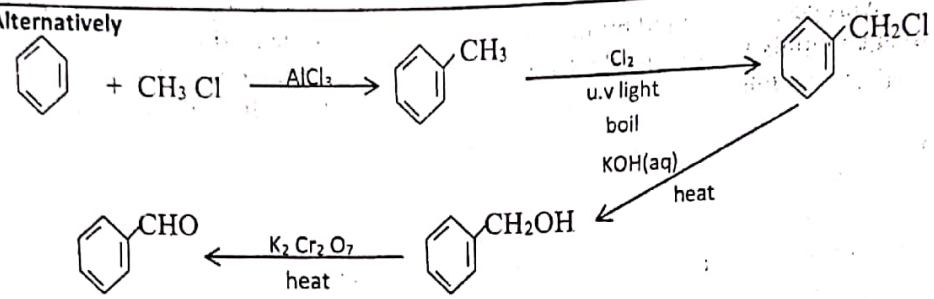
Alternatively,

$$CH_3CH=CH_2 \xrightarrow[\text{Room temperature}]{Cl_2/CCl_4} CH_3\underset{Cl}{C}H\underset{Cl}{C}H_2 \xrightarrow[\text{heat}]{KOH/Ethanol} CH_3C\equiv CH \xrightarrow[HgSO_4/60°C]{H_2O,\ \text{Dilute } H_2SO_4} CH_3\overset{O}{\overset{\|}{C}}-CH_3$$

(b)



Alternatively



(c)

$$CH_3CH_2OH \xrightarrow[(conc.H_3PO_4)]{Conc.H_2SO_4\ or} CH_2=CH_2 \xrightarrow[CCl_4]{Cl_2} CH_2\underset{Cl}{C}H_2\underset{Cl}{}$$

heat (or 170°C)

KOH/Ethanol, heat

$$HC\equiv CH \longrightarrow HC\equiv C^-Na \longrightarrow CH_3CH_2Cl \longrightarrow HC\equiv C\,CH_2\,CH_3$$

Alternatively;

$$CH_3CH_2OH \xrightarrow{SOCl_2} CH_3CH_2Cl + HC\equiv C^-Na^+ \longrightarrow HC\equiv C\,CH_2\,CH_3$$

(d)

$$CH_3CHO \xrightarrow{Na/alcohol} CH_3CH_2OH \xrightarrow{PCl_5} CH_3CH_2Cl \xrightarrow[\text{Heat in sealed tube}]{Conc.NH_3} CH_3CH_2NH_2$$

Alternatively;

$$CH_3CHO \xrightarrow[\text{alcohol}]{Na} CH_3CH_2OH \xrightarrow[Al_2O_3/400°C]{NH_3(g)} CH_3CH_2NH_2$$

Alternatively;

$$CH_3CHO \xrightarrow[\text{heat}]{K_2Cr_2O_7/H^+} CH_3COOH \xrightarrow{PCl_5} CH_3\overset{O}{\overset{\|}{C}}-Cl \xrightarrow{NH_3} CH_3\overset{O}{\overset{\|}{C}}-NH_2$$

Na, Ethanol

$$\longrightarrow CH_3CH_2NH_2$$

(e)

$$CH_2=CH_2 \xrightarrow[2.\ H_2O/warm]{1.conc.\ H_2SO_4} CH_3CH_2OH \xrightarrow[\text{heat}]{K_2Cr_2O_7/H^+} CH_3COOH$$

Alternatively;

$$CH_2=CH_2 \xrightarrow{Cl_2/CCl_4} CH_2\underset{Cl}{C}H_2\underset{Cl}{} \xrightarrow[\text{heat}]{KOH\ Ethanol} HC\equiv CH \xrightarrow[HgSO_4/60°C]{H_2O/dilute\ H_2SO_4} CH_3CHO \xrightarrow[\text{heat}]{K_2Cr_2O_7/H^+} CH_3COOH$$

Alternativetly;

$$CH_2=CH_2 \xrightarrow{HBr} CH_3CH_2Br \xrightarrow[\text{heat}]{NaOH(aq)} CH_3CH_2OH \xrightarrow[\text{heat}]{K_2Cr_2O_7/H^+} CH_3COOH$$

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Question. Eight.

(a) The spathic iron ore is **roasted in air** to form iron (III) oxide and carbon dioxide

$$4FeCO_3(s) + O_2(g) \xrightarrow{heat} 2Fe_2O_3(s) + 4CO_2(g)$$

The iron (III) oxide (haematite) is mixed with **coke** and **limestone** and introduced into the furnace from the top while hot air is fed into the furnace from the bottom

The coke burns in hot compressed air to form carbon dioxide

$$C(s) + O_2(g) \longrightarrow CO_2(g)$$

The carbon dioxide is then reduced by the coke to carbon monoxide

$$CO_2(g) + C(s) \longrightarrow 2CO(g)$$

The carbon monoxide then **reduces the haematite** to molten iron

$$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(l) + 3CO_2(g)$$

The lime stone decomposes into calcium oxide which reacts with the silica (silicon dioxide) to form slag.

$$CaCO_3 \longrightarrow CaO(s) + CO_2(g)$$

$$CaO(s) + SiO_2(s) \longrightarrow CaSiO_3(l)$$

(b) (i) **Heated** iron reacts with **steam** to form **tri iron tetraoxide** and **hydrogen**

$$3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$$

(ii) **Heated** iron reacts with **dry** chlorine to form **iron (III) Chloride**

$$2Fe(s) + 3Cl_2(g) \longrightarrow 2FeCl_3(s)$$

(iii) Iron reacts with dilute sulphuric acid to form **Iron (II) sulphate solution** and **hydrogen gas**

$$Fe(s) + H_2SO_4(aq) \longrightarrow FeSO_4(aq) + H_2(g)$$

(iv) Iron reacts with **hot concentrated** sulphuric acid to form **Iron (III) sulphate solution, water** and sulphur dioxide

$$2Fe(s) + 6H_2SO_4(aq) \longrightarrow Fe_2(SO_4)_3(aq) + 6H_2O(l) + 3SO_2(g)$$

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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1); 2005

1. The standard electrode potentials for some half-cells are shown below:-

   $Fe^{3+}(a) / Fe^{2+}(aq)$ +0.76V

   $I_2(aq) / I^-(aq)$ +0.54V

   (a) Write: (1 mark)

   (i) the cell convention for the combined cell (1½ marks)

   (ii) the equation for the overall reaction. (1½ marks)

   (b) Calculate the overall electrode potential for the cell. (1½ marks)

   (c) (i) State whether the reaction is feasible or not (½ mark)

   (ii) Give a reason for your answer in (c) (i)

2. The following reagents can be used to distinguish between classes of organic compounds. Name the class of organic compounds and in each case state what would be observed if the reagent is separately treated with a member of each class of the compounds you have named.

   (a) Reagent: copper (II) sulphate and sodium hydroxide solution. (3 marks)

   (b) Reagent: anhydrous zinc chloride and concentrated hydrochloric acid (4 marks)

3. (a) Compare the reactivity of the following metals with water.

   (i) beryllium (1 mark) (ii) magnesium (1 mark) (iii) barium (1 mark)

   (b) Write an equation for the reaction between:

   (i) the oxide of phosphorus and water (1½ marks)

   (ii) the oxide of silicon and sodium hydroxide (1½ marks)

4. (a) Define the term Osmotic pressure. (2 marks)

   (b) the osmotic pressure of a solution containing 42.0g of a substance Y is $5.62\times 10^5 Nm^{-2}$ at 20°C. Calculate the relative molecular mass of Y. (2½ marks)

5. Compare the following equations and write the IUPAC name of the main organic product in each case.

   (a) $CH_3CH_2CO_2H + PCl_5 \xrightarrow{heat}$ (1½ marks)

   (b) $HC \equiv CH \xrightarrow{Ag(NH_3)_2^+(aq)}$ (1½ marks)

6. Complete the following equation for the nuclear reactions:

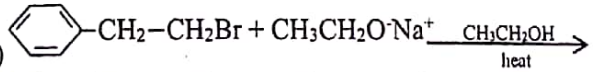
   (a) $^{239}_{94}Pu + {}^{1}_{0}n \longrightarrow {}^{91}_{39}Y + {}^{146}_{55}Cs +$ ..... (1 mark)

   (b) $^{239}_{92}U \longrightarrow {}^{239}_{93}NP +$ ..... (1 mark)

   (c) $^{226}_{88}Ra \longrightarrow {}^{4}_{2}He +$ ..... (1 mark)

7. Complete the following equations and outline a mechanism for the reaction in each case.

   (a) $CH_3CH{=}CH_2 \xrightarrow{H^+/H_2O}$ (4 marks)

   (b)  (2 marks)

8. A dark purple crystalline solid Z, dissolves in water to give a violet solution. When aqueous sodium hydroxide was added to the solution of Z drop-wise until in excess, a green precipitate was formed and it dissolved in excess sodium hydroxide to give a green solution.

   (a) Identify the cation in Z. (1 mark)

   (b) Write the formula of the species responsible for the formation of:

   (i) the violet solution (1 mark) (ii) the green solution (1 mark)

   (c) When hydrogen peroxide was added to the green solution, a yellow solution was formed, when on treatment with ethanoate solution formed a yellow solid.

   Write an equation for the reaction leading to the formation of:

   (i) the g reen solution (1½ marks) (ii) the yellow solution (1½ marks) (iii)the yellow solid. (1½ marks)

9. A solution containing 0.001mol dm^{-3} of methanoate acid is 1% ionized. Calculate:

   (i) the pH of methanoic acid solution (2 marks)

   (ii) the acid dissociation constant, K_a, for methanoic acid (2 marks)

10. (a) State:

    (i) Raoult's Law (2 marks)

    (ii) The conditions under which Raoult's Law is valid. (1 mark)

    (b) Briefly describe why some solutions do not obey Raoult's Law. (6 marks)

11. (a) A compound X, $C_8H_{10}Br$ burns with a sooty flame. Write all the possible formulae of X. (1½ marks)

    (b) When X was heated under reflux with aqueous sodium hydroxide solution, a compound Q $C_8H_{10}O$ was formed.

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(i) Identify X and Q.
(ii) Write an equation and indicate a mechanism for the reaction leading to the formation of Q from X. (1 mark)
(c) Q was covered in a one-step reaction to an alkene. Write equation and outline a mechanism for the reaction.
(d) The alkene in (c) was polymerized.
(i) Write the structural formulae of the polymer.
(ii) State the type of polymerization involved. (1 mark)

12. Write equation to show how each fluorine and chlorine react with. (½ mark)
(a) water
(i) Fluorine (1½ marks) (ii) Chlorine (1½ marks)
(b) Cold dilute sodium hydroxide solution:
(i) Fluorine (1½ marks) (ii) Chlorine (1½ marks)
(c) Hot concentrated sodium hydroxide solution:
(i) Fluorine (1½ marks) (ii) Chlorine (1½ marks)

13. The Kinetics data for the reaction between P and sodium hydroxide is shown in the table below:

Concentration of P ($moll^{-1}$)	0.105	0.088	0.074	0.051	0.037	0.026	0.016	0.010
Time (hours)	0.0	3.5	7.0	14.5	20.0	27.0	35.5	45.0

(a) Plot a graph of concentration of P against time. (3½ marks)
(b) Determine:
(i) the half-life of P. (2½ marks)
(ii) the order of the reaction (1 mark)
(iii) the rate constant for the reaction (2 marks)

14. (a) (i) State what is meant by the term thermo-setting plastic. (2 marks)
(ii) Give one example of a synthetic thermo-setting plastic. (2 marks)
(b) Nylon-6, 10 can be formed by reacting 1, 6-diamio hexane with decane dioyl dichloride, $ClOC\{CH_2\}_8COCl$.
(i) Write an equation for the formation of nylon 6, 10. (2 marks)
(ii) State the type of polymerization involved in the formation of nylon 6, 10. (1 mark)
(c) The osmotic pressure of a solution containing 2g dm^{-3} of nylon 6, 10 at 25°C was 0.155mmHg. Calculate the relative molecular mass of nylon 6, 10. [R=0.0821 atm l^{-1} °C mol^{-1}] (2½ marks)
(d) State one use of nylon 6, 10. (½ mark)

15. (a) (i) Write the electronic configuration of copper. (1 mark)
(ii) State two properties which show copper as a d-block element. (1 mark)
(b) Excess ammonia was shaken with equal volume of trichloromethane and a 0.05M aqueous solution of copper (II) sulphate and allowed to stand. Some ammonia reacted with copper (II) ions to form a ammonia in the trichloromethane and in the aqueous layers were 0.725 mol^{-1} and 0.021 mol^{-1} respectively. (The partition coefficient K_D of ammonia between water and trichloromethane is 25)
Calculate:
(i) the concentration of free ammonia in the aqueous layer. (2 marks)
(ii) the concentration of ammonia that formed the complex with copper. (2 marks)
(iii) the value of n in the complex. (3 marks)

16. A compound P contains 52.2% carbon, 13.0% hydrogen, the rest being oxygen.
(a) Determine the empirical formula of P. (2 marks)
(b) When vaporised, 0.1g of P occupied 78.8cm^3 at 157°C and a pressure of 740 mmHg.
(i) Calculate the formula mass of P. (2½ marks)
(ii) Determine the molecular formula of P. (1½ marks)
(iii) Write the structural formulae of all the possible isomers of P. (1 mark)
(c) P does not react with sodium metal. Identify P. (½ marks)
(d) Write an equation to show how P can be prepared from methanol. (1½ marks)

17. (a) State:
(i) how the solubility product of a sparingly soluble salt may be determined. (2 marks)
(ii) how the solubility of a sparingly soluble salt can be affected by adding a common ion. (1 mark)
(b) Calcium fluoride is a sparingly soluble salt in water. Write:
(i) an equation for the solubility of calcium fluoride. (1 mark)
(ii) an expression for the solubility product, K_{sp} of calcium fluoride. (1 mark)
(c) Calculate the solubility of calcium fluoride in a solution containing 0.35$moll^{-1}$ of fluoride ions at 25°C. ($K_{sp}=1.7\times10^{-10}$ at 25°C) (3 marks)
(d) State one application of solubility product. (1 mark)END

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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1); 2005

1. (a) (i) $Pt(s) \mid I^-(aq), I_2(aq) \parallel Fe^{3+}(aq), Fe^{2+}(aq) \mid Pt(s)$
   (ii) $2I^-(aq) + 2Fe^{3+}(aq) \longrightarrow I_2(aq) + 2Fe^{2+}(aq)$

   (b) $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$
   $= 0.76 - 0.54$
   $= +0.22 volts$

   (c) (i) The reaction is **feasible**
   (ii) The overall electrode potential (Emf) of the cell is **positive.**

2. (a) **Class** – carbonyl compounds
   Observations; - Aldehydes; Reddish –brown solid
   - Ketones; No observable change

   (b) **Class** – Alcohols
   Observations; - Primary alcohols –give no observable change at room temperature
   Secondary alcohols –give a cloudy solution (or two layers of solution) within 5 – 10minutes.
   -Tertiary alcohols –give a cloudy solution (or two layers of solution) immediately.

3. (a) (i) **Doesnot** react with **cold water** or **hot water** or **steam**
   (ii) Reacts **very slowly with cold** water and **slowly** with boiling water or **steam.**
   (iii) Reacts **vigorously** with **water**

   (b) (i) $P_4O_{10}(s) + 6H_2O(l) \longrightarrow 4H_3PO_4(aq)$
   or, $P_2O_5(s) + 3H_2O(l) \longrightarrow 2H_3PO_4(aq)$
   or, $P_4O_6(s) + 6H_2O(l) \longrightarrow 4H_3PO_3(aq)$
   or, $P_2O_3(s) + 3H_2O(l) \longrightarrow 2H_3PO_3(aq)$
   (ii) $SiO_2(s) + 2NaOH(aq) \longrightarrow Na_2SiO_3(aq) + H_2O(l)$
   or, $SiO_2(s) + 4NaOH(aq) \longrightarrow Na_4SiO_4(s) + 2H_2O(l)$
   or, $SiO_2(s) + 2\bar{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + H_2O(l)$

4. (a) **Pressure** which must be applied to a **solution to balance** the tendency of solvent molecules to flow from the solvent to the solution across a **semi permeable membrane**

   (b) Using; $\pi v = \frac{m}{mr} RT$
   Then; $Mr = \frac{mRT}{\pi v}$
   $Mr = \frac{42.0 \times 8.314 \times (20+273)}{5.62 \times 10^5 \times v}$

   Note – The question lacked the volume of the solution, hence the candidate could not proceed with the evaluation.

5. (a) $CH_3CH_2CO_2H + PCl_5 \xrightarrow{heat} CH_3CH_2COCl + HCl + POCl_3$
   Name of main organic product – **Propanoyl chloride**

   (b) $HC{\equiv}CH \xrightarrow{Ag(NH_3)_2^+(aq)} AgC{\equiv}CAg + 2\dot{N}H_4(aq)$
   Name of main organic product – **silver dicarbide**

6. (a) $^{239}_{44}Pu + {}^{1}_{0}n \longrightarrow {}^{91}_{39}Y + {}^{146}_{55}Cs + 3{}^{1}_{0}n$

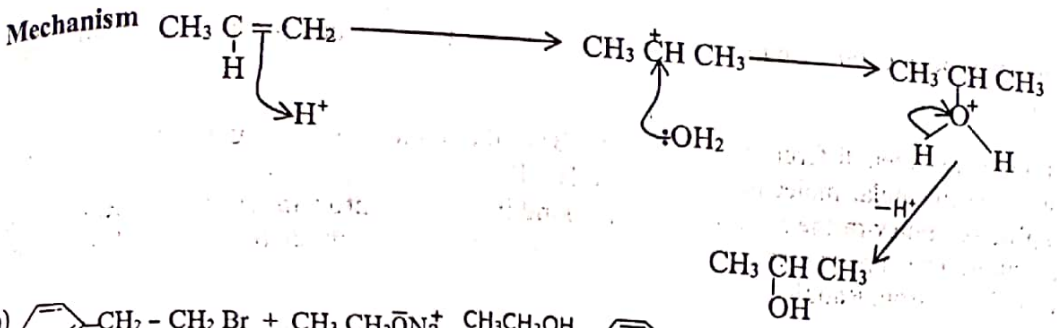
   (b) $^{239}_{92}U \longrightarrow {}^{239}_{93}Np + {}^{0}_{-1}e$

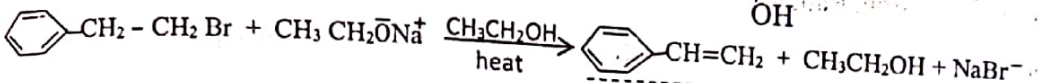
   (c) $^{226}_{88}Ra \longrightarrow {}^{4}_{2}He + {}^{222}_{86}Rn$

7. (a) $CH_3CH{=}CH_2 \xrightarrow{H^+/H_2O} CH_3\underset{\underset{OH}{|}}{C}HCH_3$

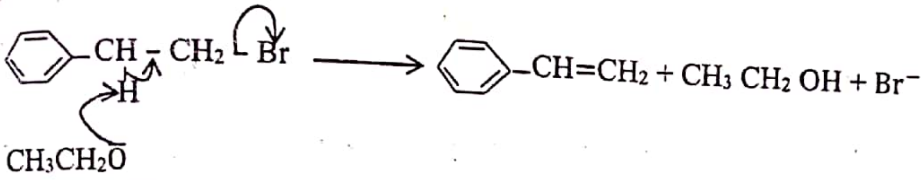
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Mechanism



(b) 

Mechanism;



8. (a) Chromium(III) ion or Cr^{3+}

(b) (i) $[Cr(H_2O)_6]^{3+}(aq)$

(ii) $[Cr(OH)_4]^{-}(aq)$ **or** $[Cr(OH)_6]^{3-}(aq)$

Note - (aq) must not be missing

(c) (i) $Cr(OH)_3(s) + \bar{O}H(aq) \longrightarrow Cr(OH)_4^{-}(aq)$

or, $Cr(OH)_3(s) + 3\bar{O}H(aq) \longrightarrow Cr(OH)_6^{3-}(aq)$

(ii) $2Cr^{3+}(aq) + 10\bar{O}H(aq) + H_2O_2(aq) \longrightarrow 2CrO_4^{2-}(aq) + 8H_2O(l)$

(iii) Not applicable

Note – c(iii) had an error, possibly it would be Lead(II) ethanoate solution not simply ethanoate solution as seen in the question

9. (i) Degree of Ionization; $\propto = \frac{1}{100} = 0.01$

Equation of Ionization of methanoic acid

$$HCOOH(aq) \longrightarrow H^{+}(aq) + HCO\bar{O}(aq)$$

Initially C O O

At equilibrium; $C - \propto C$ $\propto C$ $\propto C$

Hence; $[H^+] = \propto C$ (where c = concentration)

$= 0.01 \times 0.001 = 10^{-5}$

But; $pH = -\log_{10}[H^+]$

$= -\log_{10} 10^{-5} = 5$

(ii) $Ka = \frac{[H^+][HCO\bar{O}]}{[HCOOH]}$

$= \frac{\propto C \times \propto C}{C - \propto C}$

Hence; $Ka = \frac{\propto^2 C}{1 - \propto}$

$= \frac{(0.01)^2 \times 0.001}{1 - 0.01} = 1 \times 10^{-7} moldm^{-3}$

10. (a) (i) States that, the partial vapour pressure of a **volatile** component of an **ideal solution** equals to the product of the mole fraction of the component in solution and its pure vapour pressure at a **constant temperature**

or, States that, the relative lowering of the vapour pressure of a **volatile** solvent by a non volatile solute equals to the mole fraction of the non-volatile solute at a **given temperature**.

(ii) -Temperature must be constant

-Solute should be non-volatile

(b) If the attraction between different molecules (A - B) of the liquid mixture is **weaker** in strength than the attraction between similar molecules (A – A and B –B) The **escaping tendency** of the molecules of each kind in solution into vapour phase is **more than** from the pure liquids. The partial vapour pressure of A and B will be greater and hence the **vapour pressure**

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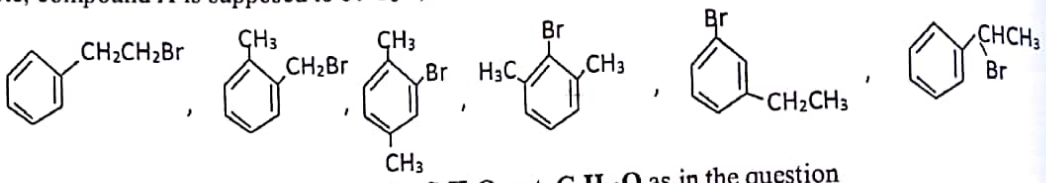
of solution will be greater than that predicted by Raoult's law and thus **positive deviation** from Raoult's law

Also;

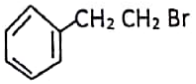
If the attraction between different molecules (A - B) of the liquid mixture is **greater** in strength than the attraction between similar molecules (A – A and B – B).

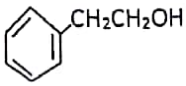
The **escaping tendency** of the molecules of each kind in solution into vapour phase is **less than** from the pure liquids. The vapour pressure of solution will be **lower** than predicted by Raoult's law and thus negative deviation from Raoult's law.

11. (a) Note; compound X is supposed to be C_8H_9Br not $C_8H_{10}Br$ as shown in the question.

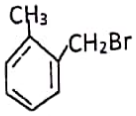


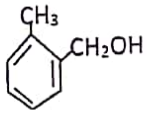
(b) (i) Note Compound Q is supposed to be C_8H_9O not $C_8H_{10}O$ as in the question

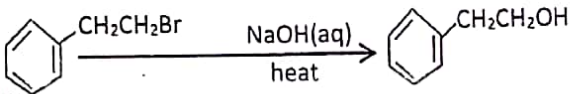
X is 

Q is 

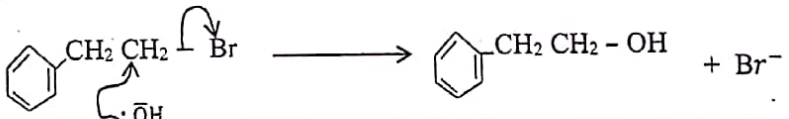
Alternatively

X is 

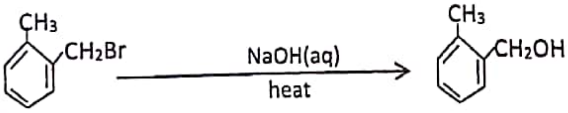
Q is 

(ii) 

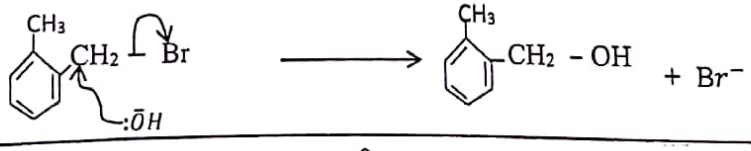
Mechanism;

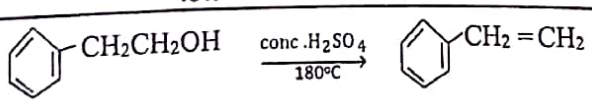


Alternatively

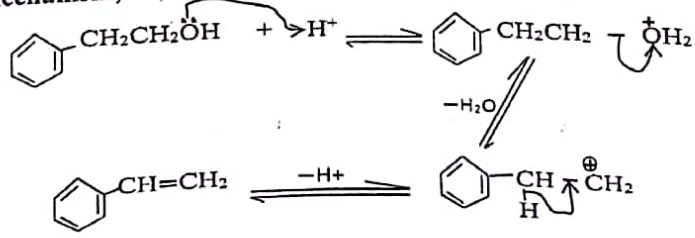


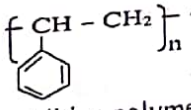
Mechanism;



(c) 

Mechanism;



(d) (i) 

(ii) Addition polymerization

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12. (a) (i) $2F_2(g) + 2H_2O(l) \longrightarrow 4HF(g) + O_2(g)$

(ii) $Cl_2(g) + H_2O(l) \longrightarrow HCl(aq) + HOCl(aq)$

(b) (i) $2NaOH(aq) + 2F_2(g) \longrightarrow 2NaF(aq) + OF_2(g) + H_2O(l)$

or $2\bar{O}H(aq) + 2F_2(g) \longrightarrow 2F^-(aq) + OF_2(g) + H_2O(l)$

(ii) $Cl_2(g) + 2NaOH(aq) \longrightarrow NaCl(aq) + NaOCl(aq) + H_2O(l)$

or $Cl_2(g) + 2\bar{O}H(aq) \longrightarrow Cl^-(aq) + \bar{O}Cl(aq) + H_2O(l)$

(c) (i) $2F_2(g) + 4NaOH(aq) \longrightarrow 4NaF(aq) + 2H_2O(l) + O_2(g)$

or $2F_2(g) + 4\bar{O}H(aq) \longrightarrow 4F^-(aq) + 2H_2O(l) + O_2(g)$

(ii) $3Cl_2(g) + 6NaOH(aq) \longrightarrow 5NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$

or $3Cl_2(g) + 6\bar{O}H(aq) \longrightarrow 5Cl^-(aq) + ClO_3^-(aq) + 3H_2O(l)$

13. (a) See graph next page

(b) (i) From the graph, 1st half life $= 14.1\ hours$

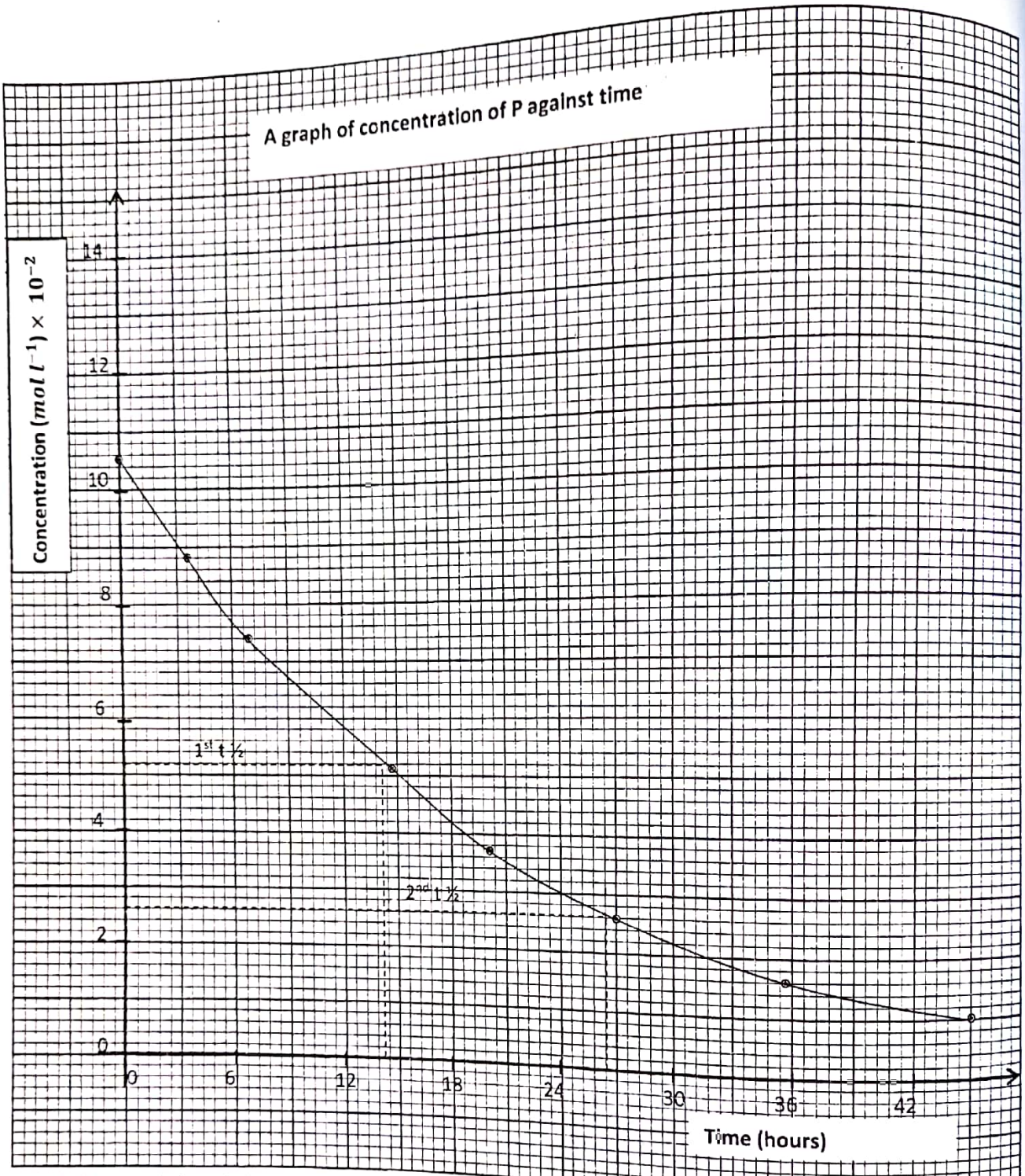
2nd half life $= 12.3\ hours$

Hence; Half life of $p = \frac{14.1+12.3}{2} = 13.2\ hours$

(ii) First order; since half-life is **almost constant**

(iii) Rate constant; $K = \frac{In2}{t½} = \frac{0.693}{13.2} = \mathbf{0.0525\ hour^{-1}}$

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14. (a) (i) Cross-linked chain polymers which cannot be melted on heating and therefore cannot be remoulded
They decompose at high temperatures

(ii) Bakelite, urea (formalaldehyde)

(b) (i)

$$n\text{Cl} - \overset{\overset{O}{\|}}{C} - (CH_2)_8 \overset{\overset{O}{\|}}{C} - \text{Cl} + nH_2N(CH_2)_6NH_2 \longrightarrow -\left(\overset{\overset{O}{\|}}{C}(CH_2)_8\overset{\overset{O}{\|}}{C} - NH(CH_2)_6NH\right)_n + nHCl$$

(ii) Condensation polymerization

(c) $\pi v = \frac{mRT}{mr}$

$\frac{0.155 \times 1}{760} = \frac{2}{mr} \times 0.0821 \times 298$

$Mr = \frac{2 \times 0.0821 \times 298 \times 760}{0.155} = 2.3986 \times 10^5$

(d) Manufacture of surgical gloves, ropes
Manufacture of fishing nets, linings of curtains, carpets,

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15. (a) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$
or $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$

(ii) -Copper forms coloured compounds
-Copper exhibits variable oxidation states ie +1 and +2
-Copper forms complexes

(b) (i) $K_D = \frac{[freeNH_3]in\ aqueous\ layer}{[NH_3]\ in\ organic\ layer}$

Hence; $[NH_3]$free in aqueous layer $= K_D \times [NH_3]$ in organic layer
$= 25 \times 0.725 = \mathbf{18.125moll^-}$

(ii) $\begin{bmatrix} complexedNH_3 \\ in\ aqueous\ layer \end{bmatrix} = \begin{bmatrix} total\ NH_3 \\ in\ aqueous\ layer \end{bmatrix} - \begin{bmatrix} freeNH_3 \\ in\ aqueous\ layer \end{bmatrix}$
$= 0.021 - 18.125$

Note; The question had an error because the concentration of the total ammonia in aqueous layer is less than the concentration of the free ammonia in the aqueous layer. Therefore candidates would not proceed with the calculation and thus would not even get the value of n.

16. (a) Percentage of oxygen in $P = 100 - (52.2 + 13.0) = 34.8\%$

Composition of P;	C	H	O
Moles;	$\frac{52.2}{12}$	$\frac{13.0}{1}$	$\frac{34.8}{16}$
	4.35	13.0	2.175
Mole ratio;	$\frac{4.35}{2.175}$	$\frac{13.0}{2.175}$	$\frac{2.175}{2.175}$
	2 :	6 :	1

Emperical formula of P is C_2H_6O

(b) Using; $Pv = \frac{m\ RT}{mr}$

$mr = \frac{mRT}{Pv}$

$= \frac{0.1 \times 8.31 \times (157+273)}{\left(\frac{740}{760} \times 101325\right) \times (78.8 \times 10^{-6})} = 45.98g$

Alternatively;

Using; $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$V_2 = \frac{P_1V_1T_2}{P_2T_1}$

$= \frac{740 \times 78.8 \times 273}{760 \times (157+273)}$

$= \mathbf{48.7123cm^3}$

Hence; $48.7123cm^3 of\ P\ weigh\ 0.1g$

$\therefore 22400cm^3\ of\ P\ weigh\ \frac{22400 \times 0.1}{48.7123}$

$formula\ mass\ of\ P = \mathbf{45.98g}$

(ii) $(C_2H_6O)_n = 45.98$

$(2 \times 12)n + (6 \times 1)n + (1 \times 16)n = 45.98$

$46n = 45.98$

$\therefore n = \frac{45.98}{46} \simeq 1$

Therefore molecular formula of P is C_2H_6O.

(iii) CH_3CH_2OH and CH_3OCH_3

(c) CH_3OCH_3

(d) $2CH_3OH \xrightarrow[140°C]{Conc.\ H_2SO_4} CH_3\ OCH_3$

17. (a) (i) -By titration or volumetric analysis
-By conductivity measurements
-Ion exchange method.

(ii) The solubility of a sparingly soluble salt **reduces.**

(b) (i) $CaF_2(s) \rightleftharpoons Ca^{2+}(aq) + 2F^-(aq)$

or $CaF_2(s) + (aq) \rightleftharpoons Ca^{2+}(aq) + 2F^-(aq)$

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(ii) $Ksp[Ca^{2+}][F^-]^2$

(c) Let the solubility of CaF_2 in a solution of fluoride ions $= xmoll^{-1}$

Hence; $[Ca^{2+}] = xmoll^{-1}$

$[F^-] = 2x + 0.35 \simeq 0.35moll^{-3}$ (since x is negligible)

$$Ksp = [Ca^{2+}][F^-]^2$$

$$1.7 \times 10^{-10} = (x) \times (0.35)^2$$

$$x = \frac{1.7 \times 10^{-10}}{(0.35)^2}$$

$$= 1.388 \times 10^{-9} moll^{-1}$$

(d)-Purification of common salt (sodium chloride)

-Precipitation of salts in qualitative analysis

-Purification or salting out of soap.

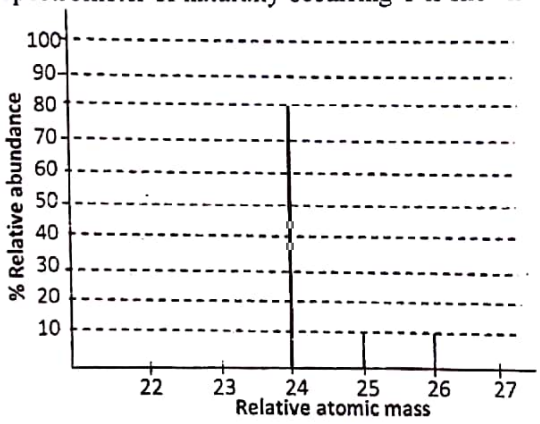
QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2005

1. (a) The first, second, third and fourth ionization energies of an element Y are 736, 1451, 7740 and 10,500 respectively.

(i) State the group in the Periodic Table towhich Y belongs and explain your answer.(4 marks)

(ii) Explain why the second ionization is greater than the first ionization energy. (3 ½ marks)

(b) The mass spectrometer of naturally occurring Y is shown in the figure below.



(i) Briefly describe how the mass spectrum was btained (8 marks)

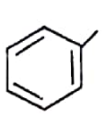
(ii) State why the mass spectrum of Y shows three peaks. (2 ½ marks)

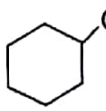
(iii) Calculate the relative atomic mass of Y. (2 marks)

2. Complete the following equations and in each case outline a mechanism for the reaction.

(a) $CH_3 CH(CH_3) CH_2 CH_3 \xrightarrow[\text{heat}]{ET\bar{O}/EtOH}$ (2 marks)

(d)  $+ CH_3 CH = CH_2 \xrightarrow{H^+}$ (4 ½ marks)

(c)  $\xrightarrow{Cl_2/UV}$ (3 ½ marks)

(d)  $\xrightarrow[\text{heat}]{OH^-(aq)}$ (2 marks)

(e) $(CH_3)_2C = O +$  $\xrightarrow{H^+}$ (5 marks)

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(f) $CH_3\overset{OH}{\overset{|}{C}}HCH_3 \xrightarrow[\text{heat}]{conc.H_2SO_4}$ (3 marks)

3. Carbon, silicon, tin and lead are elements in Group IV of the Periodic Table.
   (a) State;
   (i) the common oxidation state shown by elements in Group IV of the Periodic Table
   (ii) how the stability of the oxidation states of Group IV elements vary down the group. (*Illustrate your answer with the chlorides of carbon and lead*) (3 marks)
   (b) Give a reason for your answer in (a) (ii) (1 mark)
   (c) Discuss the reactions of the chlorides of each element with water. (6 marks)
   (d) Write equations for the reaction between;
   (i) the oxide of each element and sodium hydroxide. (6 marks)
   (ii) lead(IV) oxide and concentrated hydrochloric (1 ½ marks)
   (iii) lead(IV) oxide and warm concentrated hydrochloric acid. (1 ½ marks)

4. (a) Explain what is meant by the fooling terms.
   (i) molar conductivity. (2 marks)
   (ii) electrolytic conductivity (2 marks)
   (b) State the relationship between the two conductivities in (a) (1 mark)
   (c) Draw sketch-graphs to show how molar conductivitis of the following vary with concentration;
   (i) a strong electrolyte (1 ½ marks)
   (ii) a weak electrolyte (½ marks)
   (d) Explain the shapes of the graphs in (c) (4 marks)
   (e) The table below shows the variation of conductivity with volume of ammonia when two inert electrodes connected to a conductivity metre were immersed in $50cm^3$ of 0.025M Zinc nitrate solution and 2 cm^3 portions of 0.5M ammonia, added at intervals.

Volume of ammonia solutions (cm^3)	0	2	4	6	8	10	12	14
Conductivity of resultant solution ($\Omega^{-1}cm^{-1}$)	1.2	1.16	1.12	1.08	1.05	1.045	1.06	1.10

   (i) Draw a graph of conductivity of solution versus volume of ammonia. (3 marks)
   (ii) Determine the volume of ammonia solution that gave the lowest conductivity (1 marks)
   (iii) Determine the formula of the species present in the solution in (e)(i) (4 marks)

5. Be, Mg, Ca, Sr and Ba are elements in group II of the Periodic Table.
   (a) Describe and explain the trend in the reactivity of elements with cold water down the group(8 mks)
   (b) Compare the solubility and basicity of the hydroxides of group II elements with hydroxides of group I elements. (3 ½ marks)
   (c) (i) Explain why beryllium and aluminium show a diagonal relationship. (2 marks)
   (ii) Write equations to show how beryllium and aluminium each react with concentrated sodium hydroxide solution. (3 marks)
   (d) A chloride of beryllium Z, contains 11.25% beryllium and 88.75% of chlorine.
   (i) Calculate the empirical formula of Z. (1 ½ marks)
   (ii) Determine the molecular formula of Z. (The vapour density of Z = 80) (1 mark)
   (iii) Write the structure formula of Z. (1 mark)

6. (a) (i) Describe how the molecular mass of a substance can be determined using freezing point depression method. (Diagram not required) (7 marks)
   (ii) Explain why the method you have described in (a)(i) is not suitable for determining the molecular mass of a polymer. (2 marks)
   (b) Calculate the freezing point of a solution containing 4.2g of ethane – 1, 2 – diol (molecular mass = 62) in 30g of water. (Kf of water = 1.86°C $mol^{-1}Kg^{-1}$) (4 marks)
   (c) The osmotic pressure of various concntrations of solute X in methyl benzene at 25°C are given in the table below.

Concentration / g dm^{-3}	1.0	2.0	3.0	4.0	5.0	6.0
Osmotic pressure / Nm^{-2}	23	37	53	75	92	109

   (i) Plot a graph of osmotic pressure against concentration. (3 marks)
   (ii) Use the graph you have drawn to determine the molecular mass of X. ($R = 8.314\ JK^{-1}mol^{-1}$) (4 marks)

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7. Briefly explain each of the following observations:
   (a) Sodium chloride melts at 800°C whereas Aluminium chloride sublimes at 180°C (3 marks)
   (b) Graphite and copper are both conductors of electricity. (4 marks)
   (c) Iodine is much more soluble in potassium iodide than in water. (3 marks)
   (d) A solution of sodium thiosulphate becomes cloudy with the formation of a yellow precipitate when left standing in air. (2 marks)
   (e) Phenylamine is a weaker base than ethylamine. (4 marks)
   (f) Phenol is a stronger acid than cyclohexanol. (4 marks)

8. (a) (i) Write the formula and the name of one ore of copper. (1 mark)
   (ii) Describe how pure copper can be extracted from the ore you have named in (a)(i). (Write equations for all reactions that take place) (8 marks)
   (b) State the conditions under which copper reacts with the following acids and in each case write an equation for the reaction:
   (i) sulphuric acid. (3 marks) (ii) nitric acid (3 marks)
   (c) State what would be observed and write an equation for the reaction which will take place when the following reagents are added dropwise to a solution of copper(II) sulphate until in excess:
   (i) concentrated hydrochloric acid (3 marks) (ii) sodium hydroxide solution. (2 marks)

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2005

Question. One.

(a) (i) Group II

Explanation;

There is a **very large** difference between the 2nd and 3rd ionization energies compared to the difference between the 1st and 2nd as well as the difference between the 3rd and 4th ionization energies. This implies that the third electron is removed from an inner energy level that is full of electrons and hence **stable,** hence indicating that the element has only **two electrons** in the outer energy level and therefore belongs to group (II) of the periodic Table.

(ii) When the first electron is removed, the **nuclear charge remains constant** but the **number of electrons decreases** and the neutral atom forms a **positively charged ion**.

The **effective nuclear charge for the fewer remaining electrons therefore increases** and hence the outer energy level electrons in the ion experience **stronger nuclear attraction** resulting into higher second ionization energy than the first ionization energy.

(b) (i) See solution. 1(b) 2007 Paper 2

(ii) Y has **three Isotopes** with Isotopic masses 24, 25 and 26

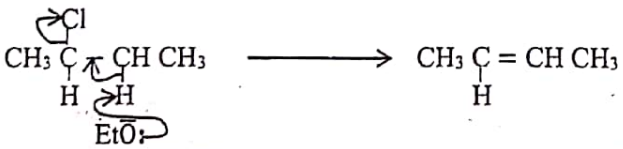
(iii) Relative atomic mass of $Y = \frac{\Sigma(Isotopic\ mass \times relative\ abundance)}{\Sigma(relative\ abundance)}$

$= \frac{(24\times80)+(25\times10)+(26\times10)}{100} = 24.3$

Question. Two.

(a) $CH_3\underset{Cl}{C}HCH_2CH_3 \xrightarrow[heat]{Et\bar{O}/EtOH} CH_3\underset{H}{C}=CHCH_3$

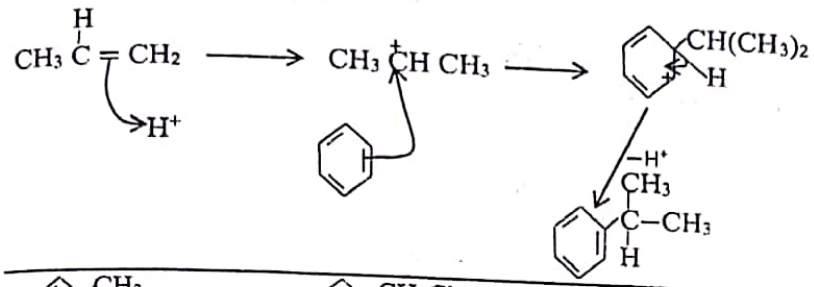
Mechanism;

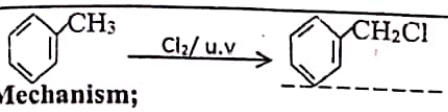


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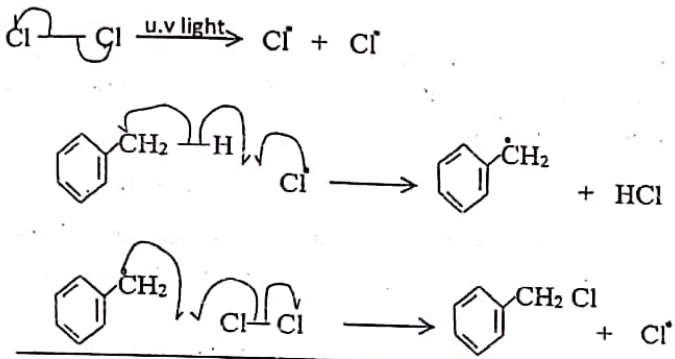
(b) 

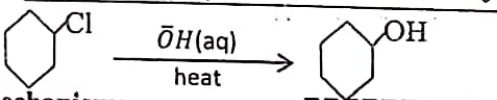
Mechanism;



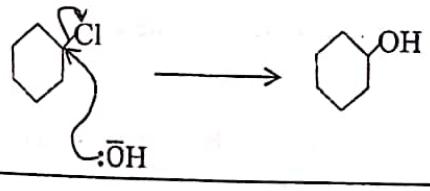
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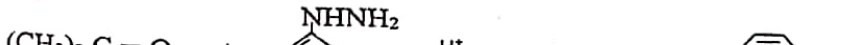
Mechanism;



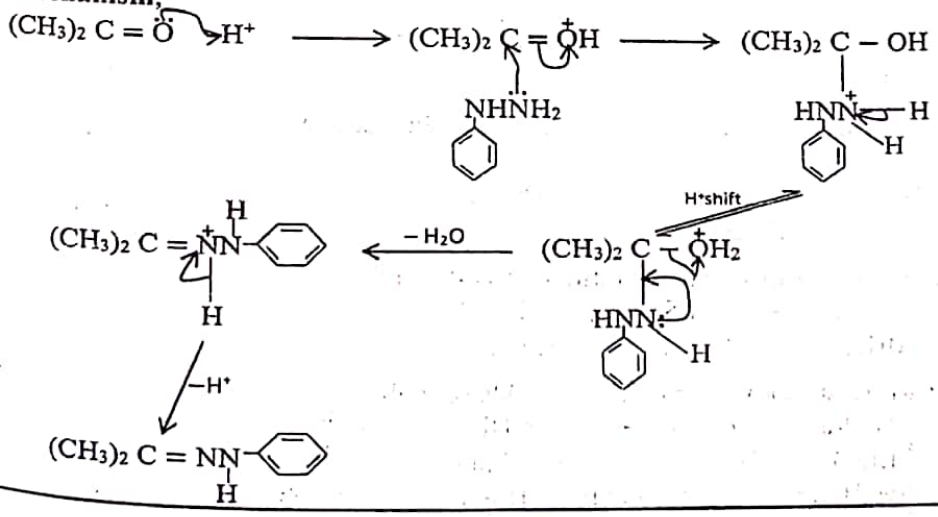
(d) 

Mechanism;



(e) 

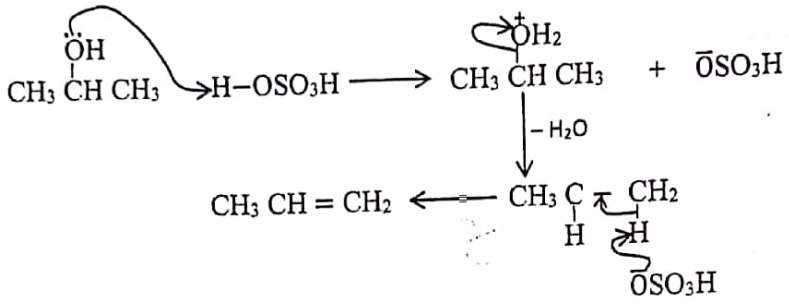
Mechanism;



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(f) $CH_3CH(OH)CH_3 \xrightarrow[\text{heat}]{\text{Conc.}H_2SO_4} CH_3CH=CH_2$

Mechanism;



Question. Three.

(a) (i) +2 and +4

(ii) The stability of the +2 oxidation state **increases down** the group while the stability of the +4 oxidation state **decreases down the group**. Eg; lead (IV) chloride is very **unstable** and readily decomposes to form lead (II) chloride and chlorine;

$PbCl_4(l) \longrightarrow PbCl_2(s) + Cl_2(g)$

But; carbon tetrachloride is stable even at high temperatures and hence **cannot be decomposed**

(b) Down the group from one element to the next, there is **increase in atomic radius** which **increases the tendency** for the two **outer subshell electrons not to participate in bonding** (inert pair effect)

(c) Carbon tetra chloride **does not** react with water

Silicon (IV) chloride **hydrolyses** in water to form **silicic acid** or **silicon hydroxide** or hydrated **silicon (IV) oxide** and **hydrogen chloride gas**

$SiCl_4(l) + 3H_2O(l) \longrightarrow H_2SiO_3(aq) + 4HCl(g)$

or $SiCl_4(l) + 4H_2O(l) \longrightarrow Si(OH)_4(s) + 4HCl(g)$

or $SiCl_4(l) + 4H_2O(l) \longrightarrow SiO_2 \cdot 2H_2O(s) + 4HCl(g)$

Tin (IV) chloride hydrolyses in water to give **tin (IV) oxide** and **hydrogen chloride gas**

$SnCl_4(l) + 4H_2O(l) \longrightarrow SnO_2 \cdot 2H_2O(s) + 4HCl(g)$

or $SnCl_4(l) + 2H_2O(l) \longrightarrow SnO_2(s) + 4HCl(g)$

Tin (II) chloride undergoes **partial hydrolysis** to form a **basic chloride** and **hydrogen chloride gas**

$SnCl_2(s) + H_2O(l) \rightleftharpoons Sn(OH)Cl(s) + HCl(g)$

Tin (II) chloride hydrolyses in **hot excess water** to form tin (II) hydroxide;

$SnCl_2(s) + 2H_2O(l) \rightleftharpoons Sn(OH)_2(s) + 2HCl(g)$

Lead (IV) chloride hydrolyses in water to form **lead (IV) oxide** and **hydrogen chloride gas.**

$PbCl_4(l) + 2H_2O(l) \longrightarrow PbO_2(s) + 4HCl(g)$

or $PbCl_4(l) + 4H_2O(l) \longrightarrow PbO_2 \cdot 2H_2O(s) + 4HCl(g)$

Lead (II) chloride is not hydrolysed in water

(d) (i) **Reactions of the oxides of carbon with sodium hydroxide solution**

$CO(g) + NaOH(aq) \longrightarrow HCOONa(aq)$

$CO_2(g) + 2NaOH(aq) \longrightarrow Na_2CO_3(aq) + H_2O(l)$; **or**

$CO_2(g) + 2\bar{O}H(aq) \longrightarrow CO_3^{2-}(aq) + H_2O(l)$

Reactions of the oxides of silicon with sodium hydroxide solution

$SiO_2(s) + 2NaOH(aq) \longrightarrow Na_2SiO_3(aq) + H_2O(l)$

or $SiO_2(s) + 2\bar{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + H_2O(l)$

Reactions of the oxides of tin with sodium hydroxide solution

$SnO(s) + 2NaOH(aq) + H_2O(l) \longrightarrow Na_2Sn(OH)_4(aq)$; or

$SnO(s) + 2\bar{O}H(aq) + H_2O(l) \longrightarrow Sn(OH)_4^{2-}(aq)$; or

$SnO(s) + 2NaOH(aq) \longrightarrow Na_2SnO_2(aq) + H_2O(l)$; or

$SnO(s) + 2\bar{O}H(aq) \longrightarrow SnO_2^{2-}(aq) + H_2O(l)$

$SnO_2(s) + 2NaOH(aq) + 2H_2O(l) \longrightarrow Na_2Sn(OH)_6(aq)$ or;

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$SnO_2(s) + 2\bar{O}H(aq) + 2H_2O(l) \longrightarrow Sn(OH)_6^{2-}(aq)$; or
$SnO_2(s) + 2NaOH(aq) \longrightarrow Na_2SnO_3(aq) + H_2O(l)$; or
$SnO_2(s) + 2\bar{O}H(aq) \longrightarrow SnO_3^{2-}(aq) + H_2O(l)$

Reactions of the oxides of lead with sodium hydroxide solution

$PbO(s) + 2NaOH(aq) + H_2O(l) \longrightarrow Na_2Pb(OH)_4(aq)$; or
$PbO(s) + 2\bar{O}H(aq) + H_2O(l) \longrightarrow Pb(OH)_4^{2-}(aq)$; or
$PbO(s) + 2NaOH(aq) \longrightarrow Na_2PbO_2(aq) + H_2O(l)$; or
$PbO(s) + 2\bar{O}H(aq) \longrightarrow PbO_2^{2-}(aq) + H_2O(l)$

$PbO_2(s) + 2NaOH(aq) + 2H_2O(l) \longrightarrow Na_2Pb(OH)_6(aq)$; or
$PbO_2(s) + 2\bar{O}H(aq) + 2H_2O(l) \longrightarrow Pb(OH)_6^{2-}(aq)$; or
$PbO_2(s) + 4NaOH(aq) + H_2O(l) \longrightarrow Na_4Pb(OH)_6(aq)$; or
$PbO_2(s) + 4\bar{O}H(aq) + H_2O(l) \longrightarrow Pb(OH)_6^{4-}(aq)$; or
$PbO_2(s) + 2NaOH(aq) \longrightarrow Na_2PbO_3(aq) + H_2O(l)$; or
$PbO_2(s) + 2\bar{O}H(aq) \longrightarrow PbO_3^{2-}(aq) + H_2O(l)$

(ii) $PbO_2(s) + 4HCl(aq) \longrightarrow PbCl_4(aq) + 2H_2O(l)$
or, $PbO_2(s) + 6HCl(l) \longrightarrow H_2PbCl_6(aq) + 2H_2O(l)$

(iii) $PbO_2(s) + 4HCl(aq) \longrightarrow PbCl_2(aq) + 2H_2O(l) + Cl_2(g)$
or $PbO_2(s) + 6HCl(aq) \longrightarrow PbCl_4^{2-}(aq) + 2H^+(aq) + Cl_2(g) + 2H_2O(l)$

Question. Four.

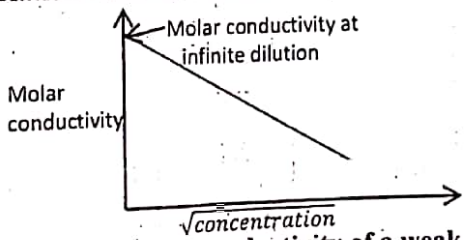
(a) (i) The conductance of an aqueous solution containing **one mole** of electrolyte placed between two electrodes each of **unit cross-sectional area** and **unit distance apart.**

Molar conductivity; $\Lambda = \frac{Electrolytic\ conductivity;k}{Concentration;c}$

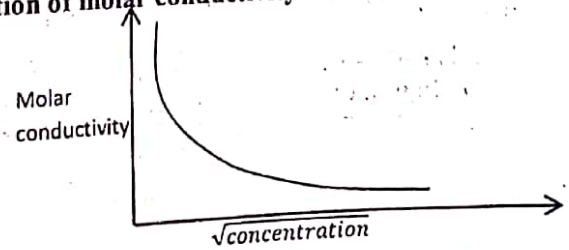
(ii) The conductance of an **aqueous** solution of an electrolyte contained between two electrodes of unit cross-sectional area and unit distance apart.
or, The reciprocal of resistivity
ie Electrolytic conductivity; $k = \frac{1}{\zeta}$; where; ζ = resistivity

(b) Molar conductivity equals to electrolytic conductivity devided by the concentration of the electrolyte,
ie $\Lambda = \frac{k}{c}$ where; Λ= molar conductivity; k = Electrolytic conductivity and
c = concentration of electrolyte

(c) (i) **A sketch graph showing variation of molar conductivity of a strong electrolyte with concentration.**



(ii) **A sketch graph showing variation of molar conductivity of a weak electrolyte with concentration**

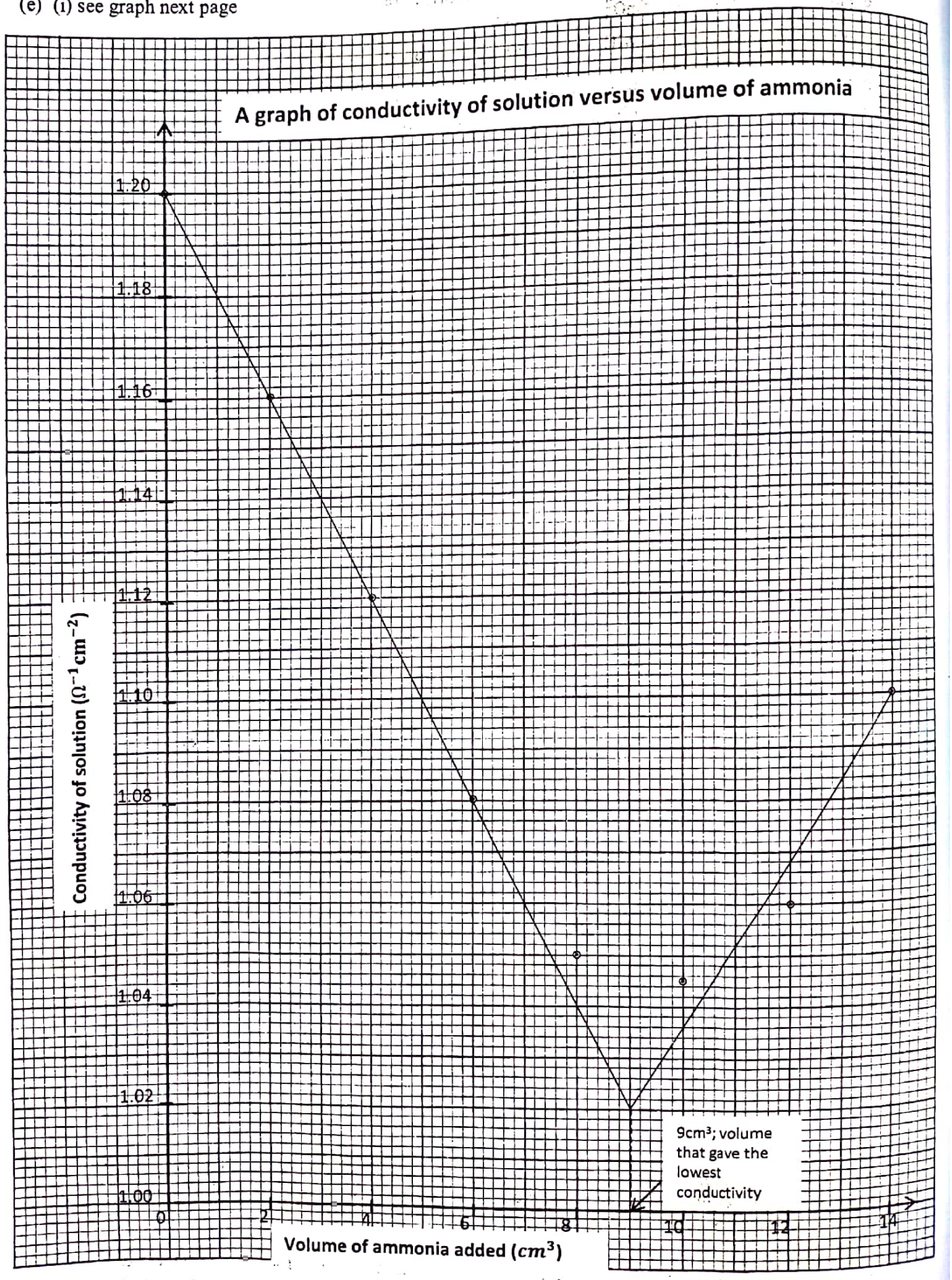


(d) **Strong electrolyte**
Increase in the concentration of the strong electrolyte, **increases the number of conducting ions** per unit volume.The **ions get close together** resulting into **increased ionic interference** (dragging effect) which **reduces the mobility of the ions** hence a **decrease in the molar conductivity.**

Weak electrolyte
Increase in concentration of a weak electrolyte, **decreases its degree of ionization** which results into **decrease in the number of conducting ions** per unit volume hence **decrease in molar conductivity**

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(e) (i) see graph next page



(ii) $9cm^3$ (see graph)

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(iii) Number of moles of zinc ions in $50cm^3 = \frac{50}{1000} \times 0.025$

$= 1.25 \times 10^{-3}$ moles

Moles of NH_3 that reacted with $Zn^{2+} = \frac{9}{1000} \times 0.5 = 0.0045$ moles

Equation of reaction;

$Zn^{2+}(aq) + nNH_3(aq) \longrightarrow Zn(NH_3)_n^{2+}(aq)$

0.0045 moles of NH_3 reacted with 1.25×10^{-3} moles of Zn^{2+}

n moles of NH_3 reacted with 1mole of Zn^{2+}

Hence; $n = \frac{0.0045}{1.25 \times 10^{-3}} = 4$

Thus; the formula of the species is; $Zn(NH_3)_4^{2+}$

Question. Five.

(a) The reactivity of the group (II) elements with cold water **increases down the group** from Beryllium to Barium.

This is due to the **increase in the solubility of the metal hydroxide** formed that is brought about by the **increasing cationic radius** that results into **decrease in both the lattice energy** and **hydration energy** of the metal hydroxide. However, the **lattice energy decreases more rapidly** than the hydration energy hence the increase in the solubility

Reactivity increases down the group also because of **increase in atomic radius** that leads to **increase in the reducing property** of the elements from Beryllium to Barium

Beryllium **does not** react with cold water. The rest of the elements react with cold water to form a **metal hydroxide** and **hydrogen gas**

$M(s) + 2H_2O(l) \longrightarrow M(OH)_2(aq) + H_2(g)$ (where M = Mg, Ca, Sr and Ba)

(b) The hydroxides of group (I) elements are **more soluble** and **more basic** than those of group (II) elements. In both group (I) and group (II), down the group, the elements form hydroxides whose **solubility** and **basicity increases** down group of the elements.

(c) (i) Both beryllium and aluminium form cations with the **same** charge density

Both beryllium and aluminium have **similar electronegativity** values

Both beryllium and aluminium have the **same electrode potential values**

(ii) $Be(s) + 2NaOH(aq) + H_2O(l) \longrightarrow Na_2Be(OH)_4(aq) + H_2(g)$

or, $Be(s) + 2\bar{O}H(aq) + H_2O(l) \longrightarrow Be(OH)_4^{2-}(aq) + H_2(g)$

or, $Be(s) + 2NaOH(aq) \longrightarrow Na_2BeO_2(aq) + H_2(g)$

or, $Be(s) + 2\bar{O}H(aq) \longrightarrow BeO_2^{2-}(aq) + H_2(g)$

$2Al(s) + 2NaOH(aq) + 6H_2O(l) \longrightarrow 2NaAl(OH)_4(aq) + 3H_2(g)$

or, $2Al(s) + 2\bar{O}H(aq) + 6H_2O(l) \longrightarrow 2Al(OH)_4^-(aq) + 3H_2(g)$

or, $2Al(s) + 2NaOH(aq) + 2H_2O(l) \longrightarrow 2NaAlO_2(aq) + 3H_2(g)$

or, $2Al(s) + 2\bar{O}H(aq) + 2H_2O(l) \longrightarrow 2AlO_2^-(aq) + 3H_2(g)$

(d) (i) Composition of Z;

	Be	Cl
Number of moles;	$\frac{11.25}{9.0}$	$\frac{88.75}{35.5}$
	1.25	2.5
Mole ratio;	$\frac{1.25}{1.25}$	$\frac{2.5}{1.25}$
	1 :	2

Empirical formula of Z is $BeCl_2$

(ii) Molecular mass of $z = 2 \times$ vapour density

$= 2 \times 80 = 160g$

Hence; $(BeCl_2)n = 160$

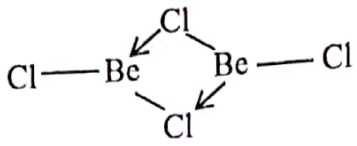
$(9 \times 1)n + (35.5 \times 2)n = 160$

$n = \frac{160}{80} = 2$

Therefore; molecular formula of z *is* Be_2Cl_4

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(iii)



Question. Six.

(a) -A known amount of the pure solvent (**ag**) is placed in a test tube which is fitted with a thermometer and a stirrer.
-The test tube is then inserted in a boiling tube air jacket.
-The boiling tube air jacket is placed in a freezing mixture
-The solvent in the test tube is continueosly stirred until it starts to solidify
-The steady temperature at which the pure solvent begins to solidify is read from the thermometer and recorded as T_1°C and this is the freezing point of the pure solvent
-The test tube containing solvent is removed from the boiling tube air jacket and warmed to melt the solvent
-A known mass (**mg**) of a substance whose molecular mass is being determined is then added to the solvent and stirred to make a solution.
-The freezing temperature of solution T_2°C is recorded

Treatment of results

Freezing point depression $= (T_1 - T_2)$°C

Let; Freezing point depression constant for solvent $= k_f$

ag of solvent dissolved mg of substance

Thus; 1000 g of solvent dissolved $\left(\frac{1000\times m}{a}\right)$g of substance

$(T_1 - T_2)$°C is depression caused by $\left(\frac{1000\times m}{a}\right)$g of substance

Therefore; (k_f)°C is depression caused by $\left[\frac{k_f}{(T_1-T_2)} \times \frac{1000\times m}{a}\right]$g

Hence, molecular mass of substance $= \left[\frac{k_f}{(T_1-T_2)} \times \frac{1000\times m}{a}\right]$g

(ii) Polymers are very **large molecules** with **higher molecular masses** and therefore in dilute solutions, **very few particles** of the polymer would be present and these would cause **very small depressions** in freezing point which are **difficult to measure** using the ordinary laboratory thermometers.

(b) 30g of water contained 4.2g of ethane-1-2-diol

1000g of water contained $\left(\frac{1000\times 4.2}{30}\right)$g of ethane -1, 2-diol

$= 140g$ of ethane -1, 2-diol

62g of ethane -1, 2-diol caused a depression of 1.86°C

∴ 140g of ethane -1, 2-diol caused a depression of $\left(\frac{140\times 1.86}{62}\right)$ °C

Freezing point of solution = freezing point of water – freezing point depression caused

$= (0 - 4.2)$°C $= -4.2$°C

(c) (i) See graph

(ii) **Note;** From the laws of osmotic pressure;

Osmotic pressure; π is directly proportional to the concentration of solution(c)

ie, $\pi \propto c$

But concentration of solution is inversely proportional to the volume.

ie, $c \propto \frac{1}{v}$

Hence, $\pi \propto \frac{1}{v}$ .....(1)

Also; osmotic pressure is directly proportional to Temperature; T

ie; $\pi \propto T$ ..... (ii)

Combining (i) and (ii); πv = (constant)T; hence for n moles of solute in a volume (v)

$\pi v = nRT$

But; $n = \frac{m}{mr}$ (*where m = mass of solute and mr is its molecular mass*)

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Hence; $\pi = \left(\frac{m}{v}\right)\frac{RT}{mr}\left(where\ \left(\frac{m}{v}\right) = concentration\right)$

Hence; a graph of osmotic pressure, π against concentration, gives a straight line with a positive gradient and passes through the orgin;

The slope (gradient) of the line equals to $\frac{RT}{mr}$

From the graph

$$Slope = \frac{99-20}{5.5-1.1} = 17.95 Nm^{-2}/gdm^{-3}$$

$$Slope = \frac{RT}{mr}$$

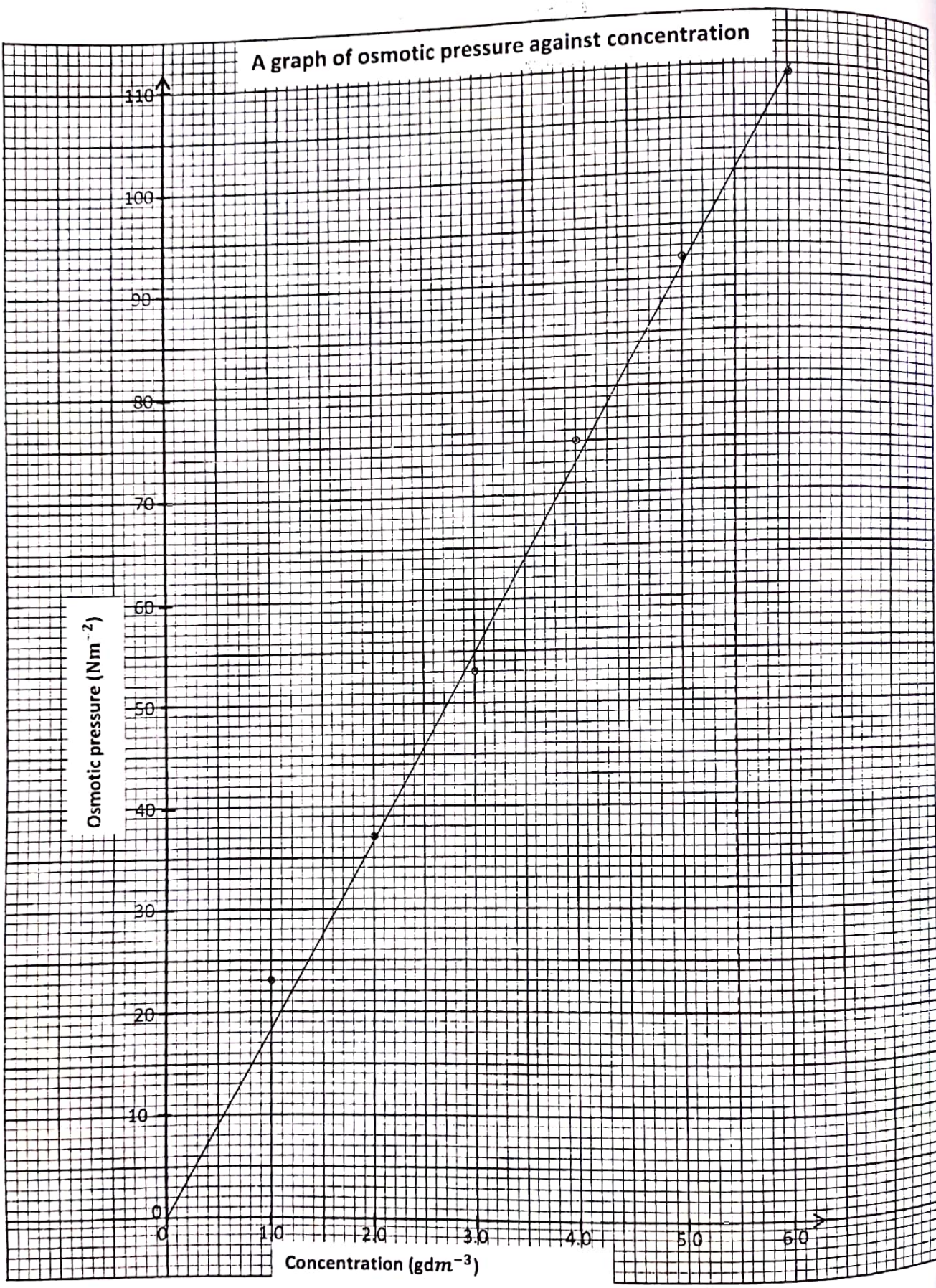
Hence; molecular mass of $x, mr = \frac{RT}{Slope}(R = molar\ gas\ constant)$

$$= \frac{8.314\times(25+273)}{17.95}$$

$$= 138.026 \times 10^3 \simeq \mathbf{138026}$$

Note The answer has been multiplied by 10^3 to change the gdm^{-3} into gm^{-3}, since $R = 8.314 NMmo1^{-1}K^{-1}$ and $1dm^3 = 10^{-3}m^3$

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Question. Seven.

(a) The sodium ion in sodium chloride has a **smaller charge of +1** and a **bigger ionic radius** than the aluminium ion in aluminium chloride which has a charge of +3
Sodium ion therefore has a **smaller charge density** than aluminium ion. And as a result sodium chloride forms a **giant ionic structure** in which the sodium and chloride ions are held together by **strong ionic bonds** which require **a higher heat energy** to be broken hence a higher **melting point of 800°C**
Aluminium chloride however has a **covalent layer structure** with **weak vander waals** forces between the aluminium chloride molecules. These vander waals forces require less heat energy to be broken hence giving aluminium chloride a **lower melting point**

(b) Both graphite and copper have **free mobile electrons** which can conduct electricity

(c) Iodine molecules are **non polar** but water molecules are **polar**. Since the two interactions are different, the solubility of iodine in water decreases
However iodine is more soluble in potassium iodide because iodine **reacts** with the potassium iodide to form a **soluble complex** of **potassium tri iodide ie**

$KI(aq) + I_2(aq) \rightleftharpoons KI_3(aq)$

or $I^-(aq) + I_2(aq) \rightleftharpoons I_3^-(aq)$

(d) The carbon **dioxide** present in the air dissolves in sodium thiosulphate solution to form weak carbonic acid

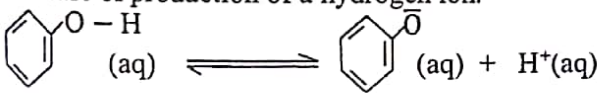
$CO_2(g) + \underset{\substack{from\\ Na_2S_2O_3(aq)}}{H_2O(l)} \rightleftharpoons \underbrace{2H^+(aq) + CO_3^{2-}(aq)}_{\text{carbonic acid}}$

The **hydrogen ions react** with the thiosulphate ions to form **insoluble sulphur**

$2H^+(aq) + S_2O_3^{2-}(aq) \longrightarrow S(s) + H_2O(l) + SO_2(g)$

(e) The strength of an amine depends on the **availability of the lone pair of electrons.**
In phenylamine, the lone pair of electrons on the nitrogen atom **interracts with the delocalised electrons of the benzene ring** and this makes the lone pair of electrons in phenylamine **less available** to accept a proton.
In ethylamine, the ethyl group bonded to the nitrogen atom **pushes the bonding electrons towards** the nitrogen atom (ie has a ppositive inductive effect).This makes the lone pair of electrons on the nitrogen atom **more available** to accept a proton, hence making Ethyl amine a stronger base than phenylamine.

(f) The acidic strength **depends on the ease with which a** substance **produces aproton or hydrogen ion.**
In phenol, the **lone pair of electrons on the oxygen atom interracts with the delocalized** electrons of the benzene.
This makes the oxygen-hydrogen bond to be **polar** and hence **weaker** and so can easily be broken, hence the ease of production of a hydrogen ion.



Cyclohexanol, does not contain delocalized electrons and hence oxygen-hydrogen remains **less polar** and hence relatively **more strengthened** and so cannot easily be broken to release a hydrogen ion;

Question. Eight.

(a) (i) $CuFeS_2$ copper pyrites

(ii) The ore is **pulverized** or **crushed** into powder
The ore is then **mixed with water** containing **frothing agents**
Air is then blown into the mixture. The ore rises to the surface in a froth while the earthly impurities become wetted by water and sink to the bottom
The froth is **skimmed off**, and an **acid is added** to break it and then the **ore is filtered off.**
The ore is then roasted in air to convert it into copper (I) sulphide, iron (II) oxide and sulphur dioxide

$2CuFeS_2(s) + 4O_2(g) \longrightarrow Cu_2S(s) + 2FeO(s) + 3SO_2(g)$

The roasted ore is then **heated in absence of air** to convert the iron (II) oxide to iron (II) silicate

$FeO(s) + SiO_2(s) \longrightarrow FeSiO_3(l)$

The ore is then heated in a **controlled amount of air** to produce **impure copper**

$2Cu_2S(s) + 3O_2(g) \longrightarrow 2Cu_2O(s) + 2SO_2(g)$

or; $Cu_2S(s) + 2Cu_2O(s) \longrightarrow 6Cu(s) + SO_2(g)$

This **impure copper** is then made the **anode** and a pure copper plate the cathode during **electrolysis** of **copper (II) sulphate solution**

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The impure copper anode **dissolves** in solution and produces copper (II) ions which are then deposited as **pure** copper at the cathode.

ie reaction at anode; $Cu(s) \longrightarrow Cu^{2+}(aq) + 2e$

reaction at cathode; $Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$

(b) (i) **Conditions; Hot** and **concentrated** sulphuric acid

Equation; $Cu(s) + 2H_2SO_4(l) \longrightarrow CuSO_4(aq) + 2H_2O(l) + SO_2(g)$

(ii) **Condition hot** and **concentrated** nitric acid

Equation; $Cu(s) + 4HNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + 2H_2O(l) + 2NO_2(g)$

Condition; Dilute or **moderately concentrated** nitric acid

Equation; $3Cu(s) + 8HNO_3(aq) \longrightarrow 3Cu(NO_3)_2(aq) + 4H_2O(l) + 2NO(g)$

(c) (i) The **blue** solution turns **green** and finally **yellow**

$Cu^{2+}(aq) + 4Cl^-(aq) \longrightarrow CuCl_4^{2-}(aq)$

(ii) **Blue precipitate, insoluble** in excess sodium hydroxide

$Cu^{2-}(aq) + 2\overline{O}H(aq) \longrightarrow Cu(OH)_2(s)$

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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2004

1. (a) State Graham's law.
(b) A certain volume of oxygen diffused through a porous membrane in 120s. Under the same conditions the same volume of a gas X diffuses in 112s. Calculate the relative molecular mass of X. (3 mrks)

2. Complete the following equations and in each case outline a mechanism for the reaction.
(a) $CH_3\overset{O}{\overset{\|}{C}}CH_3 + NaHSO_3 \longrightarrow$ (2½ marks)

(b)  $+ HNO_3 \xrightarrow{conc.H_2SO_4}$ (4½ marks)

3. (a) Identify element X in the following equation for a nuclear reaction.
$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{160}_{62}Sn + 4{}^{1}_{0}n + X.$ X is..... (1 mark)

(b) An element Y has three naturally occurring isotopes with isotopic masses and relative abundance as shown below:

Isotopic mass	Relative abundance (%)
23.98	78.60
24.98	10.11
25.98	11.29

Calculate the average atomic mass of Y.

4. (a) Complete the table below: (2 marks)

Element	Formula of oxide	Type of bonding in the oxide	Structure of the oxide
Al			
Si			
P			

(b) Write an equation for the reaction between the oxide of aluminium and sodium hydroxide. (1½ marks)

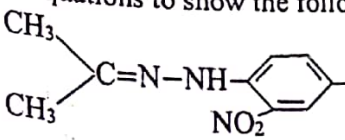
5. State what would be observed and write equation for the reaction that would take place when the following pairs of compounds are reacted.
(a) Propanol and silver nitrate in aqueous ammonia (2 marks)
(b) But-2-ene and acidified potassium permanganate solution. (2 marks)

6. During the extraction of aluminium, a current of 0.2 ampere was passed for one hour through aluminium sulphate solution.
(a) Write an equation for the reaction that took place at each electrode. (3 marks)
(b) Calculate the mass of aluminium produced. (3 marks)

7. A bromo alkane Y with molecular, C_4H_9Br when reacted with concentrated hydrochloric acid in the presence of anhydrous zinc chloride formed two layers of liquids immediately.
(a) Write the name and the structural formula of Y. (1 mark)
(b) Write an equation and indicate a mechanism for the reaction between Y and sodium methoxide in methanol. (3 marks)

8. (a) (i) State how the melting point and boiling point of group(II) metals differ from those of group I. (1 mark)
(ii) Give a reason for your answer in (a) (i) (1 mark)
(b) State reasons why beryllium differs from the rest of the elements in group(II) of the Periodic Table. (4 mrks)

9. (a) Write:
(i) an equation for the ionization of methylamine in water. (1½ marks)
(ii) the expression for the base dissociation constant K_b, for methylamine. (1 mark)
(b) The hydrogen ion concentration of a 1M methylamine solution is 2.5×10^{-13}. calculate K_b for methylamine. (2 marks)

10. Write equations to show the following compounds can be synthesized.
(a)  from propan-2-ol. (2 marks)

(b) $CH_3CH_2C\equiv C\,CH_2CH_3$ from but-1-ene. (4½ marks)

(c)  from nitrobenzene. (2 ½ marks)

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11. Compare the reactivity of fluorine and chlorine with the following compounds
(*in each case illustrate your answer with equations*)
(a) Water (5 marks)
(b) Concentrated sodium hydroxide solution (4 marks)
(1 mark)

12. (a) Define electrolytic conductivity
(b) The molar ionic conductivity at infinite dilution of some ionic species are shown below:

Ion	$\lambda^o(\Omega^{-1}cm^2mol^{-1})$
Na^+	50.1
OH^-	198.6
H^+	349.8
Cl^-	76.4

Calculate the electrolytic conductivities for:
(i) 0.01M sodium hydroxide solution (2 marks)
(ii) A solution made by mixing $50cm^3$ of 0.01M sodium hydroxide and $50cm^3$ of 0.02M hydrochloric acid. (5 marks)
(c) State two uses of conductivity measurements. (1 mark)

13. Name a reagent that can be used to distinguish between each of the following pairs of compounds. In each case, state what would be observed when the compounds are separately treated with the reagent you have named.
(a) CH_3CHO and CH_3CH_2CHO (3 marks)
(b) $CH_3CH_2CH_2NH_2$ and $CH_3NHCH_2CH_3$ (3 marks)
(c) $CHO_3COO^-Na^+$ and $\begin{matrix}COO^-Na^+\\ |\\ COO^-Na^+\end{matrix}$ (3 marks)

14. (a) The rate of a chemical reaction is given by the relationship: Rate = $k[A]^a[B]^b$.
State:
(i) what each of the following stands for: [A], a and b (3 marks)
(ii) one factor that can affect the value of k. (1 mark)
(b) Write an equation for the decomposition of dinitrogen oxide. (1 mark)
(c) At 858K, the half life of dinitrogen oxide is 75.09 hours. Calculate:
(i) the rate constant for the decomposition of dinitrogen oxide. (2 marks)
(ii) the total pressure after 75.09 hours at 858k, if the initial pressure was one atmosphere. (2 marks)

15. Write equations for the reactions which would take place and in each case, state what would be observed when:
(a) Concentrated ammonia solution is added dropwise until in excess to an aqueous solution of cobalt(II) sulkphate and the resulting solution allowed to stand in air (4 marks)
(b) Excess concentrated hydrochloric acid is added to an aqueous solution of copper (II) sulphate. (2½ marks)
(c) Sodium carbon solution is added dropwise until in excess, to an aqueous solution of chromium (III) sulphate. (2½ marks)

16. (a) When 8.8g of a hydrocarbon, Z was burnt in excess air 14.4g of water and $13.44dm^3$ of carbon dioxide were obtained at a.t.p. Determine the empirical formula of Z. (3 marks)
(b) The vapour density of Z is 22. Write the name and the molecular formula of Z. (1 mark)
(c) (i) Write equations to show how Z can be synthesized from an alcohol. (2½ marks)
(ii) Indicate a mechanism for the first stage of the reaction in (c) (i) . (2 marks)

17. The solubility product of Lead (II) chloride is $1.6\times 10^{-5}mol^3l^{-3}$ at 25°C.
(a) Write an expression for the solubility product of Lead(II) chloride. (1 mark)
(b) Calculate:
(i) the concentration of the chloride ion in $moll^{-1}$ in a saturated solution of Lead(II) chloride at 25°C. (3½ marks)
(ii) the solubility of Lead(II) chloride in grams per litre at 25°C. (2½ marks)
(c) (i) State what would be observed if a saturated solution of Lead(II) ethanoate was added to a solution of lead(II) chloride at 25°C. (1 mark)
(ii) Give a reason for your answer in (c) (i) (1 mark)

END

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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2004

1. (a) States that; The rate diffusion of a gas is **inversely proportional** to the square root of its density at **constant temperature.**

(b) $\frac{Rate\ of\ diffusion\ of\ O_2}{Rate\ of\ diffusion\ of\ X} = \sqrt{\frac{Rmm\ of\ X}{Rmm\ of\ O_2}}$

$\frac{V}{120} / \frac{V}{112} = \sqrt{\frac{Rmm X}{32}}$

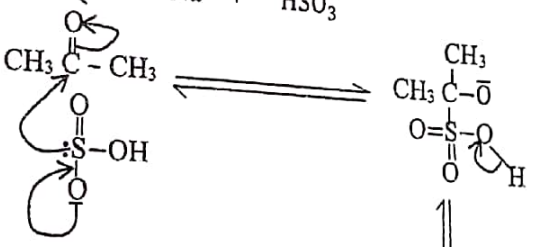
$\frac{112}{120} = \sqrt{\frac{Rmm X}{32}}$

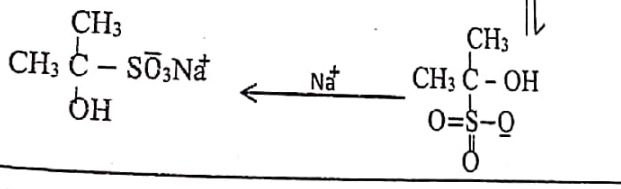
Hence; $Rmm\ of\ X = \frac{32\times(112)^2}{(120)^2} = 27.9$

2. (a) $CH_3\overset{O}{\overset{\|}{C}}CH_3 + NaHSO_3 \longrightarrow CH_3\overset{OH}{\underset{CH_3}{C}}-SO_3^-Na^+$

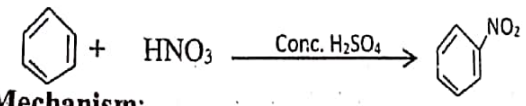
Mechanism;

$NaHSO_3 \rightleftharpoons Na^+ + HSO_3^-$



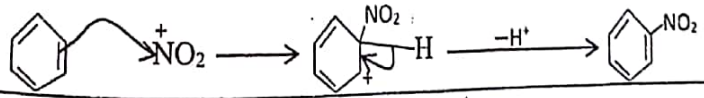


(b)



Mechanism;

$HNO_3 + H_2SO_4 \rightleftharpoons NO_2^+ + HSO_4^- + H_2O$



3. (a) $^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{160}_{62}Sn + 4{}^{1}_{0}n + X$

X is $^{72}_{30}$**Zn**

(b) $RAM = \frac{\Sigma(\text{Isotopic mas} \times \text{relative abundance})}{\Sigma(\text{relative abundance})}$

$RAM\ of\ Y = \frac{(23.98\times78.60)+(24.98\times10.11)+(25.98\times11.29)}{78.60+10.11+11.29}$

$= \frac{2430.69}{100} = 24.31$

4. (a)

Element	Formula of oxide	Type of bonding in the oxide	Structure of the oxide
Al	Al_2O_3	Ionic	Giant ionic
Si	SiO_2	Covalent	Giant molecular or Giant covalent
P	P_4O_{10} or P_2O_5 P_4O_6 or P_2O_3	Covalent	Molecular structure

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(b) $Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \longrightarrow 2NaAl(OH)_4(aq)$

or, $Al_2O_3(s) + 2\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_4^-(aq)$

or ,$Al_2O_3(s) + 2\bar{O}H(aq) \longrightarrow 2AlO_2^-(aq) + H_2O(l)$

or, $Al_2O_3(s) + 2NaOH(aq) \longrightarrow 2NaAlO_2(aq) + H_2O(l)$

5. (a) No reaction, question error

(b) Observation – solution of potassium permanganate turns from **purple** to **colourless**

Equation; $CH_3CH = CHCH_3 \xrightarrow{MnO_4^-(aq)/H^+} CH_3\underset{OH}{CH}\underset{OH}{CH}CH_3$

6. (a) **Cathode;** $Al^{3+}(aq) + 3e \longrightarrow Al(s)$

or; $2H^+(aq) + 2e \longrightarrow H_2(g)$

Anode; $4\bar{O}H(aq) \longrightarrow 2H_2O(l) + O_2(g) + 4e$

(b) Quantity of electricity passed = $current \times time$

$= 0.2 \times 60 \times 60 =$ **720 *Coloumbs.***

Amount of Faradays in 720 coloumbs of charge $= \frac{720}{96500} = 7.46 \times 10^{-3}$

Hence; 3Fradays deposit 27g of Aluminum

$\therefore 7.46 \times 10^{-3}$ *Faradays deposit* $\frac{7.46\times10^{-3}\times27}{3} g$ $= 0.067g$ ***of Aluminum***

7. (a) 2 –bromo -2 –methyl propane; $CH_3-\underset{Br}{\overset{CH_3}{\overset{|}{C}}}-CH_3$

(b) $CH_3-\underset{Br}{\overset{CH_3}{\overset{|}{C}}}-CH_3 \xrightarrow[CH_3OH]{CH_3\bar{O}Na^+} CH_2=\overset{CH_3}{\overset{|}{C}}-CH_3$

Mechanism;

$CH_2-\underset{CH_3}{\overset{CH_3}{\overset{|}{C}}}-Br \rightleftharpoons CH_3-\overset{+}{\underset{CH_3}{\overset{CH_3}{\overset{|}{C}}}} + Br^-$

$CH_3\bar{O}: + H_2C-\overset{+}{\underset{CH_3}{\overset{CH_3}{\overset{|}{C}}}} \longrightarrow CH_2=\underset{CH_3}{\overset{CH_3}{\overset{|}{C}}} + CH_3OH$

8. (a) (i) Group (II) metals have **higher** melting points and **higher** boiling points than Group (I) metals

(ii) Group (II) elements have **smaller atomic radii** and contribute **two electrons** per atom to the charge cloud towards metallic bonding hence form **stronger metallic bonds** than group (I) metals which contribute **one electron** per atom towards metallic bond formation

(b) Beryllium has the **smallest atomic radius** compared to other elements in group (II)

Beryllium forms the smallest cation with the **highest charge density** and hence highest **polarizing power.**

Beryllium has the **least negative** electrode potential compared to other group (II) elements

9. (a) (i) $CH_3NH_2(aq) + H_2O(l) \rightleftharpoons CH_3\overset{+}{N}H_3(aq) + \bar{O}H(aq)$

(ii) $Kb = \frac{[CH_3\overset{+}{N}H_3][\bar{O}H]}{[CH_3NH_2]}$

(iii) From $Kw = [H^+][\bar{O}H]$

$[\bar{O}H] = \frac{Kw}{H^+} = \frac{1\times10^{-14}}{2.5\times10^{-13}} = 0.04 mol\,l^{-1}$

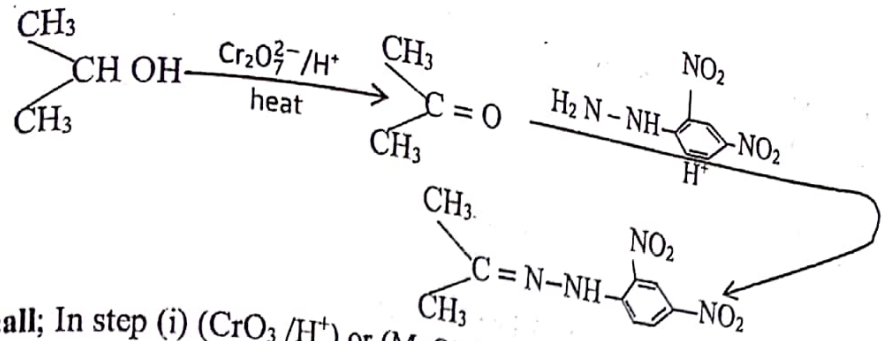
At Equilibrium; $[CH_3\overset{+}{N}H_3] = [\bar{O}H]$ also; $[CH_3NH_2] = 1M$

Hence; $Kb = \frac{[\bar{O}H]^2}{[CH_3NH_2]}$

$$Kb = \frac{(0.04)^2}{1} = 1.6 \times 10^{-3} mol l^{-1}$$

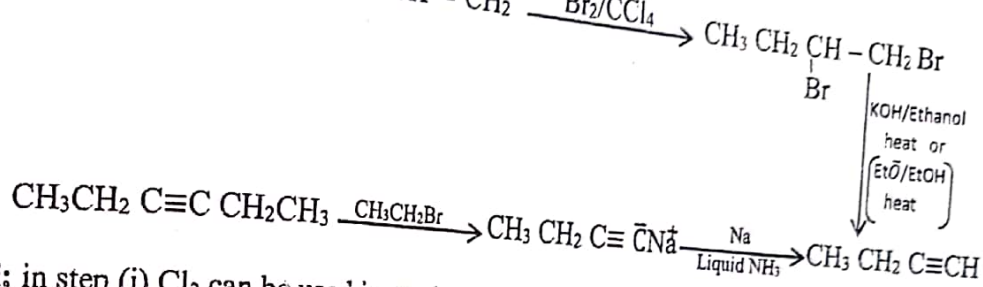
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10. (a)



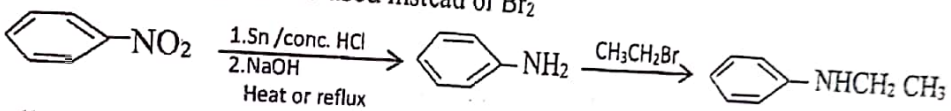
Recall; In step (i) (CrO_3 /H^+) or (MnO_4^- / conc. H_2SO_4) can be used instead of (Cr_2O_7 /H^+)

(b)



Recall; in step (i) Cl_2 can be used instead of Br_2

(c)



Recall; in step (ii) CH_3CH_2I or CH_3CH_2Cl can be used instead of CH_3CH_2Br

11. (a) Fluorine reacts with water **vigorously** to form **oxygen and hydrofluoric acid**

$2F_2(g) + 2H_2O(l) \longrightarrow 4HF(aq) + O_2(g)$

Chlorine reacts **slowly** with water forming **hyPochlorous acid and hydrochloric acid**

$Cl_2(g) + H_2O(l) \rightleftharpoons HCl(aq) + HClO(aq)$

(b) Fluorine reacts with concentrated sodium hydroxide to **give sodium fluoride, water and oxygen**

$2F_2(g) + 4NaOH(aq) \longrightarrow 4NaF(aq) + 2H_2O(l) + O_2(g)$

Chlorine reacts with concentrated sodium hydroxide solution to give **sodium chloride, sodium chlo and water**

$3Cl_2(g) + 6NaOH(aq) \longrightarrow 5NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$

12. (a) The conductance of a **unit** volume of an aqueous solution contained between electrodes of **unit cros sectional area** and **unit length a part.**

or, The reciprocal of resisitivity

(b)

$$\Lambda_o(NaOH) = \Lambda_o(Na^+) + \Lambda_o(\bar{O}H)$$
$$= 50.1 + 198.6$$
$$= 248.7 cm^2 mol^{-1}\Omega^{-1}$$

Electrolytic conductivity; $\frac{\Lambda_o \times C}{1000}$

$$= \frac{248.7 \times 0.01}{1000}$$
$$= 2.487 \times 10^{-5}\Omega^{-1}cm^{-1}$$

(ii) Moles of NaOH in $50cm^3 = \frac{50}{1000} \times 0.01 = 5 \times 10^{-4} moles$

Moles of HCl in $50cm^3 = \frac{50}{1000} \times 0.02 = 1 \times 10^{-3} moles$

$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$ + excess HCl

1mole 1mole 1mole

Moles of HCl which reacted = $5 \times 10^{-4} moles$ (since mole ratio of NaOH : HCl = 1 : 1)

Moles of excess HCl= $(1 \times 10^{-3}) - (5 \times 10^{-4})$

$= 5 \times 10^{-4} moles$

Volume of resultant solution = 50 + 50 = $100cm^3$

$100cm^3$ of resultant solution contain $5 \times 10^{-4} moles$ of excess HCl

$\therefore 1000cm^3$ of resultant solution contain $\frac{1000 \times 5 \times 10^{-4}}{100}$ moles of excess HCl

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Thus; molar concentration of excess acid in resultant solution $= 0.005M$

Λ_o(excess HCl) $= \Lambda_o(H^+) + \Lambda_o(Cl^-)$

$= 349.8 + 76.4$

$= 426.2\Omega^{-1}cm^2mol^{-1}$

$$K(excess\ HCl) = \frac{426.2 \times 0.005}{1000} = 2.13 \times 10^{-3}\Omega^{-1}cm^{-1}$$

Since mole ratio of NaOH; NaCl = 1:1

Moles of NaCl in $100cm^3$ of resultant solution = moles of NaOH which reacted

$= 5 \times 10^{-4} moles$

Molar concentration of NaCl $= \frac{5\times10^{-4}\times1000}{100} = 0.005M$

But; Λ_o(NaCl) $= \Lambda_o(Na^+) + \Lambda_o(Cl^-)$

$= 50.1 + 76.4 = 126.5\Omega^{-1}cm^2mol^{-1}$

Hence; $K(NaCl) = \frac{126.5\times0.005}{1000} = 6.325 \times 10^{-4}\Omega^{-1}cm^{-1}$

Thus; Electrolytic conductivity of solution is given by

$Ksolution = K_{(NaCl)} + K_{(excess\ HCl)}$

$= 6.325 \times 10^{-4} + 2.131 \times 10^{-3} = \mathbf{2.7635 \times 10^{-3}\Omega^{-1}cm^{-1}}$

(c)
- Determination of solubility and solubility product of sparingly soluble salts.
- Applied in conductrimetric titration
- Determination of molar conductivity at infinite dilution for strong electrolytes
- Determination of degree of ionization for weak electrolytes
- Determination of dissociation constants for weak electrolytes.

13. (a) Reagent – **Aqueous** iodine and sodium hydroxide **solution**

Observation; - CH_3CHO –gives a **yellow precipitate**

- CH_3CH_2CHO – gives **no observable change**

(b) Reagent –Sodium nitrite and cold concentrated hydrochloric acid

Observation; - $CH_3CH_2CH_2NH_2$ – gives **bubbles** of a **colourless gas** and a **colourless solution.**

- $CH_3NHCH_2CH_3$ – gives **a yellow oil**

(c) Question not applicable (had an error)

The compound $CHO_3CO\bar{O}Na^+$ is not clear.

14. (a) (i) $[A]$ -Molar concentration of A or concentration of A in mold m^{-3}(mol $litre^{-1}$)

a –order of reaction with respect to A

b –order of reaction with respect to B

(ii) Temperature

(b) $2N_2O(g) \longrightarrow 2N_2(g) + O_2(g)$

(c) $Kt½ = In2 = 0.693$

Hence; Rate constant; $K = \frac{0.693}{K½}$

$$K = \frac{0.693}{75.09} = \mathbf{9.23 \times 10^{-3} hour^{-1}}$$

(ii) After 75.09 hours (which is half life);

The amount of N_2O left = 0.5 atmospheres, and when 0.5 atmospheres of N_2O are decomposed, 0.5 atm of N_2 are formed and 0.25atm of O_2 are formed

(Since mole ration of N_2O : N_2 : O_2 = 2 : 2 : 1)

Hence; Total pressure = $(0.5 + 0.5 + 0.25)$ = **1.25atmospheres**

15. (a) **Observation;**

Blue precipitate, dissolves to give a **pale yellow solution** which **turns brown** on standing

Equation;

$Co^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Co(OH)_2(s)$

$Co(OH)_2(s) + 6NH_3(aq) \longrightarrow Co(NH_3)_6^{2+}(aq) + 2\bar{O}H(aq)$

$Co(NH_3)_6^{2+}(aq) \longrightarrow Co(NH_3)_6^{3+}(aq) + e$

(b) **Observation:** Solution of copper (II) sulphate turns from **blue to pale yellow**

Equation; $Cu(H_2O)_6^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons [CuCl_4]^{2-}(aq) + 6H_2O(l)$

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or $Cu(H_2O)_4^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons [CuCl_4]^{2-}(aq) + 4H_2O(l)$

(c) Question not clear, had an error, the sodium carbon solution added is not a correct compound, possibly the setter wanted to mean sodium carbonate solution.

16. (a) **Mass of carbon in Z**

$22.4dm^3$ of CO_2 at stp weigh 44g of CO_2 (Rmm of CO_2)

$\therefore 13.44dm^3$ of CO_2 at stp weigh $\frac{13.44\times44}{22.4}$ $= 26.4g$ **of** CO_2

Thus; 44g of CO_2 contain 12g carbon

$\therefore$ 26.4g of CO_2 contain $\frac{12}{44}\times 26.4g$ of carbon $= 7.2g$ **of carbon**

Mass of hydrogen in $Z = \frac{2}{18}\times 14.4g = 1.6g$

Composition of Z;	C		H
Moles:	$\frac{7.2}{12}$		$\frac{1.6}{1}$
	0.6		1.6
Mole ratio;	$\frac{0.6}{0.6}$		$\frac{1.6}{0.6}$
	1		2.67 (multiply by 3)
	3	:	8

Emperical formula of Z is C_3H_8

(b) Rmm of $Z = 2\times 22 = 44$

Hence; $(C_3H_8)_n = 44$

$(3\times12)n + (8\times1)n = 44$

$44n = 44$

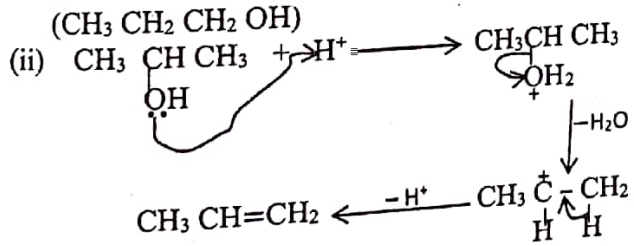
$\therefore n = \frac{44}{44} = 1$

Hence; molecular formula of Z is C_3H_8 and its name is **propane**.

(c) (i) $CH_3\underset{OH}{CH}CH_3 \xrightarrow[\text{Heat or (170 – 180°C)}]{\text{Conc. } H_2SO_4} CH_3CH=CH_2 \xrightarrow{H_2/Ni} CH_3CH_2CH_2$

or

$(CH_3CH_2CH_2OH)$

(ii) 

17. (a) $Ksp = [Pb^{2+}][Cl^-]^2$

(b) let; the $[Pb^{2+}] = xmoll^{-1}$

Hence; the $[Cl^-] = 2xmoll^{-1}$

But; $Ksp = [Pb^{2+}][Cl^-]^2$

So; $1.6\times10^{-5} = x\times(2x)^2$

$1.6\times10^{-5} = 4x^3$

$\therefore x = \sqrt[3]{\frac{1.6\times10^{-5}}{4}} = 1.59\times10^{-2}$

$\simeq 1.6\times10^{-2}$

$[Cl^-] = 2\times1.6\times10^{-2} = 3.2\times10^{-2}moll^{-1}$

(ii) RFM of $PbCl_2 = 207 + (2\times35.5) = 278.$

$solubility = 278\times1.6\times10^{-2} = 4.45gl^{-1}$

(c) (i) A white precipitate is formed

(ii) Addition of lead (II) ethanoate **increases the concentration of Lead (II) ions** (since it is a strong electrolyte) which then **react** with chloride ions to give a white precipitate of **Lead (II) chloride**

$Pb^{2+}(aq) + 2Cl^-(aq) \longrightarrow PbCl_2(s)$

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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2004

1. The vapour pressure (V.P) of water and of an immiscible liquid X at different temperature are given in the table below:

Temp/°C	92	94	96	98	100
V.P of X/KPa	6	8	12	15	17
V.P of H_2O/KPa	74	80	88	94	101

(a) On the same axes, plot graphs of vapour pressure against temperature. (4 marks)

(b) (i) Determine the vapour pressure of the mixture of X and water at the temperature given in the table above. (2 marks)

(ii) On the same axes of the graph in (a), plot a graph of the vapour pressure of the mixture verses the temperature. (2 marks)

(c) The distillate obtained from the mixture at 101KPa contained 1.6g of water and 1.1g of X. Calculate the relative molecular mass of X using the information from the graphs you have drawn (5 marks)

(d) (i) Explain the principles in the separation of mixture by steam distillation. (5 marks)

(ii) State any two advantages of steam distillation. (2 marks)

2. (a) The molar conductivity of sodium hydroxide solutions of different concentrations are shown in the table below;

Concentration/moldm^{-3}	0.01	0.04	0.09	0.16	0.25	0.36
Molar conductivity, $\Lambda/\Omega^{-1}cm^2mol^{-1}$	238	230	224	217	210	202

(i) Draw a graph of molar conductivity against the square root of concentration. (4 marks)

(ii) Explain the shape of the graph (4 ½ marks)

(iii) Determine the value of molar conductivity at infinite dilution of sodium hydroxide and indicate its units. (2 marks)

(b) Using the same conductivity cell, the resistance of a 0.1M potassium chloride solution and 0.1M bromoethanoic acid solution were found to be 24.96 and 66.50 ohms respectively at 25°C when determine using the same conductivity cell. [The conductivity of potassium chloride at 25°C is 0.01164 $\Omega^{-1}cm^{-1}$ and the molar conductivity of bromoethanoic avid at infinite dilution is $389\Omega^{-1}cm^2mol^{-1}$]

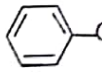
(i) Calculate the cell constant (2 marks)

(ii) Calculate the molar conductivity of the 0.1M bromoethanoic acid. (3 marks)

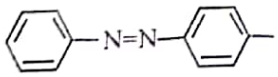
(iii) Determine the pH of 0.1M bromoethanoic acid. (4 ½ marks)

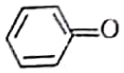
3. Write equations to show how the following compounds can be synthesized. Your answer should include reagents and conditions for the reactions.

(a) $CH_3\,CH_2O\,CH_2\,CH_3$ from ethene. (4 marks)

(b)  from benzene (5 marks)

(c) $CH_3\,CH_2\,CH\,CH_3$ with $HNCH_2CH_3$ (2 marks)

(d)  from benzene (5 marks)

(e)  from bromocyclohexane (5 marks)

4. C, Si, Ge, Sn and Pb are elements in group (IV) of the Periodic Table.

(a) Explain the following trends among the group (IV) elements:

(i) electropositivity (4 marks)

(ii) stability of +2 oxidation state. (2 ½ marks)

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(b) State four properties in which carbon differs from the rest of the members of group(IV) elements. (4 mks)
(c) Explain why carbon tetrachloride molecule is non-polar yet the bonds in carbon tetrachloride are polar. (3 marks)
(d) A sample of lead(IV) oxide was treated with warm concentrated hydrochloric acid.
(i) State what was observed. (1 ½ marks)
(ii) Write an equation for the reaction. (2 marks)
(e) Equations for some half-cell reactions are shown below:

$Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq)$, $E^\theta = +0.15V$

$PbO_2(s) + 4H^+(aq) + 2e^- \rightleftharpoons Pb^{2+}(aq) + 2H_2O(l)$, $E^\theta = +1.46V$

(i) Write the overall equation for the spontaneously feasible reaction (2 marks)
(ii) Calculate the E^θ_{cell} in (e)(i) (1 mark)

5. Explain the following observations:
(a) Although zinc belongs to the d-block elements in the Periodic Table' it does not behave as a typical transition element. (3 marks)
(b) The enthalpy of hydrogenation of cyclohexene to cyclohexane is $-120KJmol^{-1}$ whereas that of benzene to cyclohexane is $-200KJmol^{-1}$ (4 marks)
(c) Carbon dioxide is a gas at room temperature whereas silicon(IV) oxide is a solid with very high melting point (4 marks)
(d) When sodium carbonate solution was added to a solution of aluminium chloride, a white precipitate was formed and a colourless gas evolved. (5 marks)
(e) When concentrated hydrochloric acid was added to a solution of copper(II) Sulphate, the blue solution changes to yellow and on addition of water, the solution changed black. (4 marks)

6. Explain the following observations
(a) 1 – bromobutane undergoes nucleophilic substitution reaction when heated with aqueous sodium hydroxide solution whereas bromobenzene does not react under similar conditions. (4 marks)
(b) Phenol (hydroxyl benzene) is sparingly soluble in water but very soluble in dilute sodium hydroxide.(2½ mks)
(c) Iodine is sparingly soluble in water but dissolves readily in aqueous solution of potassium iodide.(3 ½ marks)
(d) Hydrogen fluoride has a higher boiling point and is a weaker acid than hydrogen chloride. (10 marks)

7. (a) State the distribution law. (2 marks)
(b) Describe how the distribution coefficient for butane-1, 4-dioic acid (succinic acid) between water and ethoxy ethane can be determined. (5 marks)
(c) $100cm^3$ of a solution contains 30g of substance =, Z.
Calculate the mass of Z that can be extracted by shaking the solution with: (3 marks)
(i) $100\ cm^3$ of ethoxyethane. (5 marks)
(ii) two $50cm^3$ portions of ethoxy ethane (5 marks)
(The distribution coefficient of Z between ethoxy ethane and water is 5)
(d) Briefly describe how the distribution law can be used to determine the complex formed between copper(II) ions and ammonia. (5 marks)

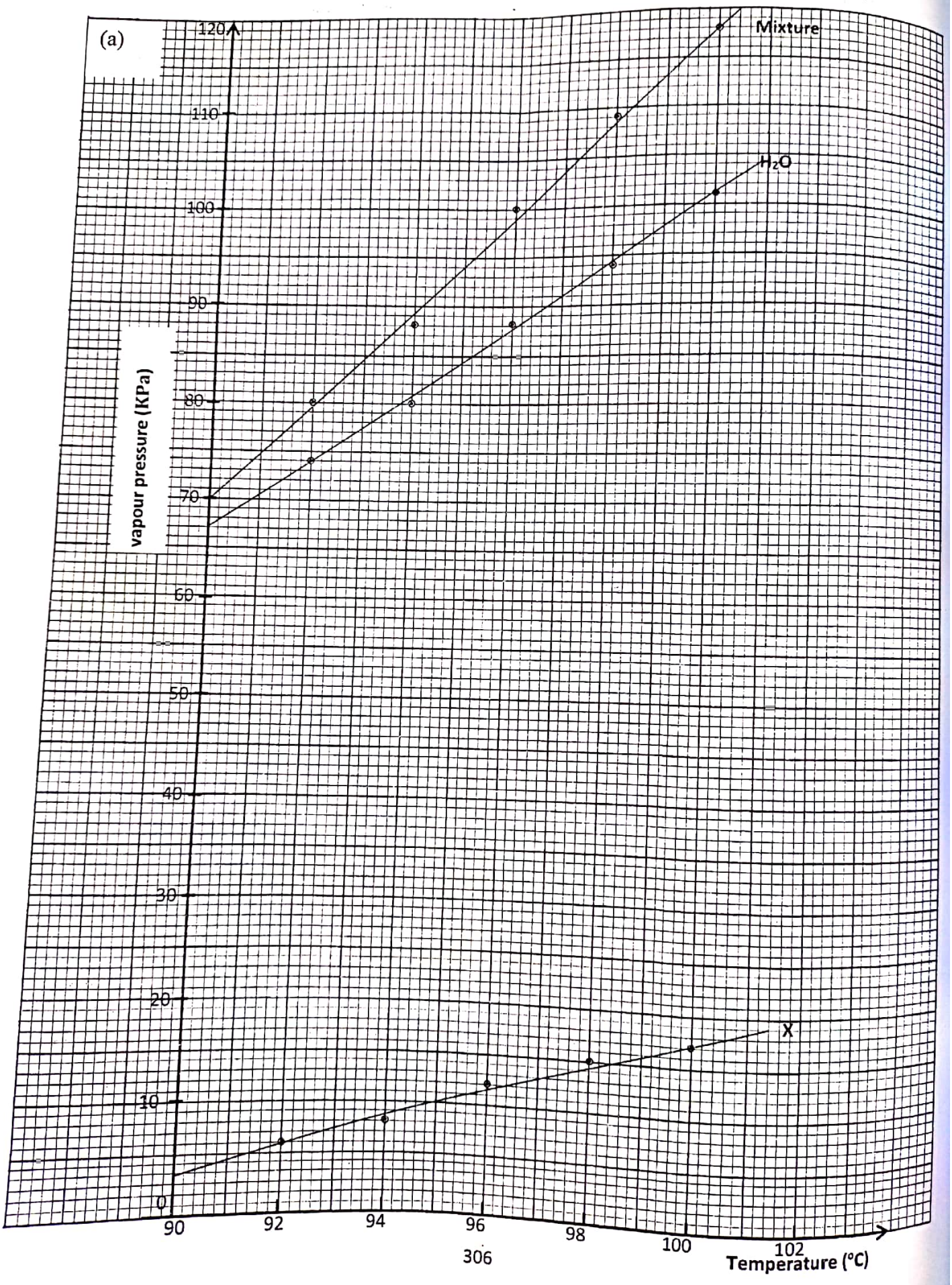
8. (a) State what would be observed and write an equation for the reaction which takes place when:
(i) magnesium is reacted with steam (3½ marks)
(ii) barium is reacted with water (3 marks)
(b) Compare the reaction of beryllium and barium with sulphuric acid under various conditions. (7 ½ marks)
(c) Explain how the solubility of the hydroxide of the elements of the group(II) elements of the Periodic Table vary down the group. (6 marks)

END

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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2004

Question. One.



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(b) (i)

Temp/°C	92	94	96	98	100
v.p of X/KPa	6	8	12	15	17
v.p of H_2O/KPa	74	80	88	94	101
v.p of mixture/KPa	80	88	100	109	118

(ii) See graph in (a)

(c) From the graph; when the v. pressure of mixture is 101KPa;
v. pressure of $H_2O = 89KPa$ *and*
v. pressure of $X = 12Kpa$
Rmm of $H_2O = (2 \times 1) + (1 \times 16) = 18$

$$\frac{mass\ of\ X\ in\ distillate}{mass\ of\ H_2O\ in\ distillate} = \frac{Rmm\ of\ X(v.pressure\ of\ X)}{Rmm\ of\ H_2O \times v.pressure\ of\ H_2O}$$

$$\frac{1.1}{1.6} = \frac{Rmm\ of\ X(12)}{18\times89}$$

$$\text{Hence; Rmm of } X = \frac{1.1\times18\times89}{1.6\times12}$$

$$= 91.78$$

(d) (i) – The substance should be **immiscible with water**. This enables each component to exert a vapour pressure independent of the other.
- The vapour pressure of the mixture is the **sum** of the vapour pressures of the components
- The substance should be able to **exert a high vapour pressure around the boiling point of water.** This enables the mixture to boil at a temperature **lower** than the boiling point of each component
- The substance should have a **high relative molecular mass** so that a lot of it can be distilled off
- The other impurities in the mixture **should be non volatile** so that they do not appear in the distillate

(ii) – Steam distillation allows a substance to distill at a temperature below its boiling point
- Steam distillation is used to purify organic substances
- Steam distillation avoids decomposition of substances that can decompose at their boiling points

Question. Two.

(a) (i)

Concentration/moldm^{-3}	0.01	0.04	0.09	0.16	0.25	0.36
Molar conductivity,Λ $(\Omega^{-1}cm^2mol^{-1})$	238	230	224	217	210	202
Square root of concentration	0.1	0.2	0.3	0.4	0.5	0.6

(ii) Sodium hydroxide is a **strong electrolyte** and therefore **completely dissociates** in aqueous solution
At a **low concentration**, the molar conductivity of sodium hydroxide solution is **high** because the ions are **wide apart** with **low ionic interference** which gives the ions **high mobility** resulting into high molar conductivity.
As the **concentration** of sodium hydroxide **increases** the ions **become closer** together and the **ionic interference increases** and consequently the ions become **less mobile** and thus the **molar conductivity decreases**

(b) (i) Using potassium chloride;

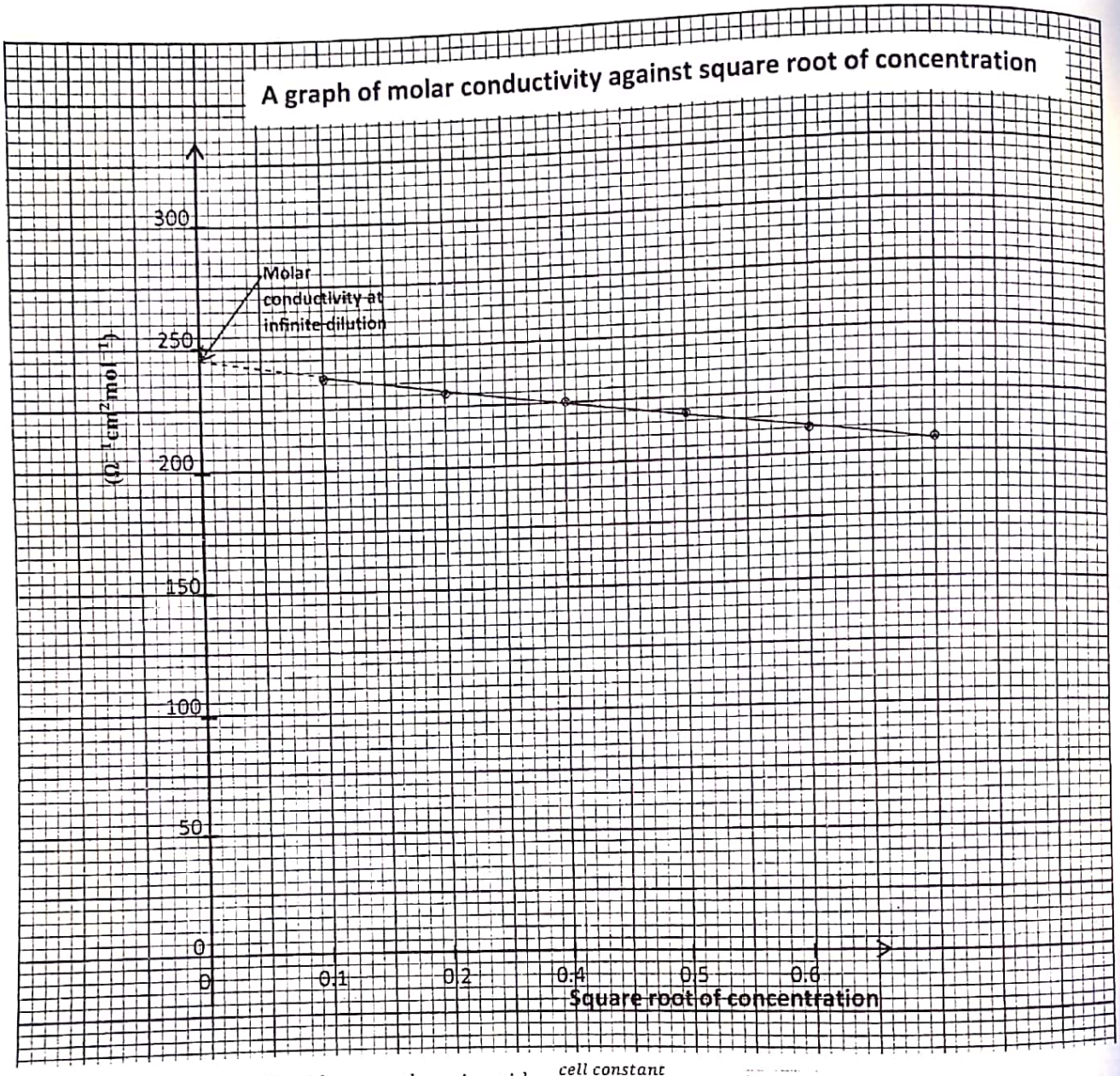
$$\text{Conductivity; } K = \frac{cell\ constant}{resistance}\left(or\ \frac{1}{R}\left(\frac{L}{A}\right)\right)$$

$$\text{Hence; Cell constant } \left(\frac{L}{A}\right) = conductivity \times resistance$$

$$= 0.01164 \times 24.96$$

$$= 0.291\ cm^{-1}$$

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(ii) conductivity; $K\ of\ bromoethanoic\ acid = \frac{cell\ constant}{resistance}$

$= \frac{0.291}{66.50} \quad = 0.00438\Omega^{-1}cm^{-1}$

Hence; Λ of bromoethanoic acid $= \frac{1000k}{concetration\ (c)}$

$= \frac{1000\times0.00438}{0.1} \quad = 43.8\Omega^{-1}cm^2mol^{-1}$

(iii) Degree of ionization of bromo ethanoic acid; $\propto$

$$\propto = \frac{\Lambda\ at\ a\ given\ concentration\ (\Lambda c)}{\Lambda\ at\ infinite\ dilution\ (\Lambda c)}$$

$$\propto = \frac{43.8}{389} = 0.1126$$

Equation of ionization of bromo ethanoic acid is;

$CH_2Br\ COOH(aq) + H_2O(l) \rightleftharpoons CH_2Br\ COO^-(aq) + H_3O^+(aq)$

$[H_3O^+] = \propto c$

$= 0.1126 \times 0.1$

$= 0.01126 moldm^{-3}$

$pH = -\log_{10}[H_3O^+]$

$= -\log_{10} 0.01126 \quad = 1.95$

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Question. Three.

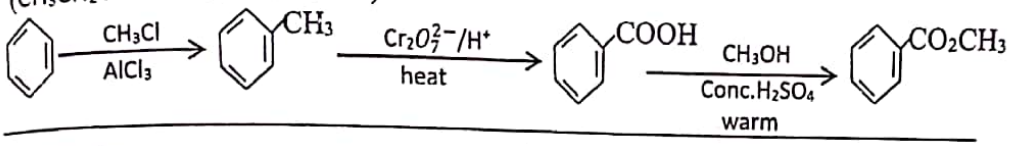
(a) $CH_2=CH_2 \xrightarrow[2.\ H_2O/warm]{1.conc.\ H_2SO_4} \underset{(Excess)}{CH_3CH_2OH} \xrightarrow[140°C]{conc.\ H_2SO_4} CH_3CH_2OCH_2CH_3$

or $CH_2=CH_2 \xrightarrow{HBr} CH_3CH_2Br \xrightarrow[heat]{NaOH(aq)} CH_3CH_2OH(excess)$

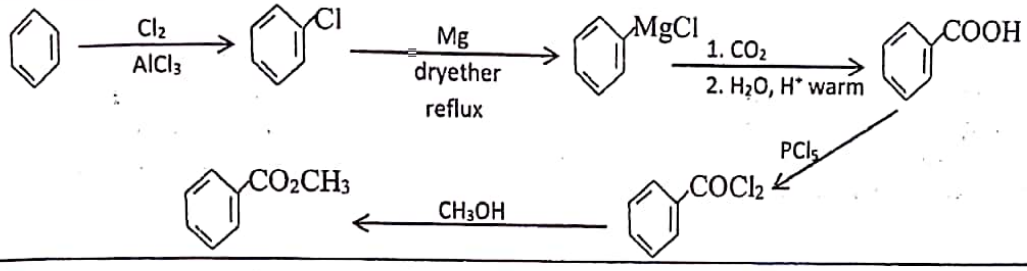
$CH_3CH_2OH \xrightarrow[140°C]{conc.\ H_2SO_4} CH_3CH_2OCH_2CH_3$

or $CH_2=CH_2 \xrightarrow{HI} CH_3CH_2I \xrightarrow[Alcohol,\ heat]{CH_3CH_2\bar{O}Na^+} CH_3CH_2OCH_2CH_3$

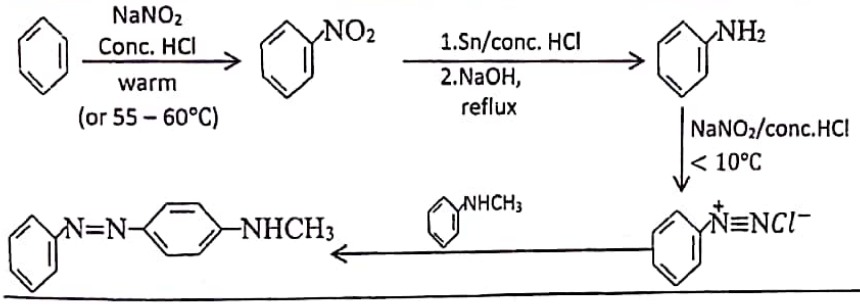
Note- In the last alter native in the last step, ($NaOH/CH_3CH_2$ and heat) can be used instead of ($CH_3CH_2\bar{O}Na^+$ /alcohol and heat)

(b) 

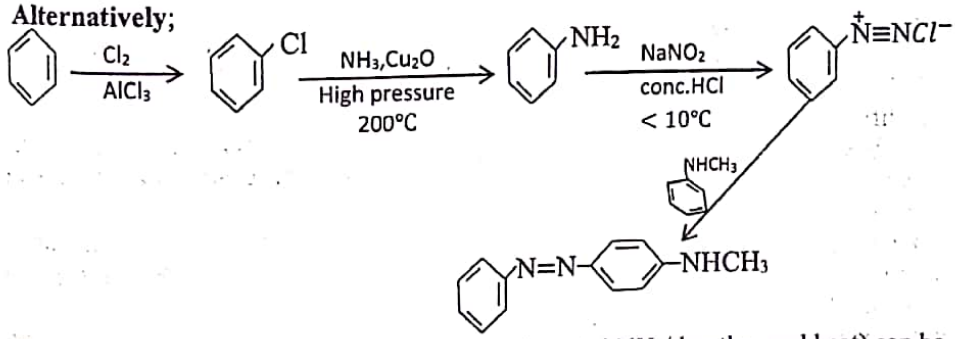
Alternatively;



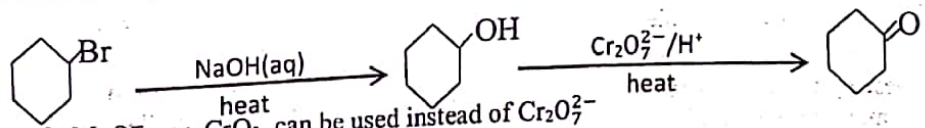
(c) $CH_3CH=CH\ CH_3 \xrightarrow{HBr} CH_3\ CH_2\ \underset{Br}{CH}\ CH_3 \xrightarrow[Alcohol,\ heat]{CH_3CH_2NH_2} CH_3CH_2\ \underset{HNCH_2CH_3}{CH}\ CH_3$

(d) 

Alternatively;



Note; In atternative 1; step 2, (H_2/Ni and heat) or ($LiAlH_4$/dryether and heat) can be used instead of (Sn/conc.HCl, NaOH and reflux)

(e) 

Note; In step 2; MnO_4^- or CrO_3 can be used instead of $Cr_2O_7^{2-}$

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Question. Four.

(a) (i) Electropositivity **increases from carbon to lead.**
From carbon to lead from one element to the next down the group, the **number of protons increases** which **increases the nuclear charge.** There is also **increase in the number of full inner energy levels** of electrons which **increases the screening effect.**
However, the increase in screening effect **outweighs** the increase in nuclear charge and consequently, **effective nuclear charge decreases** which results into **decrease in the nuclear attraction** for the outer electrons hence leading to increased **electropositivity** or loss of electrons.

(ii) Stability of +2 oxidation state **increases from carbon to lead** because of **inert pair effect.**
As the s-electrons are more penetrating, they experience a greater nuclear attraction and become relatively more stable than the p-electrons and this makes them (the s-electrons) to be less available to be involved in chemical reaction

(b) - Carbon forms gaseous oxides
- Carbon forms stable multiples bonds with its self and with other non metals
- Carbon forms compounds which are relatively inert
- Carbon unlike other elements in group (IV)
- Carbon has a maximum covalency of four
- Carbon exhibits catenation ie direct bonding between atoms of the same element
- Carbon has a much higher electronegativity value than the rest.

(c) Carbon tetra chloride is non polar because its molecule has a **tetrahedral shape** in which the carbon-chlorine bonds are **symmetrically arranged.** Since each pair of chlorine atoms attracts the bonding electrons in the **opposite directions**, the effect of the bond polarity **cancels out** and as a result the whole molecule becomes non polar inspite of the carbon-chlorine bond being polar since chlorine is **more electronegative** than the carbon and therefore **withdraws** bonding electrons toward itself hence acquiring a partial negative charge
(ie $\overset{\delta+}{C}—\overset{\delta-}{Cl}$)

(d) (i) **Greenish –yellow gas** evolved and **white solid** formed
(ii) $PbO_2(s) + 4HCl(aq) \longrightarrow PbCl_2(s) + Cl_2(g) + 2H_2O(l)$
or $PbO_2(s) + 6HCl(aq) \longrightarrow PbCl_4^{2-}(aq) + 2H^+(aq) + Cl_2(g) + 2H_2O(l)$

(e) (i) $PbO_2(s) + 4H^+(aq) + Sn^{2+}(aq) \longrightarrow Pb^{2+}(aq) + Sn^{4+}(aq) + 2H_2O(l)$

(ii) $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$
$= +1.46 - 0.15$
$= +1.31 volts$

Question. Five.

(a) The electronic configuration of both zinc atom and zinc ion have **fully filled 3d- subenergy levels.** But, the transition elements have **partially filled 3d-subenergy levels.**

(b) Cyclohexene has only **one isolated double bond** whose hydrogenation evolves 120KJ/mol. If benzene had three isolated double bonds in its structure, its hydrogenation would evolve
$3\times 120 = 360 KJmol^{-1}$
The observed difference in its hydrogenation energy of $360-200 = 160KJ$ is due to the **increased stability of the benzene structure.** This is because the structure has **three conjugate double bonds** whose pie electrons are **delocalized** over all the six carbon atoms in the ring.

(c) The **atomic radius** of carbon is **smaller** than that of silicon. As carbon and oxygen atoms can **approach each other closely**, their p-orbitals overlap leading to formation of **stable multiple bonds** between carbon and oxygen
Consequently only **discrete** carbon dioxide molecules are formed and are held together by **weak vander waal's forces.**
There is **no overlap** of p-orbitals in silicon dioxide because of the **large atomic radius** of silicon atom. Silicon then forms only **single very strong covalent bonds** with four other oxygen atoms
This gives silicon dioxide a **3-dimension giant structure** which is a solid

(d) Aluminium chloride solution is **acidic** or produces **hydrogen ions** due to **hydrolysis**
These hydrogen ions **react** with the carbonate ions to produce **carbon dioxide** gas and **insoluble aluminium hydroxide.**

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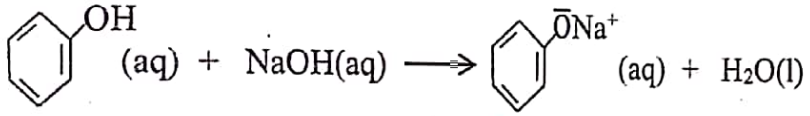
$2Al(H_2O)_6^{3+}(aq) + 3CO_3^{2-}(aq) \longrightarrow 2[Al(OH)_3 \cdot (H_2O)_3](s) + 3CO_2(g) + 3H_2O(l)$
or $Al^{3+}(aq) + 3CO_3^{2-}(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_3(s) + 3CO_2(g)$

(c) An aqueous solution of copper (II) sulphate contains **tetra aqua copper (II) ions** or **hydrated copper (II) ions;** ($Cu(H_2O)_4^{2-}$) which are blue.
When concentrated hydrochloric acid is added in excess, the chloride ions **displace** the water ligands and this leads to formation of **tetra chloro copper(II) ions** ($CuCl_4^{2-}$) which are **yellow.**
$Cu(H_2O)_4^{2-}(aq) + 4Cl^-(aq) \longrightarrow CuCl_4^{2-}(aq) + 4H_2O(l)$
However, since the above reaction is **reversible,** when water is added, the solution turns blue but **not black** as the question stated

Question. Six.

(a) In bromo benzene the **lone pair of electrons** on the bromine atom **interacts** with the **pie electrons** of the benzene ring. This **strengthens** the carbon-bromine bond making it **difficult to break** and hence no **reaction**
In 1-bromobutane, there is no such effect since it **lacks the pie electrons.** However the more **electronegative** bromine atom withdraws the bonding electrons from the carbon-bromine bond towards itself creating a **partial positive charge** on carbon and this renders it **electon deficient** and hence can be attacked by the nucleophile therefore 1-bromo butane undergoes nucleophilic substitution.

(b) Phenol has a **high proportion** of the **hydrophobic phenyl group** making it slightly soluble in water. However it is slightly **acidic** and thus can **react** with **alkaline** sodium hydroxide to form **sodium phenoxide** which is a **soluble salt**



(c) Iodine molecules are **non polar** and therefore **do not react** with water or **do not form bonds** with **polar** water molecules hence iodine is spraringly soluble in water. However, iodine reacts with potassium iodide to form **soluble potassium tri iodide**
$I_2(s) + KI(aq) \longrightarrow KI_3(aq)$
or, $I_2(s) + I^-(aq) \longrightarrow I_3^-(aq)$

(d) Fluorine atom has a **smaller atomic radius** and **highly electronegative** compared to chlorine
The hydrogen-fluorine bond is thus **highly polarized** compared to hydrogen-chloride bond. The molecules of hydrogen fluoride therefore associate through **intermolecular hydrogen bonds** which are **strong** and hence cannot easily break, making hydrogen fluoride to have higher boiling point.
The hydrogen chloride molecules on the other hand are held together by **weak vander waal's forces** and hence can easily be broken.
The covalent bond in hydrogen-fluoride is **much stronger** than in hydrogen chloride due to the **smaller atomic radius** of fluorine atoms compared to chlorine. The hydrogen-fluorine bond is **much more difficult** to break than the hydrogen - chlorine bond and thus **fewer** hydrogen-fluoride molecules ionize to form hydrogen ions

$HF(aq) \longrightarrow H^+(aq) + F^-(aq)$
$HCl(aq) \longrightarrow H^+(aq) + Cl^-(aq)$

Question. Seven.

(a) State that; The ratio of the concentration of the solute between two **immiscible solvents in contact** is a constant at a **constant temperature** provided the solute remains in the **same molecular state** in each solvent.

(b) - The succinic acid is added to the mixture of water and ether (ethoxyethane) in the same container.
- The mixture is shaken until all the acid dissolves and left to stand until equilibrium is attained at a **constant temperature**
- A **known volume** of each layer is pipetted and titrated with a **standard** solution of **sodium hydroxide** using **phenolphthalein indicator.**
- The concentration of the acid in each layer is calculated.
- The ratio of the concentration of the acid in the two layers is calculated and is the distribution coefficient, i.e

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Distribution coefficient; $K_D = \frac{concentration\ of\ succinic\ acid\ in\ water}{concentration\ of\ succinic\ acid\ in\ ethoxyethane}$

Alternatively;

- **Equal volumes** of water and ether are shaken with a **known mass** of succinic acid in the same container.
- The temperature is then noted
- After settling, a known volume of aqueous layer is titrated with a standard solution of **sodium hydroxide** using **phenolphthalein indicator**.
- The concentration of the acid in the aqueous layer is calculated and hence the **total mass** of the acid in the whole aqueous layer is determined.
- **By subtraction**, the mass of the acid in the ether layer is determined.
- The ratio of the masses in the two equal volumes of water and ether is calculated and is the distribution coefficient.

(c) (i) Let mass of z extracted by 100cm^3 of ether $= xgrams$

Mass of z left in water $= (30 - x)grams$

$concentration\ of\ Z\ in\ ether = \frac{x}{100}$ and $concentration\ of\ Z\ in\ water = \frac{30-x}{100}$

From; $K_D = \frac{concentration\ of\ Z\ in\ ether}{concentration\ of\ Z\ in\ water} = 5$

Hence; $\frac{x}{100} \times \frac{100}{(30-x)} = 5$

$x = 5(30 - x)$

$x = 150 - 5x$

Therefore; $x = 25$g

(ii) Let; mass of z extracted by the first 50cm^3 portion of ether $= ygrams$.

Hence; mass of z remaining in water after first extraction with ether $= (30 - y)$ grams

Therefore; $\frac{y}{50} \times \frac{100}{(30-y)} = 5$

$2y = 5(30 - y)$

$y = 21.43$g

Hence; in the second extraction;

Mass of z left available in water $= 30 - 21.43 = 8.57$g

Let; mass of z extracted by the second 50cm^3 portion of ether $= w$g

Mass of z left in water after second extraction with ether $= (8.57 - w)$g

$\frac{w}{50} \times \frac{100}{(8.57-w)} = 5$

$2w = 5(8.57 - w) = 5$

$w = 6.12$g

Hence; $Total\ mass\ of\ z\ extracted = 21.43 + 6.12 = 27.55$g

(d) - **Excess** aqueous ammonia is added to a **standard** solution of copper (II) ions

- Tri chloromethane is then added to the mixture, shaken and allowed to settle for some time.
- A known volume of the organic layer is pipetted and titrated with a **standard** solution of hydrochloric acid using phenolphthalein indicator
- The concentration of ammonia in the organic layer is calculated.
- From a known value of the partition coefficient; K_D, the concentration of the free ammonia in the aqueous layer is determined
- A known volume of the aqueous layer is titrated with a standard solution of hydrochloric acid using phenolphthalein indicator and the total concentration of free and complexed ammonia is calculated.
- By subtraction, the concentration of the complexed ammonia in aqueous layer is determined
- The formula of the complex formed is then determined from the ratio of the concentrations of complexed ammonia to that of the copper (II) ions

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Question. Eight.

(a) (i) magnesium **burns** with a **bright white flame** forming a **white solid**

$Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$

(ii) Barium **dissolves** to give a **colourless solution**, an **effervescence** of a **colourless gas** occurs

$Ba(s) + 2H_2O(l) \longrightarrow Ba(OH)_2(aq) + H_2(g)$

(b) **Dilute sulphuric acid**

Beryllium on warming reacts with dilute sulphuric acid to form **beryllium sulphate** solution and **hydrogen**

Barium reacts with dilute sulphuric acid to form hydrogen and **sparingly soluble barium sulphate** which retards the reaction

$Be(s) + H_2SO_4(aq) \longrightarrow BeSO_4(aq) + H_2(g)$

$Ba(s) + H_2SO_4(aq) \longrightarrow BaSO_4(aq) + H_2(g)$

Concentrated sulphuric acid

Beryllium reduces **heated concentrated** sulphuric acid to **sulphur dioxide** and water and the beryllium is oxidized to **beryllium sulphate** solution

$Be(s) + 2H_2SO_4(aq) \longrightarrow BeSO_4(aq) + SO_2(g) + 2H_2(g)$

Barium has **little** or no **effect** on hot concentrated sulphuric acid because it forms **barium sulphate** which is **sparingly soluble.**

(c) The solubility of the hydroxides of group (II) elements **increases from beryllium hydroxide to barium hydroxide.**

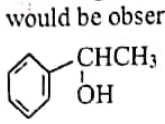
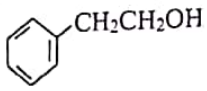
This is because from beryllium hydroxide to barium hydroxide the **cationic radius increases** hence both the **lattice energy and hydration energy decrease.**

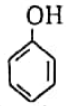
However, the **lattice energy decreases more rapidly** than hydration energy and consequently the **heat of solution becomes more exothermic** hence leading to **increased solubility.**

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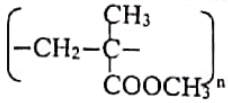
QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2003

1. (a) Define the term freezing point constant of a substance. (1½ mark)
   (b) A solution containing 1.54g of naphthalene ($C_{10}H_8$) in 18g of camphor freezes at 148.3°C. Calculate the freezing point constant of camphor. (the freezing point of camphor is 175°C) (3½ marks)
2. (a) State three properties in which beryllium resembles aluminium (3 marks)
   (b) (i) What is the name given to the type of relationship in (a)? (1 mark)
   (ii) Name another pair of elements that show the type of relationship in (a). (1mark)
3. Name one reagent that can be used to distinguish between each of the following pairs of compounds and state what would be observed in each case if the reagent is reacted with the compounds: (3 marks)

   (a)  and 

   (b)  and $CH_3CH_2CH_2CH_2OH$ (3 marks)
4. (a) Define the term molar enthalpy of hydration. (2 marks)
   (b) The table below shows enthalpies of hydration of Mg^{2+} and Cl^- ions

Ion	Enthalpy of hydration $\Delta H\ hyd/kJmol^{-1}$
Mg^{2+}	1891
Cl^-	381

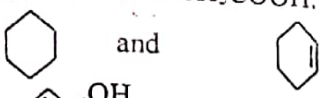
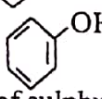
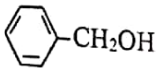
   (i) State whether the values of enthalpies of hydration given in the table above is positive or negative. Give a reason for your answer. (2 marks)
   (ii) Calculate the enthalpy of hydration of magnesium chloride. (1½ marks)
5. (a) Draw the shape of a sulphite ion SO_3^{2-} (1 mark)
   (b) Write equation to show the reaction between sulphate ions and
   (i) iron(III) chloride (1½ marks)
   (ii) potassium dichromate in acid solution (1½ marks)
6. A solution containing $2.3\times 10^{-6} mol\ dm^{-3}$ of aluminium hydroxide completely ionizes in water ($K_w = 1\times 10^{-14}$)
   (a) Write equation for the reaction of aluminium hydroxide (1½ marks)
   (b) Calculate the pH of the resultant solution. (3 marks)
7. (a) When 4.90g of an organic compound, X containing carbon and hydrogen only was burnt in oxygen, 15.78g of carbon dioxide and 5.38g of water were formed. Calculate the empirical formula of X. (2½ marks)
   (b) X was steam distilled at 80°C and 760mmHg and the distillate was found to contain 90.8% by mass of X. (The vapour pressure of water at 80°C *is*240mmHg)
   (i) Calculate the formula mass of X. (2½ marks)
   (ii) Deduce the molecular formula of X. (1 mark)
8. A crystalline solid Y dissolved in water to give a pink solution, Addition of excess aqueous sodium hydroxide produced a dirty white precipitate which reapidly turned brown on standing.
   When nitric acid was added to the solution of Y followed by sodium bismuthate solution, the solution changed from pink to purple.
   (a) Identify the cation in Y. (1 mark)
   (b) Write:
   (i) the equation for the reaction that took place when sodium hydroxide was added to the solution.
   (ii) the formula of rthe species responsible for the purple colour. (1 mark)
   (iii) equation for the leading to the formation of the brown solid. (1½ marks)
9. Perspex is a synthetic polymer of formula: 

   (a) (i) Write the structural formula of the monomer of Perspex (1 mark)
   (ii) State the type of polymerization involved in the formation of Perspex. (1 mark)
   (b) When 1.25×10^{-3} moles of Perspex was heated in the presence of silca as a catalyst, 4.85g of monomer was produced. Determine the monomer molecules (n) (3 marks)
10. (a) Name a reagent that can be used to distinguish between the following pairs of ions. In each case, state what is observed if each ion is separately treated with the reagent.
   (i) Ba^{2+} and Ca^{2+} (3 marks) (ii) NO_2^- and NO_3^- (3 marks)
   (b) Write ionic equations for the reaction between sodium hydroxide and
   (i) BeO (1½ marks) (ii) SiO_2 (1 ½ marks)

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11. Write equations to show how the following compounds can be synthesized.
(a) CH_3CHO from 1,2 – dibromoethane
(b) CH_3CO_2H from iodomethane
(c) $CH_3COOCH_2CH_3$ from chloroethane (3 marks)

12. (a) The vapour pressure of a solution containing 108.2g of a substance Y in 1000g of water at 20°C was reduced by 0.186mmHg. (*The vapour pressure of water at 20°C is 17.54mmHg*) Calculate the relative molecular mass of substance Y. (2 ½ marks) (3 ½ marks)
(b) State four assumptions made in (a) (4 marks)
(c) Explain why the vapour pressure of solution containing a non-volatile solute is less than the vapour pressure of a pure solvent. (2 marks)

13. Name the reagent that would be used to distinguish between the following pairs of compounds. In each case, state what would be observed if the reagent is treated separately with each pair of compounds.
(a) HCOOH and CH_3COOH. (3 marks)
(b)  and (3 marks)
(c)  and  (3 marks)

14. 1mole of sulphur trioxide was introduced into a $1dm^3$ vessel. The vessel was heated to 1000K until equilibrium was attained. At equilibrium 0.35 mole of sulphur trioxide was present.
(a) Write:
(i) equation for the decomposition of sulphur trioxide. (1 mark)
(ii) an expression for the equilibrium constant, k_c (1 mark)
(b) Calculate the k_c value. (3 marks)
(c) 0.2 mole of SO_2 0.1mole of O_2 and 0.7mole of SO_3 was introduced into the vessel in (a) at 1000K.
(i) Calculate the new k_c for the reaction value. (3 marks)
(ii) Using your answers in (a) (ii) and (b) (i) above, state how the position of equilibrium has been affected. (1 mark)

15. (a) Compound X, C_3H_6O reacts with 2, 4-dinitrophenyl hydrazine to form a yellow solid. Write the structural formulae of all the possible iomers of X. (1 mark)
(b) X does not react with Tolle identify X
(c) Write equation and indicate a mechanism for the reaction between X and 2, 4-dinitrophenyl hydrazine under acid conditions. (4½ marks)
(d) Write equation to show how X can be prepared from an alkene. (3 marks)

16. (a) State what is meant by the term Order of a reaction. (2 marks)
(b) Methyl ethanoate is hydrolyzed by water in the presence of an acid according to the following equation:

$$CH_3CO_2CH_3 + H_2O \overset{H^+}{\rightleftharpoons} CH_3CO_2H + CH_3OH.$$

(i) State the molecularity of the reaction (1 mark)
(ii) Determine the order of reaction (assume that the acid takes part in the reaction) (2 marks)
(iii) State the conditions under which the reaction can be overall first order.
(c) The table below shows some Kinetics data for the following reaction:

$3A + B \longrightarrow 2P$

Experiment	Initial concentration of A (mol dm^{-3})	Initial concentration of B (mol dm^{-3})	Initial rate (mol dm^{-3})
1	0.20	0.20	1.2×10^{-8}
2	0.20	0.60	1.2×10^{-8}
3	0.40	0.60	4.8×10^{-8}

(1½ marks)
(i) Write the overall rate equation. (1½ marks)
(ii) Calculate the rate constant and give its units. (1½ marks)

17. (a) Write the equation for the:
(i) Solubility of silver chromate in water. (1 mark)
(ii) Solubility constant, K_{sp} of silver chromate.
(b) The solubility of silver chromate at 25°C is $3.207\times 10^{-2} gmd^{-3}$. Calculate the solubility constant for the silver chromate at 25°C. (3 marks)
(c) Determine the molar concentration of silver ions required to precipitate silver chromate from an aqueous solution containing 0.005M chromate ions. (2 marks)
(d) A solutioncontaining silver ions was added to a solution containing 0.005M chromate ions and 0.005M chloride ions. State which of the salts AgCl or $AgCrO_4$ was precipitate first. Give a reason for your answer. (1½ marks)END
[Ksp; for AgCl = $1.96\times 10^{-10} mol^2 l^{-2}$]

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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2003

1. (a) The freezing point depression caused when **one mole** of a **non volatile** solute is dissolved in **1000g** of pure solvent.

(b) Freezing point depression = $175 - 148.3 = 26.7°C$

Molecular mass of naphthalene ($C_{10}H_8$) = $(10 \times 12) + (8 \times 1)$

$= 128g$

$18g\ of\ camphor\ dissolved\ 1.54g\ of\ naphthalene$

$\therefore 1000g\ of\ camphor\ dissolved\ \frac{1000 \times 1.54}{18}g\ of\ naphthalene$

$= 85.556g\ of\ napthalene$

85.556g of naphthalene cause a freezing point depression of 26.7°C

$\therefore 128g\ of\ naphthalene\ cause\ a$ freezing point $depression\ of\ \left(\frac{128 \times 26.7}{85.556}\right)°C$

$= \underline{39.95°C}$

Hence; freezing point constant of camphor = $39.95°C mol^{-1}Kg^{-1}$

2. (a) Both metals react with concentrated solutions of alkalis
Both metals form some covalent compounds
Both metals are rendered passive by concentrated nitric acid
Both metals form hydroxides and oxides which are amphoteric.

(b) (i) Diagonal relationship
(ii) Lithium and magnesium
Boron and silicon

3. (a) Reagent –Anhydrous zinc chloride and concentrated hydro chloric acid

Observation;  $CH\ CH_3$ –forms a **cloudy solution** within **5 -10minutes**

OH

 $CH_2\ CH_2\ OH$ **Does not** form a cloudy solution at room temperature

(b) Reagent – Neutral iron(III) chloride solution

Observation;  -Forms a purple or violet colouration

$CH_3\ CH_2\ CH_2\ CH_2\ OH$ –gives no observable change

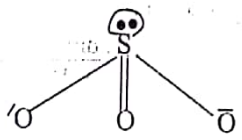
4. (a) The heat change which occurs when **one mole** of **gaseous ions** are **surrounded by water molecules** to form an **infinitely dilute solution** with **no change in pH.**

(b) (i) The values of the enthalpies of hydration of both ions are **negative**
The hydration of both ions involves **attraction of water molecules by gaseous** Ions, during which **heat energy is liberated** to the surroundings.

(ii) $\Delta Hhyd(MgCl_2) = \Delta Hhyd(Mg^{2+}) + 2\Delta Hhyd(Cl^-)$

$= -1891 + 2(-381)$

$= -2653 KJmol^{-1}$

5. (a) 

(b) (i) $2Fe^{3+}(aq) + H_2O(l) + SO_3^{2-}(aq) \longrightarrow 2Fe^{2+}(aq) + 2H^+(aq) + SO_4^{2-}(aq)$

or $2FeCl_3(aq) + H_2O(l) + SO_3^{2-}(aq) \longrightarrow 2FeCl_2(aq) + 2HCl(aq) + SO_4^{2-}(aq)$

(ii) $Cr_2O_7^{2-}(aq) + 8H^+(aq) + 3SO_3^{2-}(aq) \longrightarrow 2Cr^{3+}(aq) + 3SO_4^{2-}(aq) + 4H_2O(l)$

6. (a) $Al(OH)_3(aq) \rightleftharpoons Al^{3+}(aq) + 3\bar{O}H(aq)$

(b) $[\bar{O}H] = 3 \times 2.3 \times 10^{-6}$

$= 6.9 \times 10^{-6} moldm^{-3}$

$Kw = [H^+][\bar{O}H]$

$[H^+] = \frac{Kw}{\bar{O}H}$

$= \frac{1 \times 10^{-14}}{6.9 \times 10^{-6}} = 1.45 \times 10^{-9} moldm^{-3}$

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But; $pH = -\log_{10}[H^+]$

$= -\log_{10} 1.45 \times 10^{-9}$

$= 8.84$

7. (a) Mass of carbon in $X = \frac{12}{44} \times 15.78 = 4.30g$

$\%\ of\ carbon\ in\ X = \frac{4.30}{4.90} \times 100 = 87.76\%$

Mass of hydrogen in $X = \frac{2}{18} \times 5.38 = 0.5998g$

$\%\ of\ hydrogen\ in\ X = \frac{0.5998}{4.90} \times 100 = 12.20\%$

Composition of X;

	C		H
Moles;	$\frac{87.76}{12}$		$\frac{12.20}{1}$
	7.31		12.20
Mole ratio;	$\frac{7.31}{7.31}$		$\frac{12.20}{7.31}$
	(1		1.67) × 3
	3	:	5

Emperical formula of X is C_3H_5

(b) (i) % by mass of water in distillate = 100 − 90.8 = 9.2%

Vapour pressure of X = 760 − 240 − 520$mmHg$

Hence; $\frac{\%\ of\ X\ in\ distillate}{\%\ of\ H_2O\ in\ distillate} = \frac{V.pressure\ of\ x (Rmm\ of\ x)}{V.press\ of\ H_2O \times Rmm\ of\ H_2O}$

$\frac{90.8}{9.2} = \frac{520 \times Rmm\ of\ X}{240 \times 18}$

Formula mass of water $= \frac{90.8 \times 240 \times 18}{9.2 \times 520}$

$= 82g.$

(ii) $(C_3H_5)n = 82$

$(3 \times 12)n + (5 \times 1)n = 82$

$41n = 82$

$\therefore n = \frac{82}{41} = 2$

$\therefore$ *molecular formula of X is* C_6H_{10}

8. (a) Hydrated manganese(II) ion

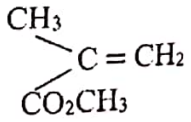
(b) (i) $Mn^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Mn(OH)_2(s)$

(ii) $MnO_4^-(aq)$

(iii) $2Mn(OH)_2(s) + O_2(g) \longrightarrow 2MnO_2 \cdot H_2O(s)$

or $2Mn(OH)_2(s) + \frac{1}{2}O_2(g) \longrightarrow M_2O_3 \cdot 2H_2O(s)$

9. (a) (i)



(ii) Addition polymerization.

(b) Molecular mass of the monomer $= (12 \times 5) + (16 \times 2) + (8 \times 1)$

Number of moles of monomers in $4.85g = \frac{4.85}{100} = 4.85 \times 10^{-2}$ moles

Hence; 1.25×10^{-3} *moles of perpex produced* 4.85×10^{-2} *moles of monomer*

$\therefore$ *1mole of perspex produced* $\frac{4.85 \times 10^{-2}}{1.25 \times 10^{-3}}$ moles of monomer

Thus; number of monomer molecules $(n) = 39$

10. (a) (i) Reagent – Potassium chromate(VI) solution and ethanoic acid

Observation; Ba^{2+} -gives a **yellow precipitate, insoluble** in ethanoic acid

Ca^{2+} - **Faint yellow** precipitate **soluble** in ethanoic acid

Alternatively,

Reagent – Ammonium oxalate solution and ethanoic acid

Observation; Ba^{2+} -gives a **white precipitate, soluble** in ethanoic acid

Ca^{2+} - gives a **white precipitate insoluble** in ethanoic acid

(ii) Reagent – Acidified Potassium dichromate (VI) **solution**

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Observation; NO_2^- - solution turns from **orange** to **green**
NO_3^- - No observable change

Alternatively;
Reagent – acidified potassium manganate (VII) **solution**
Observation; NO_2^- - Solution turns from **purple** to **colourless**
NO_3^- - No observable change

Alternatively;
Reagent -Iron (II) sulphate solution which is freshly prepared and concentrated sulphuric acid
Observation; NO_3^- -forms a brown ring at the junction of the two liquids
NO_2^- - No observable change

(b) (i) $BeO(s) + 2\bar{O}H(aq) + H_2O(l) \longrightarrow Be(OH)_4^{2-}(aq)$
or $BeO(s) + 2\bar{O}H(aq) \longrightarrow BeO_2^{2-}(aq) + H_2O(l)$
(ii) $SiO_2(s) + 2\bar{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + H_2O(l)$

11. (a) $CH_2BrCH_2Br \xrightarrow[\text{heat}]{\text{KOH/Ethanol Or } (Et\bar{O}/EtOH)} HC \equiv CH \xrightarrow[HgSO_4/60°C]{H_2O/\text{dilute } H_2SO_4} CH_3CHO$

or $CH_2BrCH_2Br \xrightarrow[\text{catalyst}]{H_2/\text{Lindlar's}} H_2C = CH_2 \xrightarrow[2.\ H_2O/\text{warm}]{1.\ \text{conc. } H_2SO_4} CH_3CH_2OH$

$CH_3CH_2OH \xrightarrow[\text{heat}]{Cr_2O_7^{2+}/H^+ \text{ or } (MnO_4^-/\text{conc.}H_2SO_4)} CH_3CHO$

(b) $CH_3I \xrightarrow[\text{heat}]{KCN/\text{Alcohol}} CH_3CN \xrightarrow[\text{heat}]{H_2O/H^+} CH_3COOH$

Alternatively;

$CH_3I \xrightarrow[\text{dryether}]{Mg} CH_3MgI \xrightarrow[H^+/H_2O]{CO_2} CH_3COOH$

(c) $CH_3CH_2Cl \xrightarrow[\text{heat}]{\bar{O}H(aq)} CH_3CH_2OH \xrightarrow[\text{or } (Cr_2O_7^{2-}/H^+)]{CrO_3/H^+} CH_3CO_2H$

$CH_3CO_2H \xrightarrow[\text{Conc. } H_2SO_4,\ \text{warm}]{CH_3CH_2OH} CH_3COOCH_2CH_3$

Alternatively;

$CH_3CH_2Cl \xrightarrow[\text{heat}]{\bar{O}H(aq)} CH_3CH_2OH \xrightarrow[\text{Conc. } H_2SO_4,\ \text{heat}]{MnO_4^-} CH_3COOH$

$CH_3COOH \xrightarrow{PCl_5 \text{ or, } SOCl_2} CH_3COCl$

$CH_3CO_2CH_2CH_3 \xrightarrow{CH_3CH_2OH} CH_3COCl$

12. (a) From Raoull's law of vapour pressure lowering;

$$\frac{P\ solvent - P\ solution}{P\ solvent} = \frac{M\ solute \times Mr\ solvent}{M\ solvent \times Mr\ solute}$$

Hence; $\frac{P\ water - P\ solution}{P\ water} = \frac{M\ Y \times Mr(H_2O)}{MH_2O \times Mr(Y)}$

$$\frac{0.186}{17.54} = \frac{108.2 \times 18}{1000 \times MrY}$$

$$\therefore Molecular\ mass\ of\ Y; MrY = \frac{17.54 \times 108.2 \times 18}{0.186 \times 1000} = \mathbf{183.66}g$$

(b) Solution should be **dilute**
Solute should be **non volatile**
Solute (Y) does not react with solvent (water)
Solute **does not associate** or **dissociate** in solution

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(c) The molescules of the non volatile solute **occupy part** of the surface of the solution hence **reducing the escaping tendency** of the volatile solvent molecules in solution into vapour phase, thereby **reducing the vapour pressure** of the solution.

13. (a) Reagent- Ammoniacal silver nitrate **solution**
Observation; HCO_2H – forms a **silver mirror** on the sides of the test tube
CH_3COOH – **No observable change**

(b) Reagent – Acidified Potassium manganate (VII) **solution**
Observation;  - Solution turns from **purple** to **colourless**

 - Gives **no observable change**

Alternatively; Reagent – Bromine water
Observation;  -Turns bromine water from **reddish brown** to **colourless**

 -Gives **no observable change**

(c) Reagent – Neutral iron (III) chloride solution
Observation;  -Gives a **purple** or **violet colouration**

 -Gives no observable change

14. (a) (i) $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$

(ii) $Kc = \frac{[SO_2]^2[O_2]}{[SO_3]^2}$

(b)

	$2SO_3(g)$	$\rightleftharpoons$	$SO_2(g)$	+	$O_2(g)$
Initially;	1mole		0		0
At **Equilibrium**	0.35mole		(1 – 0.35) = 0.65mole		½(1 – 0.35) 0.325mole

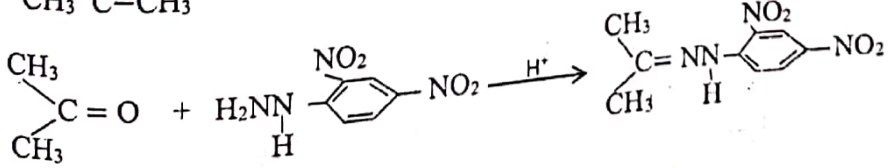
$$Kc = \frac{(0.65)^2 \times (0.325)}{(0.35)^2} = \mathbf{1.121\ moldm^{-3}}$$

(c) (i) New; $[SO_2] = 0.65 + 0.2 = 0.85M$
$[O_2] = 0.325 + 0.1 = 0.425M$
$[SO_3] = 0.35 + 0.70 = 1.05M$
New; $Kc = \frac{[SO_2]^2[O_2]}{[SO_3]^2}$
$= \frac{(0.85)^2 \times (0.425)}{(1.05)^2}$ $= \mathbf{0.279 moldm^{-3}}$

(ii) The value of the Kc in (b) is greater than that in (c)
This means that the equilibrium position has **shifted from right to left.**

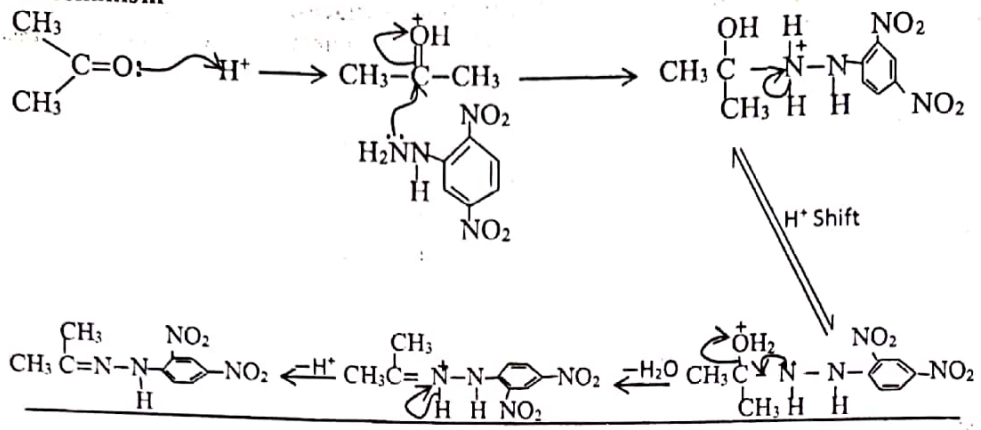
15. (a) $CH_3\overset{O}{\overset{\|}{C}}-CH_3$, $CH_3CH_2-\overset{O}{\overset{\|}{C}}-H$

(b) $CH_3\overset{O}{\overset{\|}{C}}-CH_3$

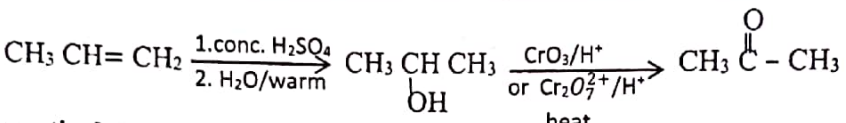
(c) 

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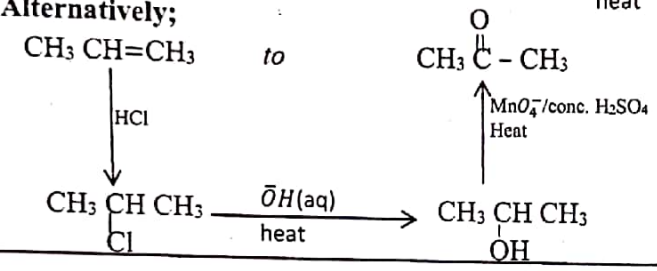
Mechanism



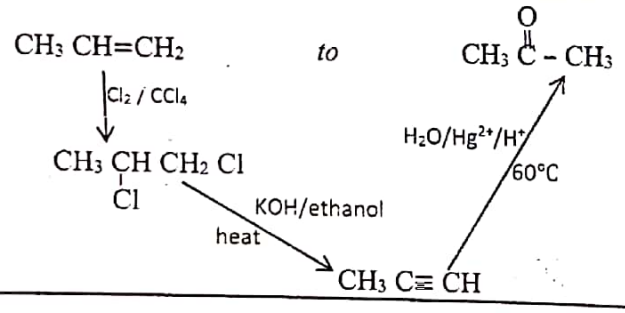
(d)



Alternatively;



or,



16. (a) The sum of the powers to which the **molar** concentrations of the reactants are raised in an **experimentally** determined rate equation.

(b) (i) Two

(ii) Three

(iii) When the water or the ester is in excess

When the concentration of the catalyst is unchanged during the reaction.

(c) (i) Rate $= k[A]^2[B]^0$

Hence; $Rate = k[A]^2$

(ii) $Rate\ constant; k = \frac{Rate}{[A]^2[B]^0}$

$= \frac{1.2\times10^{-8}}{(0.2)^2}$ (substitution using experiment 1)

$= 3.0 \times 10^{-7} mol^{-1}dm^{-3}S^{-1}$

Note: See methods of determining order of reaction from solution to question 4, 2019; P1

17. (a) (i) $Ag_2CrO_4(s) \rightleftharpoons 2Ag^+(aq) + CrO_4^{2-}(aq)$

or, $Ag_2CrO_4(s) + (aq) \rightleftharpoons 2Ag^+(aq) + CrO_4^{2-}(aq)$

(ii) $Ksp = [Ag^+]^2[CrO_4^{2-}]$

(b) Formula mass of $Ag_2CrO_4 = (2 \times 108) + (1 \times 52) + (4 \times 16) = 332g$

Solubility of Ag_2CrO_4 $\frac{3.207\times10^{-2}}{332} = 9.66 \times 10^{-5} \text{moldm}^{-3}$

Thus; $[CrO_4^{2-}] = 9.66 \times 10^{-5}$M and $[Ag^+] = 2 \times 9.66 \times 10^{-5}$M

Hence; $Ksp(Ag_2CrO_4) = [Ag^+]^2[CrO_4^{2-}]$

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$= (2 \times 9.66 \times 10^{-5})^2(9.66 \times 10^{-5})$
$= 3.6 \times 10^{-12} mol^3 dm^{-9}$

(c) $Ksp = [Ag^+]^2[CrO_4^{2-}]$

$3.6 \times 10^{-12} = [Ag^+]^2 \times 0.005$

$[Ag^+] = \sqrt{\frac{3.6 \times 10^{-12}}{0.005}} = 2.68 \times 10^{-5}$ moldm^{-3}

(d) $[Ag^+]$ required to precipitate AgCl $= \frac{Ksp(AgCl)}{[Cl^-]}$

$= \frac{1.96 \times 10^{-10}}{0.005} = 3.92 \times 10^{-8}$ moldm^{-3}

AgCl precipitated out first.

This is because the concentration of silver ions required to precipitate silver chloride is lower than that required to precipitate silver chromate.

QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2003

1. (a) State what is meant by the term **boiling point constant** of a liquid. (2 marks)
   (b) Descfribe an experiment that can be to determeine the relative molecular mass of a compound using the method of elevation of boilng point of a point. Draw a labelled diagram of the apparatus used. (2 marks)
   (c) Explain why the method you have descrfibed in (b) is not suitable for determination of the relative molecular mass of ethaoic acid in aqueous solution. (3 marks)
   (d) A solution of 2.8 g of cadmium(II) iodide in 20g of water boiled at 100.2°C at normal pressure. Calculate the relative molecular mass of cadmium(II) iodide and comment on your result.
   [The boiling point elevation constant for water is 0.52°C per mole per 1000g] (3 marks)

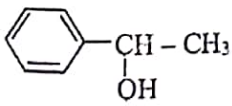
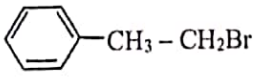
2. The molarity of a sample of hydrochloric acid about 0.1M was determined accurately by measuring the conductivity of the solution as 1.0M sodium hydroxide was added to 50cm^3 of the acid. The results were as follows:

Conductivity/$\Omega^{-1}cm^{-1}$	4.1	3.3	2.4	1.7	1.5	1.8	2.2	2.5
Volume of 1.0M NaOH/cm^3	1	2	3	4	5	6	7	8

   (a) (i) Plot a graph of conductivity against volume of 1.0M sodium hydroxide. (3 marks)
   (ii) Determine friom the graph the volume of 1.0M sodium hydroxide used to reacah the end-point.(1 mk)
   (iii) Calculate the molarity of the hydrochloric acid. (2 marks)
   (iv) Explain the shape of the graph. (3 marks)
   (b) Name one otjer application of conductivity measurement. (1 mark)
   (c) Explain what is meant by the term **standard electrode potential** (2 marks)
   (d) Some half cells and their e.m.f's are given below.

Half-cell	**e.m.f(volts)**
$I_2(aq)/2I^-(aq)$	0.54
$Fe^{3+}(aq) / Fe^{2+}(aq)$	0.76

   (i) Write the cell conversion for a cell made up of the halfcells. (1 mark)
   (ii) Write equation for the cell reaction (1 ½ marks)
   (iii) Determine the e.m.f of the cell. (1 mark)
   (iv) Calculated the standard free energy for the reaction and indicate its un it. (2 ½ marks)
   (v) State whether the reaction in (ii) is possible or not and give a reason for your answer. (2 marks)

3. (a) Name the pair(s) of functional group that can be distinguished using the following reagents. In each case, state what would be observed if each member of the pair is separately treated with the reagent.
   (i) Ammonical silver nitrate (6 marks)
   (ii) Iron(III) chloride. (3 marks)
   (b) Write equations to show how the following compoundfs can be synthesized:
   (i) Propanone from ethanol (3 marks)
   (ii) Ethyne from ethanol (5 marks)
   (iii)  from  (3 marks)

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4. (a) Explain why fluorine shows some differenced in its properties from the rest of the elements (chlorine, bromine and iodine) of the Periodic Table. (3 marks)
(b) State the differences between the chemistry of fluorine and the rest of the cleemnts of Group(VII) of the Periodic Table. (3 marks)
(c)Write equations to compare the reactions of fluorine and chlorine when they react separately with
(i) water (½ mark)
(ii) cold dilute sodoum hydroxide (3 marks)
(iii) hot concentrated sodium hydroxide (3 marks)
(d) Write equation for the reatgion beytween hydrofluoric acid and silicon dioxide (3 marks)
(1 ½ marks)

5. (a) Draw diagrams to show the change in pH when a 0.1M sodium hydroxixe solution is added in portions to;
(i) 20 cm^3 of a 0.1M hydrochloric acid. (2 marks)
(ii) 20 cm^3 of a 0.1M ethanoic acid. (2 marks)
(b) Explain the shapes of the curves in (a) (13 marks)
(c) 20 cm^3 of 0.1M sodium hydroxide solution was added to 100cm^3 of a 0.1M ethanoic acid. Calculate the pH of the resultant solution. (*Ka fro ethanoic acid is* 1.75×10^{-5}) (3 marks)

6. (a) Complete the following wequations and in deach case outline a mechanism for the reaction.
(i) $CH_3\,CH_2OH \xrightarrow[140^oC]{conc.H_2SO_4}$ (3 marks)

(ii) $(CH_3)_3CBr \xrightarrow[\text{heat}]{C_2H_5O^-K^+/C_2H_5OH}$ (3 marks)

(iii) $CH_3CH = CHCH_3 \xrightarrow{conc.H_2SO_4/H_2O}$ (4 ½ marks)

(iv)  $+ \; Br_2 \xrightarrow[\text{heat}]{Fe(s)}$ (4 marks)

(v) $CH_3CHO + NaHSO_3 \xrightarrow{H^+}$ (3 marks)

(b) Write the IUPAC names of the oproducts in (a)(i) and (a)(ii) above. (2 marks)
7. (a) Write the name and formula od one ore from which aluminium can be extracted andf descrfibe how aluminium is extracted from the ore. (8 marks)
(b) Write equations and state the conditions under which aluminium reacts with:
(i) air (2 ½ marks)
(ii) sodium hydroxide (2 ½ marks)
(iii) hydrtochloric acid (2 ½ marks)
(c) State what is observed and write equation for the reaction which takes place when aqueous ammonia is added drop-wise to a solution containing aluminium ions. (2 ½ marks)
(d) Write equation for the reaction thatg takes place when aluminium chloride is dissolved in water. (1½ marks)

8. (a) Describe how nitric acid:
(i) is manufactured (9 marks)
(ii) can react with copper (Your answer should include equations for the reactions). (5 marks)
(b) State why nitric acid is not used to acidify potassium manganite (VII) in volumetric analysis (2 marks)
(c) 1.07g of nitrogen congtaining compound was boiled with excess ssodium hydroxide solution to produce ammonia. The ammonia produced neutralized 200cm^3 of a 0.1M monobasic aacid
Calculate thje percentage by mass of nitrogen in the compound. (N = 14, H = 1) (3 marks)
(d) State two industrial uses of nitric acid. (1 mark)

END

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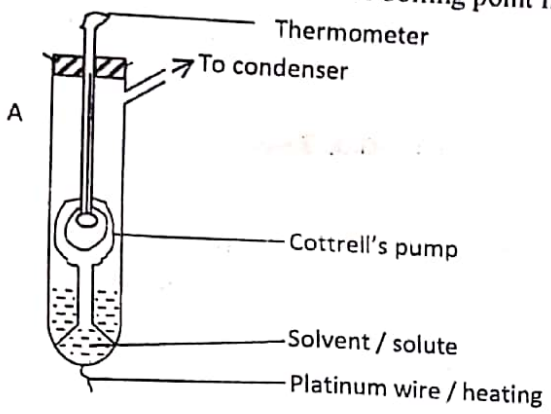
SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2 (P525/2), 2003

Question. One.

(a) The amount by which the boiling point of 1000g of a **solvent** is **elevated** by dissolving one mole of unionized, non-volatile solute in it.

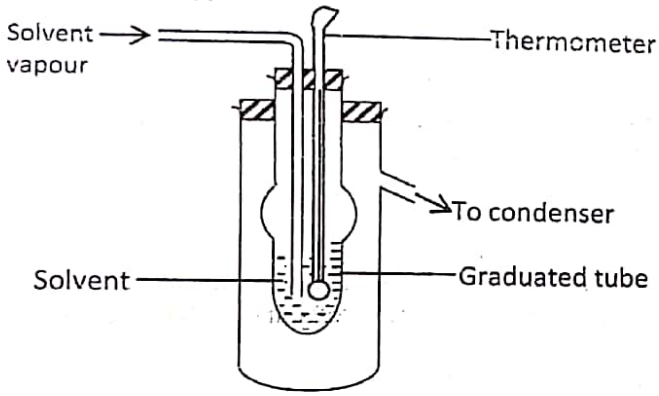
(b) Determination of RMM of a compound by elevation of boiling point method

Cottrell's Apparatus



A known mass of pure solvent (ag) is put in tube A
The solvent is **heated** and its boiling point (T_0 °C) is recorded when the temperature remains **constant**
A **known mass** of the solute (bg) is added through the side arm into the solvent
The solution is heated and its boiling point (T_1 °C) is **recorded**
or

Landsberger's apparatus



A quantity of the (pure) solvent is put in the inner graduated tube
Some amount of the (pure) solvent is boiled in another flask and the vapour passed into the inner tube until the solvent boils
The boiling point of the (pure) solvent (T_0 °C) is recorded
A known mass of the solute, **bg** is dissolved in the solvent
The boiling point of the solution (T_1 °C) is determined
The volume of the solution in the inner tube is read off and knowing its density, the mass of the solvent is calculated, **ag**

Treatment of results

Let the boiling point constant $= Kb\ per\ mole\ per$ 1000g
Elevation of boiling point, $\Delta T = (T_1 - T_0)$°C
If ag of the solvent dissolved bg of solute
1000g of solvent will dissolve $\left(\frac{1000 \times b}{a}\right)$ g of solute
ΔT°C is boiling point elevation caused by $\left(\frac{1000 \times b}{a}\right)$ g of solute
Kb is boiling point elevation caused by $\left(\frac{b}{a} \times 1000 \times \frac{Kb}{\Delta T}\right)$ g of solute
Hence RMM of solute $= \left(\frac{b}{a} \times 1000 \times \frac{Kb}{\Delta T}\right)$

(c) Ethanoic acid ionizes (partly) in aqueous solution

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This increases the number of particles of the solute in solution and thus the determined or calculated relative molecular mass becomes less than the true value or theoretical value

(d) Elevation of *bpt* of water; $\Delta T = 100.2 - 100 \quad = 0.2°C$

20g of water contained 2.8g of CdI_2

1000g of water contained $= \frac{2.8}{20} \times 1000 \quad = 140g$ of CdI_2

0.2°C is an elevation of boiling point caused by 140g of CdI_2

0.52°C is an elevation of boiling point caused by $\frac{140}{0.2} \times 0.52°C = 364g$ ofCdI_2

Hence RMM of $CdI_2 = 364$

Question. Two.

(a) (i) See graph on next page

(ii) $4.5cm^3$

(iii) $NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$

Moles of $NaOH(aq) = \frac{1.0 \times 4.5}{1000} = 4.5 \times 10^{-3} moles$

Mole ratio of HCl to NaOH = 1:1

Moles of acid $= 4.5 \times 10^{-3}$

Hence moles of acid in $1000cm^3 = \frac{4.5 \times 10^{-3}}{50} \times 1000 = 0.09M$

Molarity of $HCl = 0.09M$

(iv) Initially the conductivity is **high** due to **many highly mobile** and **highly** conducting **hydrogen ions** from the **fully ionized acid**

The conductivity **decreases** with addition of sodium hydroxide due to **neutralization** of **hydrogen ions by the hydroxyl ions** and hence the replacement of the hydrogen ions by the slower or less conducting sodium ions

At the end point, **all the acid is neutralized**, hence **minimum conductivity** due to sodium ions, chloride ions from the sodium chloride salt formed and also the ions from water formed.

Beyond the endpoint conductivity **increases** with addition of **excess highly** conducting hydroxyl ions

(b) Determining solubility of sparingly soluble salts.
Determining the degree of ionization of weak electrolytes

(c) Is the reduction electrode potential of an electrode which is the **e.m.f** of the cell

(d) measured with respect to a standard hydrogen electrode of zero volts under standard conditions of (298K and 1atm),

(d) (i) $Pt(s) \mid I^-(aq), I_2(aq), \mid Fe^{3+}(aq), Fe^{2+}(aq) \mid Pt(s)$

(ii) $2I^-(aq) + 2Fe^{3+}(aq) \longrightarrow I_2(aq) + 2Fe^{2+}(aq)$

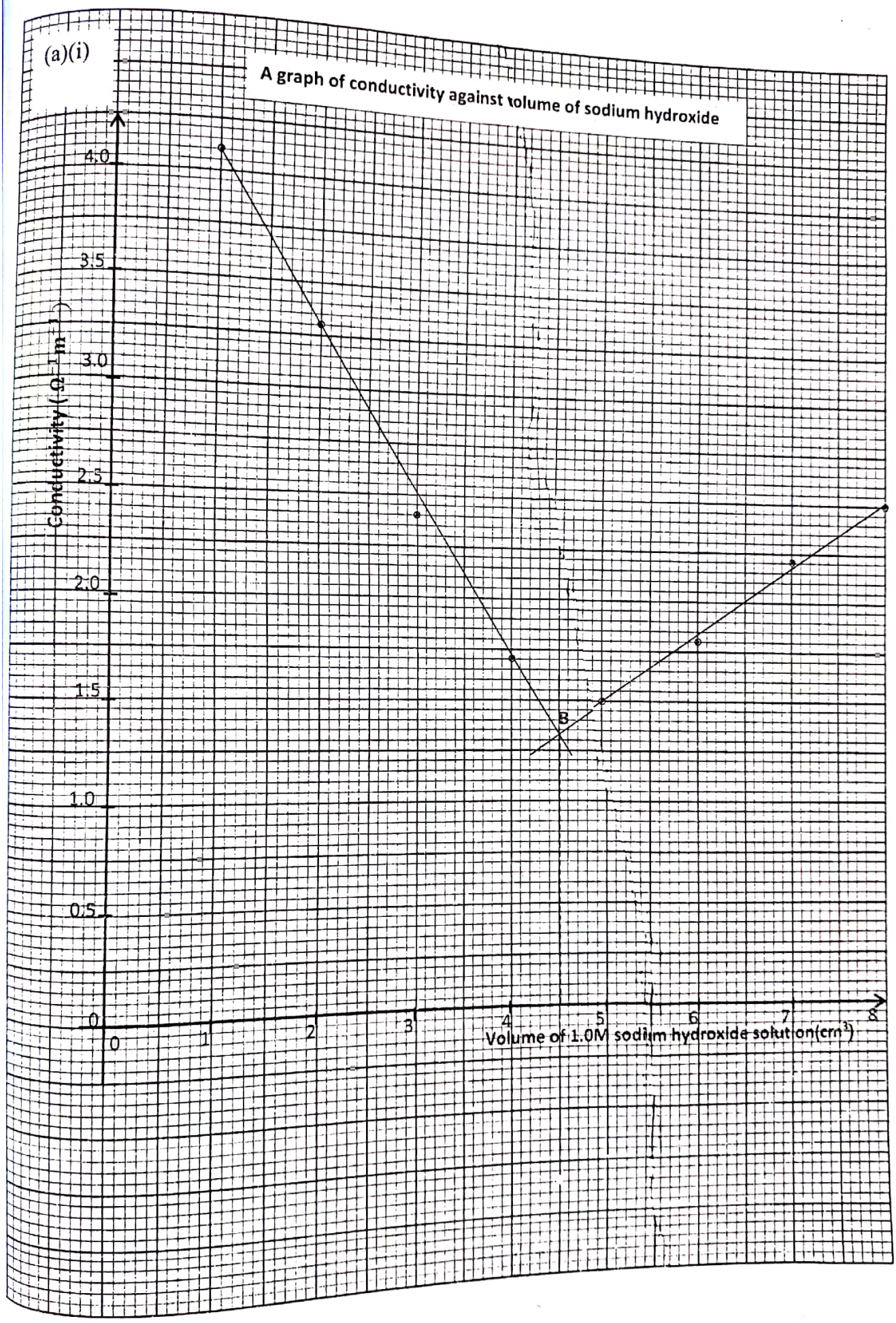
(iii) $E^{\theta}_{cell} = E^{\theta}_{RHE} - E^{\theta}_{LHE}$
$= 0.76 - 0.54 = +0.22V$

(iv) $-\Delta G = -nE^{\theta}F$
$= -2 \times 0.22 \times 96500 = -42460 Jmol^{-1} = \mathbf{-42.46KJmol^{-1}}$

(v) The reaction is possible or feasible because the value of Emf is positive and the standard free energy of cell is negative

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(a)(i)



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Question. Three.

(a) (i) Alkanal or aldehyde and alkanone or ketones

Observations: Aldehydes – silver mirror or grey precipitate
Ketone – no observable change

or, Terminal alkyne and non-terminal alkyne

Observations: Terminal alkyne – white precipitate
Non-terminal alkyne – No observable change

(ii) Phenol and carboxylic acids or aromatic amines

Observations: Phenol-violet colouration
Carboxylic acids–No observable change or
Aromatic amines – give a **green solution** in acidic solution.

or, Ethanoate or acetate and oxalate or (ethanedioate)

Observations: Ethanoate – brown solution
Oxalate – green solution

(b) (i)

$$CH_3CH_2OH \xrightarrow[heat]{Cr_2O_7^{2-}/H^+} CH_3COOH \xrightarrow{Ca(OH)_2} Ca(CH_3COO)_2 \xrightarrow{heat} CH_3\,C(=O)\,CH_3$$

or

$$CH_3CH_2OH \xrightarrow[heat]{Conc.\ H_2SO_4} CH_2{=}CH_2 \xrightarrow[Heat,\ pressure]{CO/H_2/Cu^{2+}\ catalyst} CH_3CH_2CHO \xrightarrow[dryether]{LiAlH_4}$$

$$CH_3CH_2CH_2OH \xrightarrow{Conc.\ H_2SO_4,\ heat} CH_3CH{=}CH_2 \xrightarrow{HBr} CH_3CH(Br)CH_3$$

$$CH_3CH(Br)CH_3 \xrightarrow[heat]{\bar{O}H(aq)} CH_3CH(OH)CH_3 \xrightarrow[heat]{Cr_2O_7^{2-}/H^+} CH_3-C(=O)-CH_3$$

or

$$CH_3CH_2OH \xrightarrow{PCl_5} CH_3CH_2Cl \xrightarrow{Mg(s),\ Dry\ ether,\ reflux} CH_3CH_2MgCl \xrightarrow{CO_2/H_2O}$$

$$CH_3CH_2COOH \xrightarrow[dryether]{LiAlH_4} CH_3CH_2CH_2OH \xrightarrow[170°C]{Conc.\ H_2SO_4} CH_3CH{=}CH_2 \xrightarrow{Br_2/CCl_4}$$

$$CH_3CHBrCH_2Br \xrightarrow[heat]{KOH/alcohol} CH_3C{\equiv}CH \xrightarrow[60°C]{HgSO_4/H^+} CH_3\,C(=O)\,CH_3$$

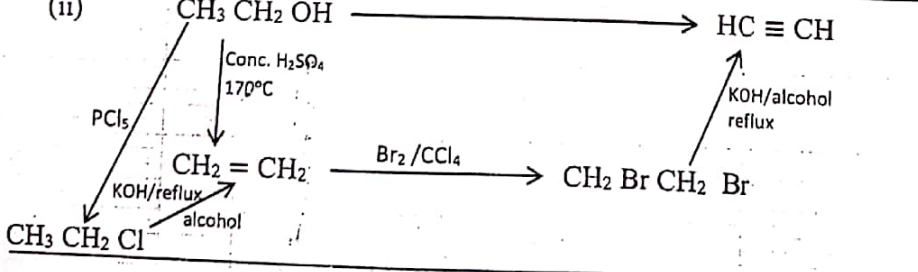
or

$$CH_3CH_2OH \xrightarrow{PCl_5} CH_3CH_2Cl \xrightarrow[heat]{KCN/alcohol} CH_3CH_2CN \xrightarrow[warm]{H_2O/H^+}$$

$$CH_3CH_2COOH \xrightarrow[dryether]{LiAlH_4} CH_3CH_2CH_2OH \xrightarrow[170°C]{Conc.\ H_2SO_4} CH_3CH{=}CH_2 \xrightarrow{HBr}$$

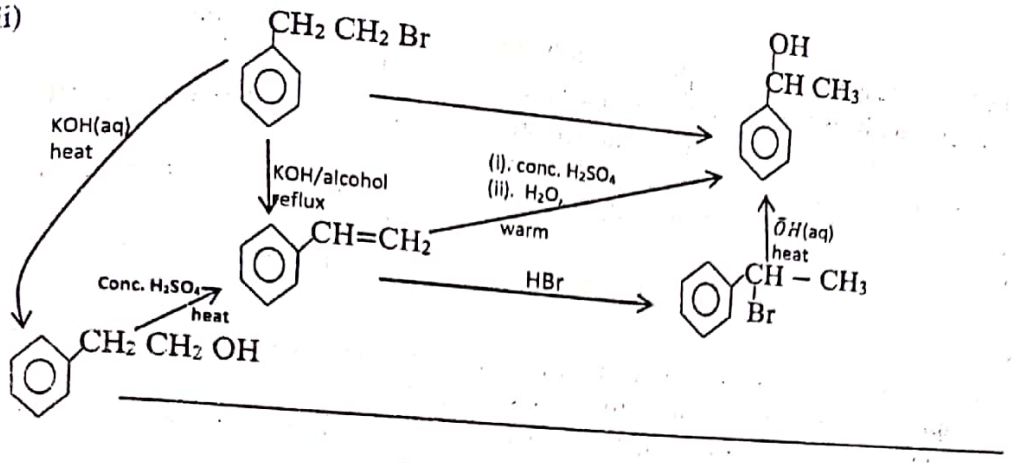
$$CH_3CH(Br)CH_3 \xrightarrow[heat]{\bar{O}H(aq)} CH_3CH(OH)CH_3 \xrightarrow[heat]{Cr_2O_7^{2-}/H^+} CH_3\,C(=O)\,CH_3$$

(ii)



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(iii)



Question. Four.

(a) Fluorine atoms have the **smallest atomic radius**
This gives rise to **very high electro negativity** or low bond energy or high lattice energies in the fluorides.
Fluorine lacks underlying d-orbitals.

(b) Hydrogen fluoride molecules are strongly held together by hydrogen bonds unlike the other hydrogen halides and this is duc to the very polar hydrogen – fluorine bonds.

- Hydrogen fluoride is a weak acid while the other hydrides of group (VII) elements are stronger acids.
- Fluorine being more electronegative than oxygen, it reacts differently with compounds containing oxygen like water and alkalis
- Fluorine has only one oxidation number while other halogens can have more than one oxidation number
- Solubility of fluorides differ markedly from the solubilities of other halides with the same metal for example calcium fluoride is insoluble while other calcium halides are soluble, silver fluoride is soluble while other silver halides are insoluble.
- Ionic character of fluorides is normally high while the others have low ionic character
- Fluorine combines directly with carbon while the others don't.
- Other elements show their highest oxidation number in combining with fluorine than with other halogens.

(c) (i) $2F_2(g) + 2H_2O(l) \longrightarrow 4HF(aq) + O_2(g)$
$Cl_2(g) + H_2O(l) \longrightarrow HCl(aq) + HClO(aq)$

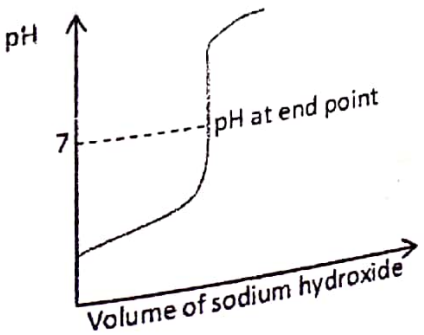
(ii) $2F_2(g) + 2OH^-(aq) \longrightarrow F_2O(g) + 2F^-(aq) + H_2O(l)$
or, $2F_2(g) + 2NaOH(aq) \longrightarrow F_2O(g) + 2NaF(aq) + H_2O(l)$
$Cl_2(g) + 2\bar{O}H(aq) \longrightarrow ClO^-(aq) + Cl^-(aq) + H_2O(l)$

(iii) $2F_2(g) + 4\bar{O}H(aq) \longrightarrow 4F^-(aq) + 2H_2O(l) + O_2(g)$
or $3Cl_2(g) + 6\bar{O}H(aq) \longrightarrow 5Cl^-(aq) + ClO_3^-(aq) + 3H_2O(l)$

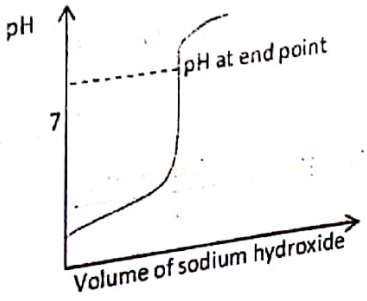
(d) $4Hf(aq) + SiO_2(s) \longrightarrow SiF_4(g) + 2H_2O(l)$
or $6HF(aq) + SiO_2(s) \longrightarrow H_2SiF_6(aq) + 2H_2O(l)$

Question. Five.

(a) (i)



(ii)



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(b) **Curve a(i)**

- Initially the PH of the acid is **low**, because it is **fully ionized** into **hydrogen ions.**
- The pH **rises gradually** as the base is added since the acid is **still in excess**
- At the end point, a very small amount of sodium hydroxide added gives a **sharp rise in pH.** This is because all the acid is completely neutralized by the base
- The pH at endpoint is 7 because a **strong salt**,sodium chloride is formed which **doesn't undergo hydrolysis**
- Beyond the endpoint, the pH **increases gradually** due to excess sodium hydroxide added.

Curve (a)(ii)

- Initially the pH of the acid is **not as low as in (a)(i)** because ethanoic acid is a **weaker** acid and **does not completely ionize** into many hydrogen ions in solution
- As the base is added, the **pH rises gradually** because the acid is **still in excess** which together with the salt formed **constitutes a buffer mixture.**
- At the endpoint, a very small amount of sodium hydroxide added gives rise to a sharp rise in pH because all the acid is completely neutralised
- The pH at the end point is **greater than 7** because the sodium ethanoate salt formed **undergoes hydrolysis** producing **hydroxyl ions** which make the solution alkaline
- Beyond the endpoint, the pH **rises gradually** due to **excess sodium hydroxide added.**

(c) $CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$

$$Ka = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$$

$$\therefore [H^+] = \frac{Ka \times [CH_3COOH]}{[CH_3COO^-]} \quad \text{---------- *}$$

Moles of the acid in $100cm^3 = \frac{0.1 \times 100}{1000} = 0.01 moles$

Moles of NaOH added $= \frac{0.1 \times 20}{1000} = 0.002 moles$

Ethanoic acid reacts with sodium hydroxide according to the equation;

$CH_3COOH(aq) + NaOH(aq) \longrightarrow CH_3COONa(aq) + H_2O(l)$

Moles of CH_3COONa formed $= 0.002 moles$

(since mole ratio of NaOH : CH_3COONa =1;1)

Moles of CH_3COOH left $= 0.01 - 0.002 = 0.008 moles$

Total volume of the resultant solution $= 20 + 100 = 120 cm^3$

$$[CH_3COOH] = \frac{0.008 \times 1000}{120} = 0.0667 \text{moll}^{-1}$$

$$[CH_3COONa] = \frac{0.002 \times 1000}{120} = 0.0167 \text{moll}^{-1}$$

But; $[CH_3COONa] = [CH_3CO\bar{O}]$

Then; substitution in equation ---------- *

$$[H^+] = 1.75 \times 10^{-5} \times \frac{0.0667}{0.0167}$$

$$= 6.99 \times 10^{-5} \text{ moll}^{-1}$$

$$pH \cong -\log[H^+]$$

$$\cong -\log 6.99 \times 10^{-5} = 4.16$$

Therefore the pH of the resultant buffer solution is 4.16.

Alternatively

$$pH = PKa + \log \frac{[SALT]}{[ACID]}$$

$$= -\log 1.75 \times 10^{-5} + \log \frac{0.0167}{0.0667}$$

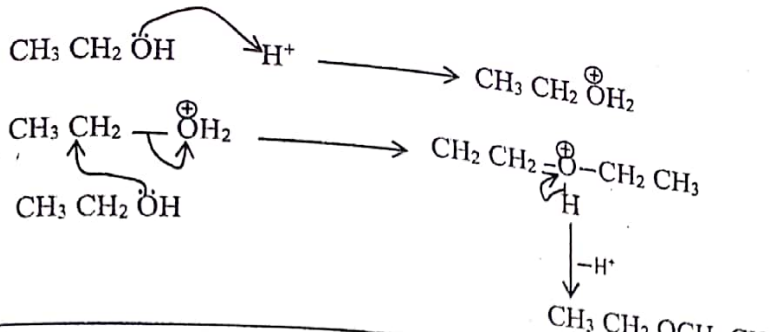
$$= 4.757 - 0.602 = 4.155$$

Question. Six.

(a) (i) $CH_3CH_2OH \xrightarrow[140°C]{\text{Conc. } H_2SO_4} CH_3CH_2OCH_2CH_3$

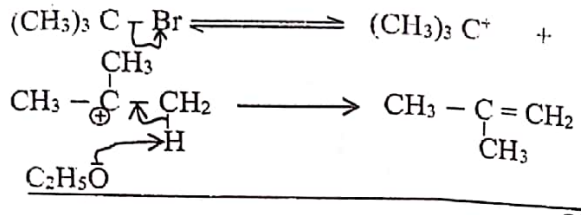
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Mechanism;



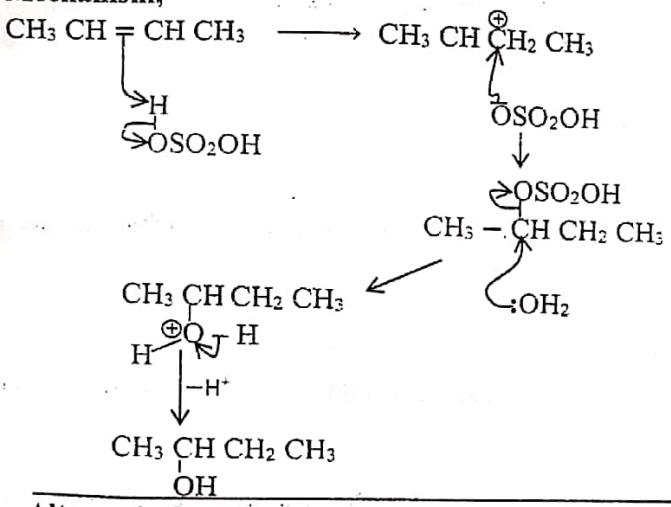
(ii) $(CH_3)_3\ C\ Br \xrightarrow[\text{heat}]{C_2H_5\bar{O}K^+/CH_3CH_2OH} CH_3 - C(CH_3) = CH_2$

Mechanism;

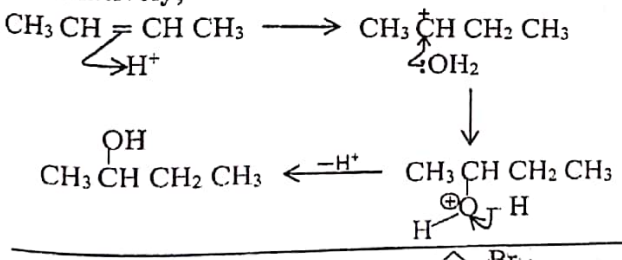


(iii) $CH_3\ CH = CH\ CH_3 \xrightarrow[H_2O]{\text{Conc. } H_2SO_4} CH_3\ CH(OH)\ CH_2\ CH_3$

Mechanism;



Alternatively;

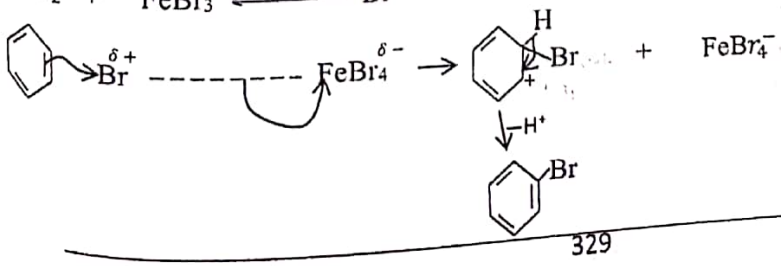


(iv)  $+\ Br_2 \xrightarrow[\text{heat}]{Fe}$  $+\ HBr$

Mechanism

$3Br_2 + 2Fe \longrightarrow 2FeBr_3$

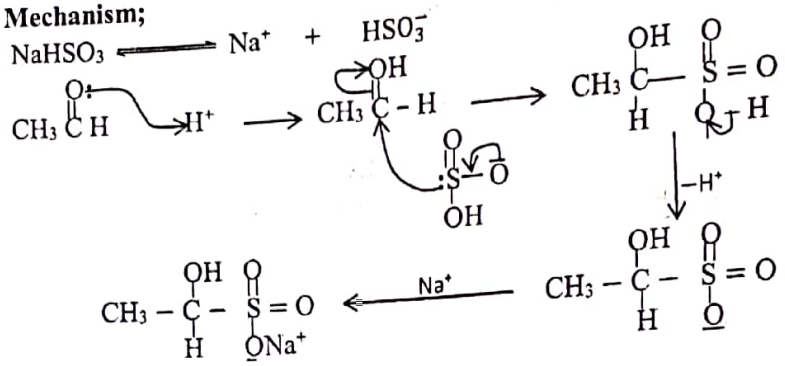
$Br_2 + FeBr_3 \rightleftharpoons Br^{\delta+} \cdots\cdots FeBr_4^{\delta-}$



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(v) $CH_3CHO + NaHSO_3 \xrightarrow{H^+} CH_3CH(OH)SO_3^-Na^+$

Mechanism;



(b) (a)(i) Ethoxyethane
(a)(ii) 2-methyl propene

Question. Seven.

(a) Name; Bauxite Formula $Al_2O_3 \cdot XH_2O$

Extraction of aluminium from Bauxite

Bauxite is **crushed** to powder form and then **heated** with **concentrated sodium hydroxide** solution
The amphoteric ore and the acidic silicon dioxide impurity in the ore dissolve in the alkali while the basic iron (III) oxide impurity in the ore remains undissolved

$Al_2O_3(s) + 2\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_4^-(aq)$

or $Al_2O_3(s) + 2\bar{O}H(aq) \longrightarrow 2AlO_2^-(aq) + H_2O(l)$

and $SiO_2(s) + 2\bar{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + H_2O(l)$

The mixture is **filtered, diluted** and **seeded** using **pure aluminium hydroxide** or **carbon dioxide gas**

$Al(OH)_4^-(aq) \longrightarrow Al(OH)_3(s) + \bar{O}H(aq)$

or; $AlO_2^-(aq) + 2H_2O(l) \longrightarrow Al(OH)_3(s) + \bar{O}H(aq)$

or; $2Al(OH)_4^-(aq) + CO_2(g) \longrightarrow 2Al(OH)_3(s) + CO_3^{2-}(aq) + H_2O(l)$

The mixture is filtered and the aluminium hydroxide is **strongly heated** to form anhydrous aluminium (III) oxide or alumina

$2Al(OH)_3(s) \Rightarrow Al_2O_3(s) + 3H_2O(g)$

The alumina is **dissolved in molten cryolite** and **electrolysed** between **graphite** electrodes at almost 900°C at **low voltage** and **high current density**.
Aluminium is discharged at the cathode

$Al^{3+}(l) + 3e \longrightarrow Al(l)$

(b) (i) Condition; Heat

$4Al(s) + 3O_2(g) \longrightarrow 2Al_2O_3(s)$

$2Al(s) + N_2(g) \longrightarrow 2AlN(s)$

(ii) Condition; **Aqueous** sodium hydroxide

$2Al(s) + 2\bar{O}H(aq) + 6H_2O(l) \longrightarrow 2Al(OH)_4^-(aq) + 3H_2(g)$

or; $2Al(s) + 2\bar{O}H(aq) + 2H_2O(l) \longrightarrow 2AlO_2^-(aq) + 3H_2(g)$

(iii) Condition; **concentrated** or **hot dilute** acid

$2Al(s) + 6H^+(aq) \longrightarrow 2Al^{3+}(aq) + 3H_2(g)$

(c) **White precipitate insoluble** in excess aqueous ammonia
Equation

$Al^{3+}(aq) + 3\bar{O}H(aq) \Longrightarrow Al(OH)_3(s)$

(d) $AlCl_3(s) + 7H_2O(l) \longrightarrow [Al(H_2O)_5OH]^{2+}(aq) + H_3O^+ + 3Cl^-(aq)$

or; $2AlCl_3(s) + 6H_2O(l) \longrightarrow 2Al(OH)_3(s) + 6HCl(aq)$

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Question. Eight.

(a) (i) **Ammonia** from the Haber's process is **mixed with excess air** and passed over **platinum catalyst** at about **700°C** and 9 atmosphere pressure to form **nitrogen monoxide** and **water**.

$$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(l)$$

The gases are **cooled** and nitrogen monoxide combined with oxygen to form nitrogen dioxide

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$

The nitrogen dioxide in the **presence of air** , is then absorbed in **hot water** to form nitric acid

$$2H_2O(l) + 4NO_2(g) + O_2(g) \longrightarrow 4HNO_3(aq)$$

(ii) Copper metal is oxidized by **dilute nitric acid** forming **copper (II) nitrate, nitrogen monoxide** and **water**

$$3Cu(s) + 8HNO_3(aq) \longrightarrow 3Cu(NO_3)_2(aq) + 2NO(g) + 4H_2O(l)$$

In **concentrated nitric acid**; copper metal is oxidized to form **copper (II) nitrate** and **nitrogen dioxide** gas

$$Cu(s) + 4HNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$$

(b) Nitric acid and potassium manganate (VII) are both very **strong oxidizing agents** therefore nitric acid would **compete** and hence interfere with the oxidizing action of the potassium manganate (VII)

(c) Ammonia reacts with the monobasic acid according to the equation:

$$NH_3(g) + HX(aq) \longrightarrow NH_4X(aq)$$

Number of moles of the acid used $= \frac{0.1 \times 200}{1000}$

$= 0.02 moles$

Since mole ratio of $NH_3 : HX = 1:1$; then;

Number of moles of NH_3 produced $= 0.02 moles$

Mass of ammonia produced $= 0.02 \times Molecular\ mass\ of\ NH_3$

But; $Molecular\ mass$ of $NH_3 = 14 + (3 \times 1) = \mathbf{17}$

Mass of ammonia in the compound $= 0.02 \times 17 = \mathbf{0.34g}$

Mass of nitrogen in the compound $= \frac{0.34 \times 14}{17} = \mathbf{0.28g}$

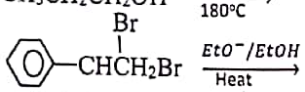
Hence;Percentage of nitrogen in the compound $= \frac{0.28}{1.07} \times 100\% = \mathbf{26.17\%}$

∴ the percentage by mass of nitrogen in the compound is 26.17%

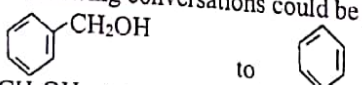
(d) -Manufacture of nitrogenous fertilizers
-Manufacture of explosives of dyes.
- Manufacture of dyes.

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QUESTIONS TO 'A' LEVEL QUESTIONS; PAPER 1 (P525/1), 2002

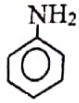
1. Write an ionic equation for the reaction between sodium hydroxide and
   (a) Silicon(IV) oxide (1½ marks) (b) Lead (II) oxide (1½ marks) (c) Aluminium (III) oxide (1½ marks)
2. The mass spectrum of chlorine shows peaks at masses 70, 72 and 74. The heights of the peaks respectively are the ratio of 9:6:1. Calculate:
   (a) the average atomic mass of chlorine (2 marks)
   (b) the relative abundance of ^{35}Cl and ^{37}Cl. (3 marks)
   (c)the half-life of a first order reaction is 100s.
   (i) Calculate the rate constant (1 mark)
   (ii) Determine the percentage of the reactant that reacted after 250s. (2 marks)
3. Complete the following equations and in each case write a mechanism for the reaction.
   (a) $CH_3CH_2CH_2OH \xrightarrow[180°C]{conc.H_3PO_4}$ (3 marks)
   (b)  (2 marks)
4. The table below shows the ionization energies (in $KJmol^{-1}$) of the five elements lettered A, B, C, D and E.

Element	1st ionization energy	2nd ionization energy	3rd ionization energy	4th ionization energy
A	500	4600	6900	9500
B	740	1500	7700	10500
C	630	1600	3000	4800
D	-900	1800	14800	21000
E	589	1800	2700	11600

   (a) Which one of these elements is most likely to form an ion with a charge of +1? Give a reason for your answer. (1½ marks)
   (b) State:
   (i) two elements which belong to the same group in the Periodic Table. (1½ mark)
   (ii) the group to which the element you have stated in (b)(i) belong. (½ mark)
   (c) (i) Write the formula of the chloride of element E (1 mark)
   (ii) Write the equation for the reaction between the chloride of element E and water. (1½ marks)
5. (a) Derive the expression for the half-life of the first order reaction. (2 marks)
   (b) The half-life of a first order reaction is 100s.
   (i) Calculate the rate constant (1 mark)
   (ii) Determine the percentage of the reactant that reacted after 250s. (1mark)
6. Show how the following conversations could be carried out. (2½ marks)
   (a) 
   (b) $CH_3CH_2CH_2OH$ to $CH_3\underset{OH}{C}HCH_3$
7. (a) One of the properties of transition metals is complex ion formation
   (i) Define the term complex ion (3 marks)
   (ii) Explain why transition metals form many complexes (2 marks)
   (b) $Fe(CN)_6^{3-}$ and $(CuCl_4)^{2-}$ are complexes formed by iron and copper respectively. State;
   (i) the oxidation state of iron and copper (2 marks)
   (ii) the co-ordination number of iron and copper (2 marks)
8. (a) Define the term partial pressure (1 mark)
   (b) The vapour pressures of pure chloroform and carbon tetrachloride are 199.1 and 114.5mmHg respectively at 25°C. (Assume that a mixture of the two liquids behave as an ideal gas and that it contains 0.96 mole of each pure liquid) Calculate; (1 mark)
   (i) the partial pressure of each component in the mixture. (1½ marks)
   (ii) the total pressure
   (c) Calculate the percentage of carbon tetrachloride in the vapour in equilibrium with the liquid mixture. (2½ marks)
9. Complete the following equations and write the IUPAC name of the major organic product. (1 mark)

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(a)  $\xrightarrow{Cl_2/U.V\ light}$ .....

(b)  $\xrightarrow[Dil.HCl,\ 0°C]{NaNO_2}$ (1½ marks)

(c) $nCH_3CH = CH_2 \xrightarrow[heat]{catalyst}$ (1½ marks)

10. State what would be observed and write equations for the reactions that take place when the following compounds are reacted. (1½ marks)
    (a) Aqueous potassium dichromate (VI) with hydrogen sulphide. (3 marks)
    (b) Aqueous iron (III) chloride with sodium carbonate. (3½ marks)
    (c) Aqueous copper (II) sulphate with potassium iodide. (2½ marks)
11. (a) An organic compound A contains carbon, hydrogen and oxygen only. On combustion, 0.463g of A gave 1.1g carbon dioxide and 0.563g of water. Determine the empirical formula of A. (3½ marks)
    (b) When vaporized, 0.1g of A occupies 54.5cm^3 at 208°C and 98.3kPA. Determine the molecular formula of A. (2½ marks)
    (c) A reacts with sodium metal with evolution of a gas. Write the structural formulae of all the possible isomers of A. (1½ marks)
    (d) A reacts with anhydrous zinc chloride and concentrated hydrochloric acid to give a cloudy solution in about 5 minutes.
        (i) Identify A (½ mark)
        (ii) Show how A could be synthesized from but-2nE. (1 mark)
12. (a) A piece of clean magnesium ribbon was added to a solution of iron (III) chloride solution.
        (i) State what was observed (1½ marks)
        (ii) Explain your observation in (a) (i) above (2 marks)
        (iii) Write stepwise equations for the reaction that took place. (4 marks)
    (b) State what would be observed if a few drops of iron (III) chloride was added to the solution of the following:
        (i) Sodium acetate (1 mark)
        (ii) Phenol (½ mark)
13. Complete the table below about the properties of different types of crystals.

Type of crystal	Force holding the crystals	Melting point (state whether low, moderate, high or very high)	Form in which electricity is conducted if any
Metallic			
Ionic			
Network Covalent			

14. (a) Write equations to show how ethanol can be formed from glucose. (1 mark)
    (b) Write equations to show how ethyne can be:
        (i) prepared from ethanol (4 marks)
        (ii) converted to methylpropyne (1½ marks)
    (c) (i) Name one reagent that can be used to confirm the formation of methylpropyne. (1 mark)
        (ii) State what would be observed if methylpropyne was reacted with the reagent you have named in (c)(i) and write equation for the reaction (1½ marks)
15. (a) The table below shows the atomic numbers of some elements and their electron affinities.

Atomic No.	11	12	13	14	15	16	17
Electron affinity (kJmol^{-1})	2.0	-6.7	3.0	13.5	6.0	20.0	36.4

        (i) Draw a graph of electron affinity versus atomic number. (3 marks)
        (ii) Explain the shape of the graph (3 marks)
    (b) List three factors which affect the size of the first ionization energy (3 marks)
16. Write equations to show how the following compounds can be synthesized.
    (a) CH_3CHO (from 1,2-dibromoethane) (3 marks)
    (b) CH_3CO_2H (from iodomethane) (2½ marks)
    (c) $CH_3CO_2CH_3$ (from ethane) (3½ marks)
17. (a) Name two plants from which vegetable oil can be obtained. (1 mark)
    (b) Soap was prepared from 9.5g of an oil containing mainly hexadecanoic acid $CH_3(CH_2)_{14}CO_2H$ as the main component of the oil.
        (i) Explain briefly how pure soap was obtained from the oil. (3 marks)
        (ii) Write equation for the reaction leading to the formation of the soap. (1 mark)
        (iii) Calculate the mass of the soap formed. (3 marks)
    (c) Name one use of the residue left after the oil has been extracted. (1 mark) END

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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1 (P525/1), 2002

1. (a) $SiO_2(s) + 2\bar{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + H_2O(l)$

(b) $PbO(s) + 4\bar{O}H(aq) + H_2O(l) \longrightarrow [Pb(OH)_6]^{4-}(aq)$

or $PbO(s) + 2\bar{O}H(aq) + H_2O(l) \longrightarrow Pb(OH)_4^{2-}(aq)$

or $PbO(s) + 2\bar{O}H(aq) \longrightarrow PbO_2^{2-}(aq) + H_2O(l)$

(c) $Al_2O_3(s) + 2\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_4^-(aq)$

or $Al_2O_3(s) + 2\bar{O}H(aq) \longrightarrow 2AlO_2^-(aq) + H_2O(l)$

2. (a) Total ratio $= 9 + 6 + 1 = 16$

$Relative\ molecular\ mass\ of\ chlorine = \frac{(9\times70)+(6\times72)+(1\times74)}{16} = 71$

$\therefore Average\ atomic\ mass\ of\ chlorine = \frac{71}{2}$, since chlorine is diatomic molecule, Cl_2

$= 35.5$

(b) Let; the relative abundance of $= Cl - 37 = x\%$

$Hence; relative\ abundance\ of\ Cl - 35 = (100 - x)\%$

Thus; $\frac{(37\times x)+35(100-x)}{100} = 35.5$

$2x = 3550 - 3500 = 50$

$\therefore x = 25$

Relative abundance of $Cl - 35 = 75\%$

Relative abundance of Cl-37=25%

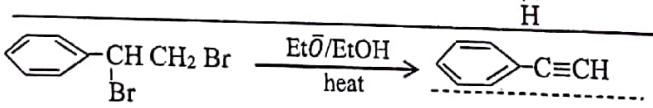
3. (a)

$CH_3CH_2CH_2OH \xrightarrow[180°C]{Conc.\ H_3PO_4} CH_3CH{=}CH_2$

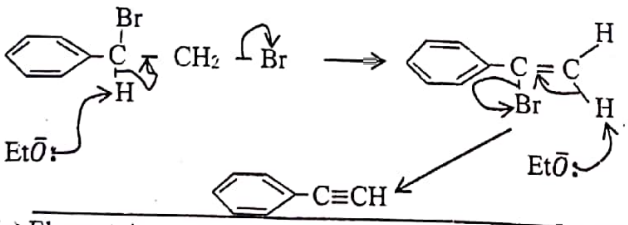
Mechanism;

$CH_3CH_2CH_2\ddot{O}H \rightarrow H^+ \rightleftharpoons CH_3CH_2CH_2{-}\overset{+}{O}H_2$

$CH_3CH{=}CH_2 \xrightleftharpoons{-H^+} CH_3\overset{H}{\underset{H}{C}}\overset{+}{C}H_2 \xleftarrow{-H_2O}$

(b) 

Mechanism;



4. (a) Element A

The difference between the first and second ionization energies is **very high** compared to the difference between the second and third ionization energies as well as the difference between the third and fourth ionization energies.

(b) (i) B and D

(ii) Group (II)

(c) (i) ECl_3

(ii) $ECl_3(s) + 3H_2O(l) \longrightarrow E(OH)_3(s) + 3HCl(aq)$

5. (a) Let; $(\frac{1}{2}a_0)$ be the concentration at half life time; $t\frac{1}{2}$

Therefore; $2.303 \log\left(\frac{a_0}{a_{0-x}}\right) = Kt$

$2.303 \log\left(\frac{a_0}{a_0 - \frac{1}{2}a_0}\right) = K\ t\frac{1}{2}$

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$$2.303 \log 2 = K\, t\tfrac{1}{2}$$
$$2.303 \times (0.3010) = K\, t\tfrac{1}{2}$$
$$t\tfrac{1}{2} = \frac{0.693}{K}$$

(b) (i) Rate constant; $K = \frac{0.693}{t\frac{1}{2}} = \frac{0.693}{100}$

$$= 6.93 \times 10^{-3} second^{-1}$$

(ii) Let; the initial percentage of the reactant be 100 and x the percentage that reacted hence percentage that did not react = $(100 - x)$

Using, $2.303 \log\left(\frac{N_o}{N_t}\right) = \lambda t$

Thus: $2.303 \log\left(\frac{100}{100-x}\right) = 6.93 \times 10^{-3} \times 250$

$$\log_{10}\left(\frac{100}{100-x}\right) = \frac{1.7325}{2.303}$$

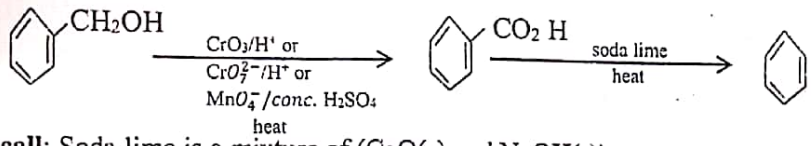
$$\log\left(\frac{100}{100-x}\right) = 0.7523$$

$$\frac{100}{100-x} = 10^{0.7523} = 5.653$$

$$x = \frac{465.3}{5.653} = 82.3$$

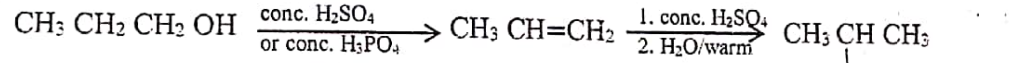
$\therefore$ *percentage that reacted* = 82.3%

(a)

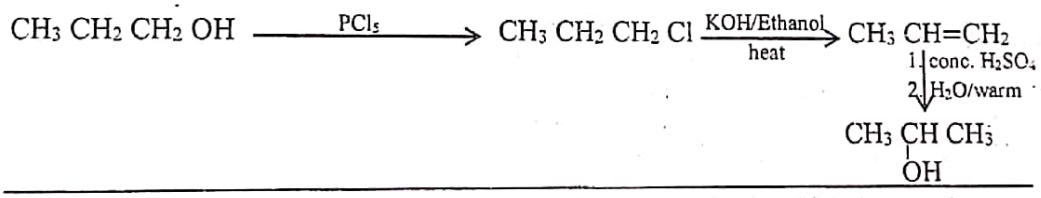


Recall; Soda lime is a mixture of (CaO(s) and NaOH(s))

(b)



Alternatively;



(a) (i) A complex ion is a **positively** or **negatively charged** species in which the cental atom which is usually a metal forms **coordinate (dative)** bonds with atoms or group of atoms with **negative charge** or **lone pair of electrons.**

(ii) Transition metals posses **vacant 3d–orbitals** which can accommodate lone pair of electrons from electron rich species (ligands)
Transition metals also form ions with **high charge densities** and therefore **high polarizing power** and so can strongly attract the ligands.

(b) (i) Iron +3 Copper +2

(ii) Iron 6 Copper 4

(a) The pressure which a gas alone would exert if it occupied a volume which was originally occupied by a mixture of gases of which the gas was a component

(b) (i) From Raoult's law;

Partial pressure of chloroform; $P_{CHCl_3} = X_{CHCl_3} \cdot P^0_{CHCl_3}$ (X = mole fraction)

$$= \left(\frac{0.96}{0.96+0.96}\right) \times 199.1 = 99.55 mmHg.$$

Partial pressure of carbon tetrachloride; $P_{CCl_4} = X_{CCl_4} \cdot P^0_{CCl_4}$

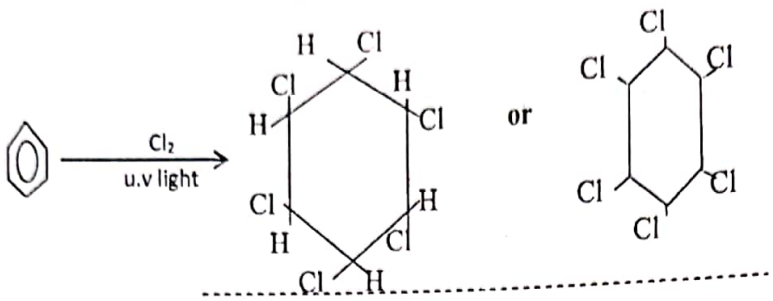
$$= \left(\frac{0.96}{0.96+0.96}\right) \times 114.5$$
$$= 57.25 mmHg.$$

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(ii) Total pressure = $P_{CHCl_3} + P_{CCl_4}$
$= 99.55 + 57.25 = \mathbf{156.80 mmHg.}$

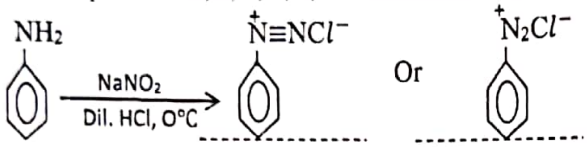
(c) % of CCl_4 in the vapour = $\frac{57.25}{156.80} \times 100 = \mathbf{36.51\%}$

9. (a)



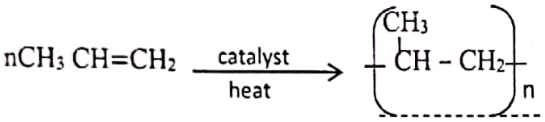
Name of product **1, 2, 3, 4, 5, 6 – hexa chloro cyclo hexane**

(b)



Name of product **Benzene diazonium chloride**

(c)



Name of product **Poly propene**

10. (a) Colour of the potassium dichromate (VI) solution changes from **orange** to **green** and a **yellow solid** formed.

$Cr_2O_7^{2-}(aq) + 8H^+(aq) + 3H_2S(aq) \longrightarrow 2Cr^{3+}(aq) + 3S(s) + 7H_2O(l)$

Or, $K_2Cr_2O_7(aq) + 8H^+(aq) + 3H_2S(aq) \longrightarrow 2Cr^{3+}(aq) + 2K^+(aq) + 3S(s) + 7H_2O(l)$

(b) **A reddish – brown precipitate** formed and **effervescence** occurred, and a **colourless gas** evolved

$2Fe^{3+}(aq) + 3CO_3^{2-}(aq) + 3H_2O(l) \longrightarrow 2Fe(OH)_3(s) + 3CO_2(g)$

or, $2FeCl_3(aq) + 3Na_2CO_3(aq) + 3H_2O(l) \longrightarrow 2Fe(OH)_3(s) + 6NaCl(aq) + 3CO_2(g)$

(c) A **brown solution** and a **white solid** formed

$2Cu^{2+}(aq) + 4I^-(aq) \longrightarrow Cu_2I_2(s) + I_2(aq)$

or, $2CuSO_4(aq) + 4KI(aq) \longrightarrow Cu_2I_2(s) + I_2(aq) + 2K_2SO_4(aq)$

11. (a) mass of carbon = $\frac{12}{44} \times 1.1 = 0.3g$

$mass\ of\ hydrogen = \frac{2}{18} \times 0.563 = 0.0626g$

$mass\ of\ oxygen = 0.463 - (0.3 + 0.0626) = 0.1004g$

Composition of A;	C	H	O
Moles;	$\frac{0.3}{12}$	$\frac{0.0626}{1}$	$\frac{0.1004}{16}$
	0.025	0.0626	0.0063
Mole ratio;	$\frac{0.025}{0.0063}$	$\frac{0.0626}{0.0063}$	$\frac{0.0063}{0.0063}$
	4 :	10 :	1

Emperical formula of A is $\mathbf{C_4H_{10}O}$

(b) using; $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$volume\ of\ A\ at\ stp;\ V_2 = \frac{P_1V_1T_2}{T_1P_2}$

$= \frac{98.3 \times 54.5 \times 273}{(208+273) \times (101325 \times 10^{-3})} = \mathbf{30cm^3}$

$30cm^3\ of\ A\ weigh\ 0.1g$

$\therefore 22400cm^3\ of\ A\ weigh \frac{22400 \times 0.1}{30} g$

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Molecular mass of $A = 74.67$

Or, Using; molecular mass $= \frac{mRT}{Pv}$

$= \frac{0.1 \times 8.314 \times (208+273}{(98.3 \times 10^3) \times (54.3 \times 10^{-6})} = 74.65$

Hence; $(C_4H_{10}O)n = 74.65$

$(4 \times 12)n + (10 \times 1) + (1 \times 16)n = 74.65$

$n = \frac{74.65}{74} = 1$

Molecular formula is $\mathbf{C_4H_{10}O}$

(c) $CH_3\,\underset{\underset{CH_3}{|}}{CH}\,CH_2\,OH$ $\quad CH_3\,CH_2\,CH_2\,CH_2\,OH$ $\quad CH_3\,\underset{\underset{OH}{|}}{CH}\,CH_2\,CH_3$ $\quad CH_3\,\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}-OH$

(d) (i) $CH_3\,\underset{\underset{OH}{|}}{CHCH_2}\,CH_3$

(ii) $CH_3\,CH{=}CH\,CH_3 \xrightarrow[2.\ H_2O/warm]{1.\ conc.\ H_2SO_4} CH_3\,\underset{\underset{OH}{|}}{CH}\,CH_2\,CH_3$

12. (a) (i) **Effervescence** occurs, **colourless gas** was evolved and **a reddish brown precipitate** formed.

(ii) The hydrated iron (III) ion, $[Fe(H_2O)_6]^{3+}$, present in solution was **hydrolysed** by the water to form an **acidic solution** which reacted with the magnesium to form hydrogen gas.

(iii) $[Fe(H_2O)_6]^{3+}(aq) + H_2O(l) \rightleftharpoons [Fe(H_2O)_5\,OH]^{2+}(aq) + H_3O^+(aq)$

$[Fe(H_2O)_5OH]^{2+}(aq) + H_2O(l) \rightleftharpoons [Fe(H_2O)_4 2(OH)]^{+}(aq) + H_3O^+(aq)$

$[Fe(H_2O)_4 2(OH)]^{+}(aq) + H_2O(l) \rightleftharpoons [Fe(H_2O)_3\,3(OH)]\ (s) + H_3O^+(aq)$

$Mg(s) + 2H_3O^+(aq) \longrightarrow Mg^{2+}(aq) + H_2(g) + 2H_2O(l)$

(b) (i) Reddish brown solution

(ii) Violet or purple colouration

13.

type of crystal	Force holding the crystals	Melting point (state whether low, moderate, high or very high)	Form in which electricity is conducted if any
metallic	**Molecular orbital extending throughout the crystal**	**moderate**	**Both in solid or molten or (fused)**
Ionic	**Electrostatic forces attraction between anions and cations**	**high**	**Molten and aqueous solution**
Network covalent	**Covalent bonds**	**Very high**	**Does not conduct.**

4. (a) $C_6H_{12}O_6 \xrightarrow[zymase]{enzyme} 2CH_3CH_2OH + 2CO_2(g)$

(b) (i) $CH_3CH_2OH \xrightarrow[heat]{Conc.\ H_2SO_4} H_2C=CH_2 \xrightarrow{Br_2\,/\,CCl_4} Br\,CH_2\,CH_2\,Br$

$Br\,CH_2\,CH_2\,Br \xrightarrow[heat]{KOH/\ CH_3CH_2OH} HC\equiv CH$

Recall; in the last step, the ethoxide ion ($Et\bar{O}$) can be used instead of KOH

(ii) $HC\equiv CH \xrightarrow[Liquid\ NH_3]{Na} HC\equiv \bar{C}Na^+ \xrightarrow{CH_3CH_2Cl} CH_3CH_2C\equiv CH$

(c) (i) Ammonical silver nitrate **solution**

or, Ammoniacal copper(I) chloride **solution.**

(ii) White precipitate

$CH_3C\equiv CH + AgNO_3 \xrightarrow{NH_3} CH_3C\equiv CAg + HNO_3$

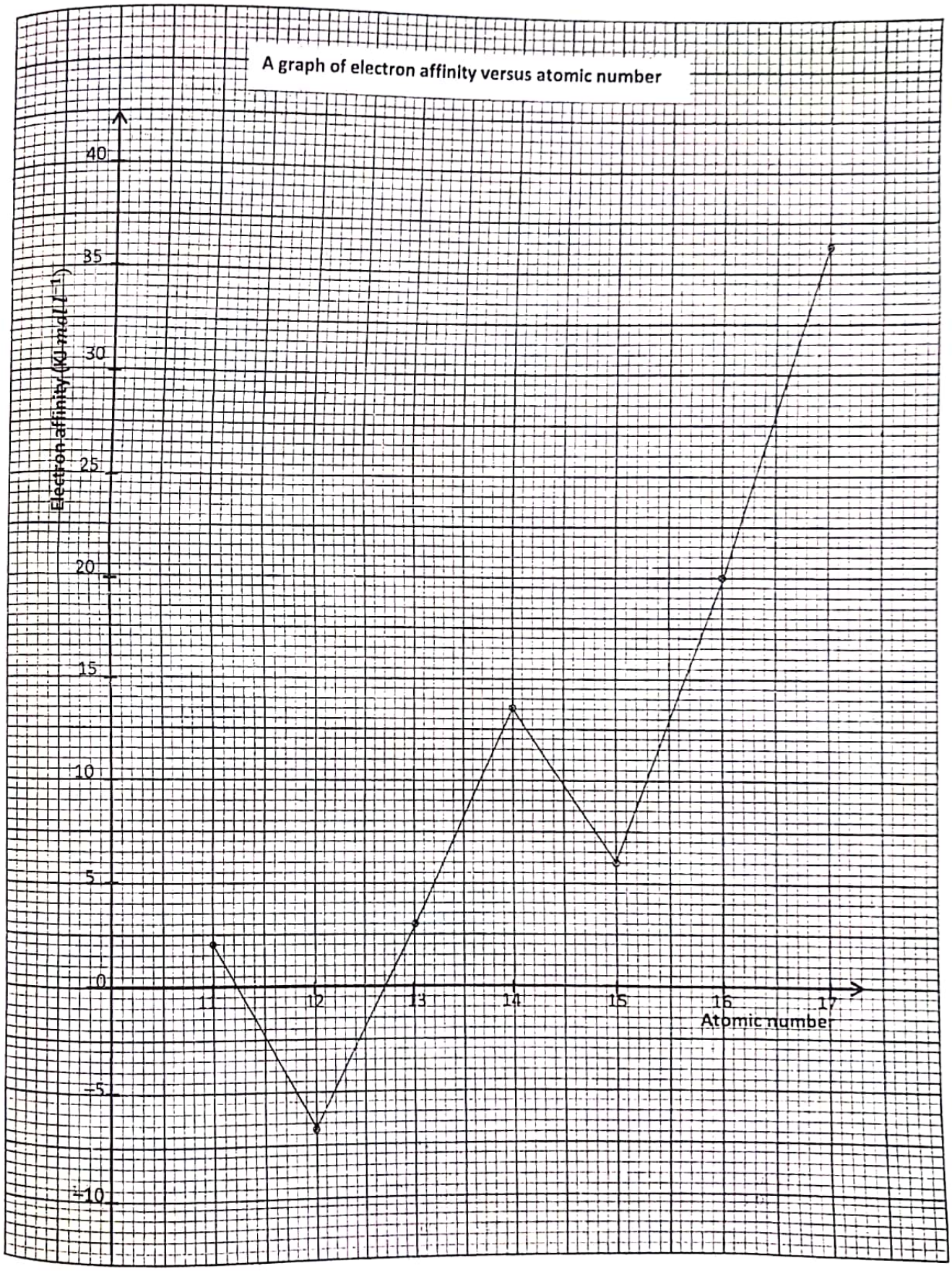
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or,Reddish –brown precipitate

$$CH_3C \equiv CH + CuCl \xrightarrow{NH_3} CH_3C \equiv Cu + HCl$$

15. (a) (i)

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(ii) Electronic configuration of elements with atomic numbers;

$12 \longrightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2$, $15 \longrightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$,

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There is a **general increase** in electron affinity with increase in atomic numbers. This is because of the **increase in effective nuclear charge** which results into **increases in the attraction** for incoming (added) electron hence increase in electron affinity.
However, the electron affinities of elements with atomic numbers 12 and 15 are **lower than expected**. This is because, the element with atomic number 12 has a **fully filled** outer sub-energy level while element with atomic number 15 has a **half filled** outer sub energy level as shown in the electronic configurations above. These electronic configurations are **energetically stable** and hence **resist the addition of an electron** and hence **less energy** is released.

(b) -Effective nuclear charge
-Atomic radius
-The shielding of the outer energy level electrons by the electrons in the lower energy orbitals
-Electronic configuration

16. (a) $Br\,CH_2\,CH_2\,Br \xrightarrow[\text{heat}]{Et\bar{O}/EtOH} HC\equiv CH \xrightarrow[Hg^{2+}/60°C]{H_2O/\text{dilute } H_2SO_4} CH_3CHO$

or

$Br\,CH_2\,CH_2\,Br \xrightarrow[\text{heat}]{KOH/\text{Ethanol}} HC\equiv CH \xrightarrow[H_2/\text{lindlar's catalyst}]{LiAlH_4 \text{ or } NaBH_4 \text{ or}} H_2C=CH_2 \xrightarrow[2.\ H_2O/\text{warm}]{1.\ \text{conc. } H_2SO_4} CH_3\,CH_2\,OH \xrightarrow[\text{or } (Cr_2O_7^{2-}/H^+)\ \text{or } (MnO_4^-/\text{conc. } H_2SO_4)]{CrO_3/H^+} CH_3\,CHO$

(b) $CH_3I \xrightarrow[\text{heat}]{KCN/\text{Alcohol}} CH_3\,CN \xrightarrow[\text{heat}]{H_2O/H^+} CH_3COOH$

Alternatively;

$CH_3\,I \xrightarrow{Mg/\text{ dryether}} CH_3\,Mg\,I \xrightarrow{CO_2} CH_3\,\underset{\underset{O}{\|}}{C}-OMgI \xrightarrow{H_2O/H^+} CH_3\,COOH$

(c) $H_2C=CH_2 \xrightarrow[2.\ H_2O/\text{warm}]{1.\ \text{conc. } H_2SO_4} CH_3\,CH_2\,OH \xrightarrow[\text{heat}]{CrO_3/H^+} CH_3\,COOH$

$CH_3\,COOH \xrightarrow[H_2SO_4/\text{heat}]{CH_3OH} CH_3\,CO_2\,CH_3$

Alternatively;

$H_2C=CH_2 \xrightarrow[2.\ H_2O/\text{warm}]{1.\ \text{conc. } H_2SO_4} CH_3\,CH_2\,OH \xrightarrow[\text{or } (MnO_4^-/\text{conc. } H_2SO_4)\ \text{heat}]{CrO_3/H^+} CH_3\,COOH \xrightarrow[\text{or } SOCl_2]{PCl_5} CH_3\,COCl \longrightarrow CH_3\,CO_2\,CH_3$

17. (a) Cotton, simsim, ground nuts, coconuts, sunflower
(b) (i) The oil is **heated** with **sodium hydroxide** or **potassium hydroxide**. A solution of **sodium chloride** is added to **precipitate** the soap and to dissolve the glycerol.
The crude soap is **dissolved** or suspended in hot water and brine (sodium chlorine solution) added to **precipitate out the soap** which is then dried.

(ii)
$$\begin{array}{l} CH_2-O-\underset{\underset{O}{\|}}{C}(CH_2)_{14}CH_3 \\ CH-O-\underset{\underset{O}{\|}}{C}(CH_2)_{14}CH_3 \\ CH_2-O-\underset{\underset{O}{\|}}{C}(CH_2)_{14}CH_3 \end{array} \xrightarrow[\text{heat}]{NaOH} \begin{array}{l} CH_2OH \\ CH-OH \\ CH_2-OH \end{array} + 3CH_3(CH_2)_{14}C\bar{O}_2Na^+$$

Molecular mass of sodium salt; $CH_3(CH_2)_{14}C\bar{O}_2Na^+ = (16\times12)+(31\times1)+(2\times16)+(1\times23) = 278g$
According to the equation leading to the formation of soap;
806g (1mole) of oil produced 3× 278g (3moles) of soap.

$\therefore 9.5g\ of\ oil\ produced \frac{9.5\times3\times278}{806} = 9.8g\ of\ soap$

(c) -Animal feed, -Fertilizer

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1. (a) A compound X, vapour density 58, contains carbon 62.07%, hydrogen 10.34%, the rest being oxygen. X does not burn with a sooty flame
(i) Calculate the empirical formula X. (C =12, H = 1, O = 16) (3 marks)
(ii) Determine the molecular formula of X. (2 marks)
(b) Hydrolysis of X yielded compounds, Y, $C_4H_{10}O$ and Z, $C_2H_4O_2$
Both Y and Z react with metallic sodium. Z reacted with sodium carbonate but Y did not.
(i) Identify Z (1 mark)
(ii) Write the names and structural formulae of all the possible isomers of Y. (4 marks)
(iii) Name a reagent that can be used to distinguish between the isomers in (b)(ii) and state what would be observed if the reagent is reacted separately with each of the isomers. (4 marks)
(c) When Y was warmed with acidified potassium dichromate solution, there was no observable change.
(i) Identify Y (1 mark)
(ii) Write the structural formula of Y (1 mark)
(d) (i) Write equation and outline a mechanism for the reaction between Y and concentrated phosphoric acid (3 ½ marks)
(ii) Write the IUPAC name of the product in (d)(i) (½ mark)

2. (a) State Raoult's law (3 marks)
(b) A mixture of ethanoic acid (b.p 118°C) and pyridine (b.p 123°C) shows negative deviation from Raout's law
(i) Draw a vapour pressure / composition curve for the mixture of ethanoic acid and pyridine and indicate the line for ideal behavior (4 marks)
(ii) Explain the shape of the curve in relation to Raoult's law (6 marks)
(c) (i) Explain what is meant by the term **steam distillation**. (3 marks)
(ii) When a compound Y, was steam distilled at standard atmospheric pressure, the temperature of distillation was 96°C. The vapour pressure of water at this temperature was 730 mmHg and the distillate contained 74% water. Calculate the relative molar mass of Y. (4 marks)

3. (a) The atomic numbers and atomic radii of some transition metals are given in the table below.

Element	Si	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Atomic number	21	22	23	24	25	26	27	28	29	30
Atomic radii A°	1.44	1.32	1.22	1.17	1.17	1.16	1.16	1.15	1.17	1.25

(i) Plot a graph of atomic number versus atomic radii (4 marks)
(ii) Explain the shape of your graph (7 marks)
(b) (i) Write the outer electronic configuration of manganese (1 mark)
(ii) State then possible oxidation states of manganese (2 ½ marks)
(iii) How does acidity of the oxides of manganese vary with increasing oxidation state? (½ mark)
(iv) What is the change in the oxidation state of manganese when potassium manganate(VII) is reduced under alkaline conditions (1 mark)
(c) State four applications of potassium manganate(VII) in the laboratory and an oxidizing agent. (4 marks)

4. (a) (i) Define the term **standard electrode potential** (1 mark)
(ii) Why is it not possible to measure standard electrode potential absolutely? (2 marks)
(iii) Discuss the factors which affect the value of standard electrode potentials (5 ½ marks)
(b) Describe a standard hydrogen half-cell (2 marks)
(c) How would you measure standard electrode potential of a metal in solution of its ions? (3 marks)
(d) $Ca^{2+}(aq) + 2e^- \longrightarrow Ca(s)$ $E^o = -2.87$
$Mg^{2+}(aq) + 2e^- \longrightarrow Mg(s)$ $E^o = -2.37$
A cell was set up as below
$Mg(s)/Mg^{2+}//Ca^{2+}(aq)/Ca(s)$ (2 marks)
(i) Calculate the e.m.f of the cell (3 marks)
(ii) What conclusion can you draw from your e.m.f value in (d)(i) above

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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2 (P525/2), 2002

1. (a) A compound X, vapour density 58, contains carbon 62.07%, hydrogen 10.34%, the rest being oxygen. X does not burn with a sooty flame
   (i) Calculate the empirical formula X. (C =12, H = 1, O = 16) (3 marks)
   (ii) Determine the molecular formula of X. (2 marks)
   (b) Hydrolysis of X yielded compounds, Y, $C_4H_{10}O$ and Z, $C_2H_4O_2$
   Both Y and Z react with metallic sodium. Z reacted with sodium carbonate but Y did not.
   (i) Identify Z (1 mark)
   (ii) Write the names and structural formulae of all the possible isomers of Y. (4 marks)
   (iii) Name a reagent that can be used to distinguish between the isomers in (b)(ii) and state what would be observed if the reagent is reacted separately with each of the isomers. (4 marks)
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   (ii) When a compound Y, was steam distilled at standard atmospheric pressure, the temperature of distillation was 96°C. The vapour pressure of water at this temperature was 730 mmHg and the distillate contained 74% water. Calculate the relative molar mass of Y. (4 marks)

3. (a) The atomic numbers and atomic radii of some transition metals are given in the table below.

Element	Si	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Atomic number	21	22	23	24	25	26	27	28	29	30
Atomic radii A°	1.44	1.32	1.22	1.17	1.17	1.16	1.16	1.15	1.17	1.25

   (i) Plot a graph of atomic number versus atomic radii (4 marks)
   (ii) Explain the shape of your graph (7 marks)
   (b) (i) Write the outer electronic configuration of manganese (1 mark)
   (ii) State then possible oxidation states of manganese (2 ½ marks)
   (iii) How does acidity of the oxides of manganese vary with increasing oxidation state? (½ mark)
   (iv) What is the change in the oxidation state of manganese when potassium manganate(VII) is reduced under alkaline conditions (1 mark)
   (c) State four applications of potassium manganate(VII) in the laboratory and an oxidizing agent. (4 marks)

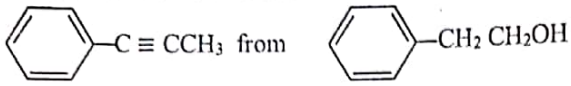
4. (a) (i) Define the term **standard electrode potential** (1 mark)
   (ii) Why is it not possible to measure standard electrode potential absolutely? (2 marks)
   (iii) Discuss the factors which affect the value of standard electrode potentials (5 ½ marks)
   (b) Describe a standard hydrogen half-cell (2 marks)
   (c) How would you measure standard electrode potential of a metal in solution of its ions? (3 marks)
   (d) $Ca^{2+}(aq) + 2e^- \longrightarrow Ca(s)$ $E^o = -2.87$
   $Mg^{2+}(aq) + 2e^- \longrightarrow Mg(s)$ $E^o = -2.37$
   A cell was set up as below
   $Mg(s)/Mg^{2+}//Ca^{2+}(aq)/Ca(s)$ (2 marks)
   (i) Calculate the e.m.f of the cell (3 marks)
   (ii) What conclusion can you draw from your e.m.f value in (d)(i) above

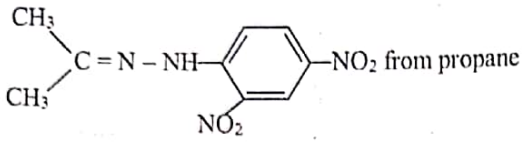
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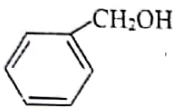
5. Write equations to show how the following compounds can be synthesised.

(a) $CH_3\,CH_2\,CH_2\,CO_2\,H$ from propan – 1 – ol (4 marks)

(b) $CH_3\,CH_2\,CH_3$ from 1 – bromobutane (4 marks)

(c)  from (6 marks)

(d)  from propane (3 ½ marks)

(e)  from benzene (2 ½ marks)

6. Discuss the reactivity of Group IV elements (carbon, silicon, germanium, tin and lead) of the Periodic Table with:

(a) water (4 ½ marks)

(b) dilute acids (6 marks)

(c) concentrated acid (10 marks)

7. (a) Explain what is meant by:

(i) "Osmosis" (3 marks)

(ii) "Osmotic pressure" (3 marks)

(b) State the significance of osmosis (1 mark)

(c) Describe a method which can be used to determine the osmotic pressure of a solution (7 marks)

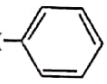
(d) State the conditions under which solutions do not obey the laws of osmotic pressure (3 marks)

(e) The osmotic pressure of a solution containing 1.24% a polymer is 3.1×10^{-3} atmosphere, 25°C. Determine the relative molecular mass of the polymer (R = 0.0821) (3 marks)

8. Complete the following equations and in each case outline a mechanism for the reaction.

(a) $CH_3\,CH_2\,CH_2Br + CH_3\,CH_2\bar{O}Na^+ \xrightarrow[\text{heat}]{CH_3CH_2OH}$ (2 marks)

(b)  $+ CH_3CH{=}CH_2 \xrightarrow{H_2SO_4}$ (4 marks)

(c) $CH_3CH_2CHO + H_2N-NH-$  $\xrightarrow{H^+}$ (4 ½ marks)

(d)  $\xrightarrow{Heat}$ (2 marks)

(e) $CH_3\overset{\overset{OH}{|}}{C}HCH_3 + \text{conc. } H_3PO_4(aq) \xrightarrow{Heat}$ (3 ½ marks)

(f) $CH_3CH = CHCH_3 \xrightarrow{Cl_2/H_2O}$ (4 marks)

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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2(P525/2), 2002

Question. One.

(a) (i) Percentage of oxygen in X = 100 − (62.07 + 10.34) = 27.59%

Composition of X;

	C	H	O
Number of moles;	$\frac{62.07}{12}$	$\frac{10.34}{1}$	$\frac{27.59}{16}$
	5.1725	10.34	1.7244
Mole ratio;	$\frac{5.1725}{1.7244}$	$\frac{10.34}{1.7244}$	$\frac{1.7244}{1.7244}$
	3 :	6 :	1

Empirical formula of X is C_3H_6O.

(ii) Molecular mass of X = $2 \times (vapour\ density)$

$= 2 \times 58 = 116$

Hence; $(C_3H_6O)n = 116$

$(3 \times 12)n + (6 \times 1)n + (1 \times 16)n = 116$

$58n = 116$

$\therefore n = \frac{116}{58} = 2$

Therefore, molecular formula of X is $C_6H_{12}O_2$

(b) (i) Ethanoic acid or CH_3COOH

(ii) Butan-1-ol; $CH_3CH_2CH_2CH_2OH$

2-methylpropan-1-ol; $CH_3CH(CH_3)CH_2OH$

Butan -2-ol; $CH_3CH(OH)CH_2CH_3$

2 –methyl propan -2-ol; $CH_3-C(CH_3)_2-OH$

(iii) Reagent – solution of **concentrated hydrochloric acid** and **anhydrous zinc chloride.**

Observation;

Butan -1-ol and 2-methyl propan -1-ol show no **observable change** at room **temperature.**

Butan -2-ol – forms a **cloudy solution** after five minutes

2-methyl propan -2-ol – forms a **cloudy solution immediately.**

(c) (i) 2-methyl propan -2-ol

(ii) $CH_3C(=O)-O-C(CH_3)_2-CH_3$

(d) (i) $(CH_3)_3C-OH \xrightarrow[\text{heat}]{\text{Conc. } H_3PO_4} (CH_3)_2C=CH_2 + H_2O$

Mechanism;

$CH_3-C(CH_3)_2-OH \xrightarrow{H^+} CH_3-C(CH_3)_2-OH_2 \longrightarrow H-C(H)-C^+(CH_3)-CH_3 \xrightarrow{-H^+} CH_2=C(CH_3)-CH_3$

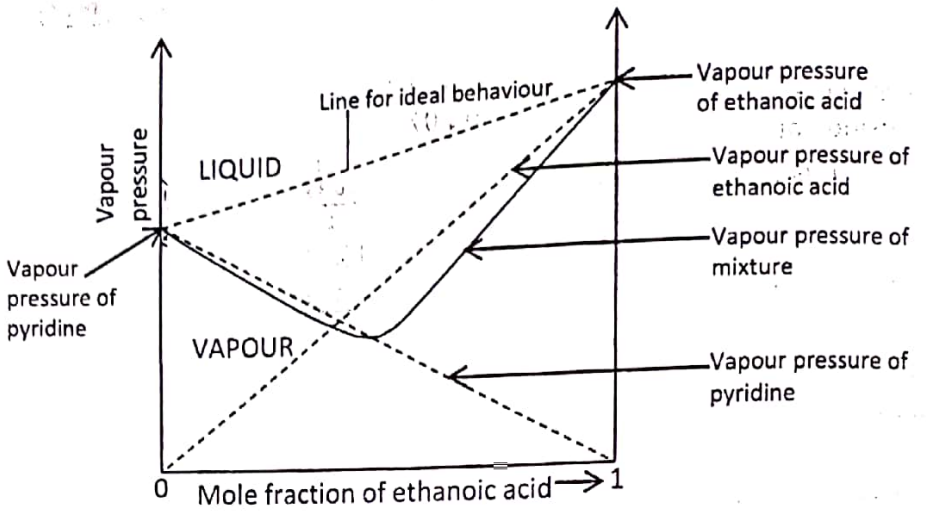
(ii) 2-methyl propene

Question. Two.

(a) Raoult's law states that, the partial vapour pressure of a **volatile component** of an **ideal solution** is a product of its molefraction in solution and the vapour pressure of the pure component at a **constant temperature.**

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(b) (i)



(ii) The vapour pressure of the mixture of pyridine and ethanoic acid is **lower** than that of an ideal solution.
This is due to **reduced escaping tendency** of the molecules of pyridine and ethanoic acid in solution into vapour phase as a result of the **intermolecular forces** between pyridine and ethanoic acid molecules in solution being **greater** than the intermolecular forces between pure liquid components.

(c) (i) Steam distillation is a method used to separate a **volatile component** which is **immiscible with water** from other impurities and the mixture **boils at a temperature less than 100°C**

(ii) Total pressure = standard atmospheric pressure
$= 760mmHg$
Vapour pressure of Y = 760 − 730 =**30mmHg**
Percentage of Y in distillate = 100 −74 = **26%**

$$\frac{\%\ of\ Y\ in\ distillate}{\%\ of\ H_2O\ in\ distillate} = \frac{vapour\ pressure\ of\ Y \times molar\ mass\ of\ Y}{vapour\ pressure\ of\ H_2O \times molar\ mass\ of\ H_2O}$$

$$\frac{26}{74} = \frac{30 \times molar\ mass\ of\ Y}{730 \times 18}$$

Relative molar mass of $Y = \frac{26 \times 730 \times 18}{74 \times 30}$ = **153.89**

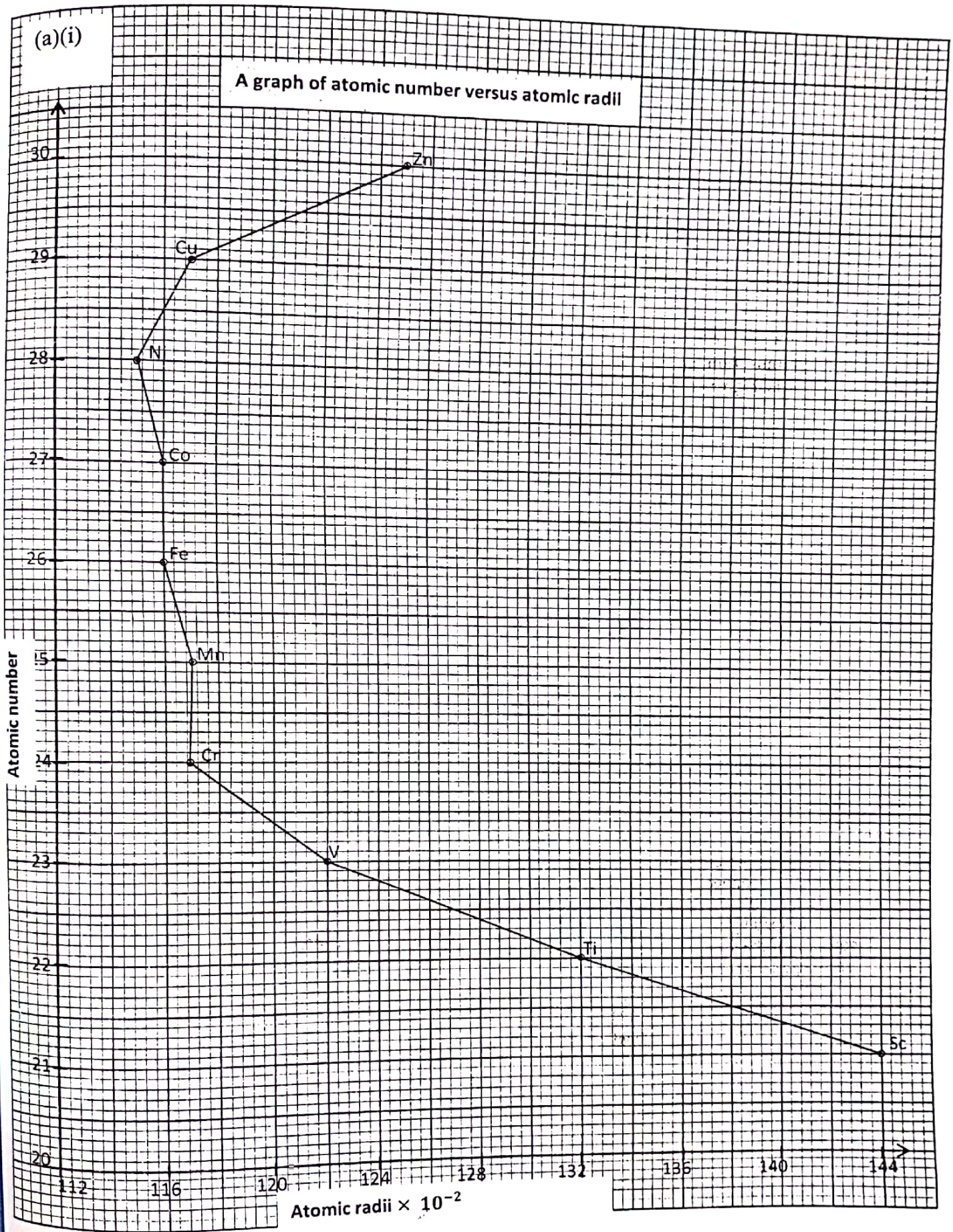
Question. Three.

(a) (i) See graph next page
NOTE: The question instructed candidates to plot a graph of atomic number against atomic radius, however, the best graph would be atomic radius plotted against atomic number, and hence explained as follows.

(ii) The atomic radius of transition metals **decreases slightly from scandium to Nickel** and then **increases from copper to zinc**
Along the transition series from scandium to Nickel, increase in atomic number, **increases the nuclear charge** and an electron is added to the inner 3d sub-energy level which greatly **increases the screening effect.**
Therefore, the increasing nuclear charge is **roughly** balanced by the relatively greater screening effect and as a result **effective nuclear slightly increases** and thus the outer electrons are **less attracted** by the nucleus hence the **slight decrease in atomic radius**.
However zinc with electronic configuration; $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}4s^2$ and copper with electronic configuration; $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}4s^1$ have full inner 3d-subshells of electrons and this offers a **greater shielding effect** to the outer 4s electrons hence the increase in atomic radius from Nikel to copper then to zinc.

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(a)(i)



(b) (i) $3d^5 4s^2$

(ii) +2, +3, +4, +5, +6 and +7

(iii) Acidity of the oxides of manganese **increases** with increasing oxidation state.

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(iv) Oxidation state **changes from +7 to +4**

(c) – Used in volumetric analysis as a **self indicator** to determine end points of titrations
- Used in preparation of chlorine from hydrochloric acid and oxygen from hydrogen peroxide
- Used to test for the presence of reducing agents such as aldehydes, primary and secondary alcohols etc.
- Standard solution of potassium manganate (VII) can be used to estimate the concentration of iron (II) salts and oxalates in given substances.

Question. Four.

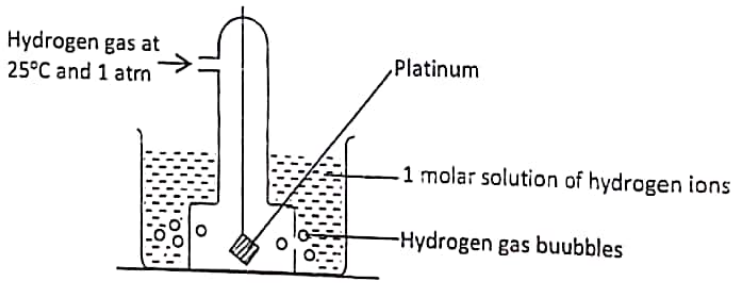
(a) (i) The potential difference between the half cell of an electrode in which the electrode is dipped in a one **molar** aqueous solution of its ions and the standard hydrogen electrode at **298K** and **1atm pressure.**

(ii) This is because in determination of standard electrode potential of an electrode, it is necessary to have a second electrode, but this second electrode also produces its own electromotive force (Emf), thus making the measurement relative rather than absolute.

(iii) – **Atomisation energy** or **sublimation energy**.
- The higher the atomization energy, the lower is the electrode potential value because it becomes difficult to convert the element into gaseous atoms
- **Ionization energy**
  The higher the ionization, the lower the electrode potential of the element because it is difficult to convert the gaseous atoms into gaseous ions
- **Hydration energy**
  The higher the hydration energy the higher the electrode potential because the gaseous ions can easily be hydrated in aqueous solution.

(b) A standard hydrogen half cell consists of **hydrogen gas bubbles** on surface of **platinum** foil which is in a **one molar** solution of **hydrogen ions** at **298K**, and **1atm pressure.**

Illustration



(c) The metal whose electrode potential is to be determined is dipped in a **1molar solution of its ions**
The metal is connected externally to the hydrogen electrode via a **voltimeter**
The metal half cell is connected internally to the hydrogen half cell by a **salt bridge.**
The Emf read by the voltimeter is standard electrode potential of the metal since the standard electrode potential of the standard hydrogen electrode is taken to be **0.0volts**
(see dagram in solution to question 4.(a) 2007 P2)

(d) (i) Emf cell $= E^{\theta}_{cathode} - E^{\theta}_{anode}$
$= -2.87 - (-2.37) = \mathbf{-0.5volts}$

(ii) The cell reaction is **not feasible** because the Emf of the cell is **negative.**

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Question. Five.

(a) $CH_3CH_2CH_2OH \longrightarrow CH_3CH_2CH_2Cl$

$CH_3CH_2CH_2Cl \xrightarrow[\text{heat}]{\text{KCN, Alcohol}} CH_3CH_2CH_2CN \xrightarrow[\text{heat}]{H_2O/H^+} CH_3CH_2CH_2COOH$

or

$CH_3CH_2CH_2OH \xrightarrow{PCl_5} CH_3CH_2CH_2Cl \xrightarrow[\text{heat}]{\text{Mg/dryether}} CH_3CH_2CH_2MgCl$

$CH_3CH_2CH_2MgCl \xrightarrow[2.H_2O/H^+]{1.HC(=O)-H} CH_3CH_2CH_2CH(OH) \xrightarrow[\text{heat}]{Cr_2O_7^{2-}/H^+} CH_3CH_2CH_2COOH$

or

$CH_3CH_2CH_2OH \xrightarrow{PCl_5} CH_3CH_2CH_2Cl \xrightarrow[\text{heat}]{Mg,\ \text{dryether}} CH_3CH_2CH_2MgCl \xrightarrow[2.H_2O/H^+]{1.CO_2/\text{heat}} CH_3CH_2CH_2COOH$

(b) $CH_3CH_2CH_2CH_2Br \xrightarrow[\text{or } SOCl_2]{PCl_5 \text{ or } PCl_3} CH_3CH_2CH_2CH_2OH$

$CH_3CH_2CH_2CH_2OH \xrightarrow[\text{Heat}]{Cr_2O_7^{2-}/H^+ \left(\text{or } MnO_4^-, \text{Conc.} H_2SO_4, \text{heat}\right)} CH_3CH_2CH_2COOH$

$CH_3CH_2CH_2COOH \xrightarrow[\text{heat}]{\text{Soda lime}} CH_3CH_2CH_3$

Note Soda lime is a mixture of (solid NaOH and solid CaO)

Or

$CH_3CH_2CH_2CH_2Br \xrightarrow[\text{Ethanol, heat}]{NaOH(aq)} CH_3CH_2CH=CH_2$

$CH_3CH_2CH=CH_2 \xrightarrow[2.H_2O/Zn,\ CH_3COOH]{1.O_3/CCl_4\ /<20^\circ C} CH_3CH_2CHO$

$CH_3CH_2CHO \xrightarrow[\text{dryether}]{LiAlH_4} CH_3CH_2CH_2OH \xrightarrow[\text{heat}]{\text{Conc. } H_2SO_4} CH_3CH=CH_2 \xrightarrow[\text{Ni or Pt catalyst}]{H_2} CH_3CH_2CH_3$

or

$CH_3CH_2CH_2CH_2Br \xrightarrow[\text{Ethanol, heat}]{KOH} CH_3CH_2CH=CH_2$

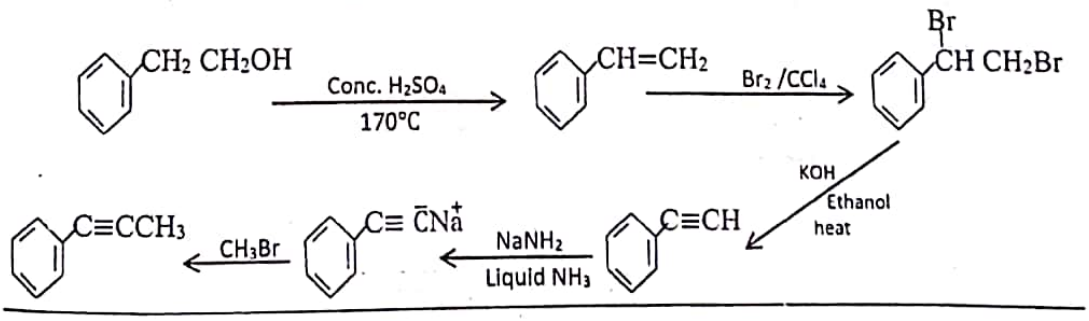
$CH_3CH_2CH=CH_2 \xrightarrow[2.H_2O/Zn/\ CH_3COOH]{1.O_3/CCl_4\ /<20^\circ C} CH_3CH_2CHO$

$CH_3CH_2CHO \xrightarrow[\text{dryether}]{LiAlH_4} CH_3CH_2CH_2OH \xrightarrow{PCl_5} CH_3CH_2CH_2Cl$

$CH_3CH_2CH_2Cl \xrightarrow[\text{Couple, aqueous alcohol}]{\text{Zn - Cu}} CH_3CH_2CH_3$

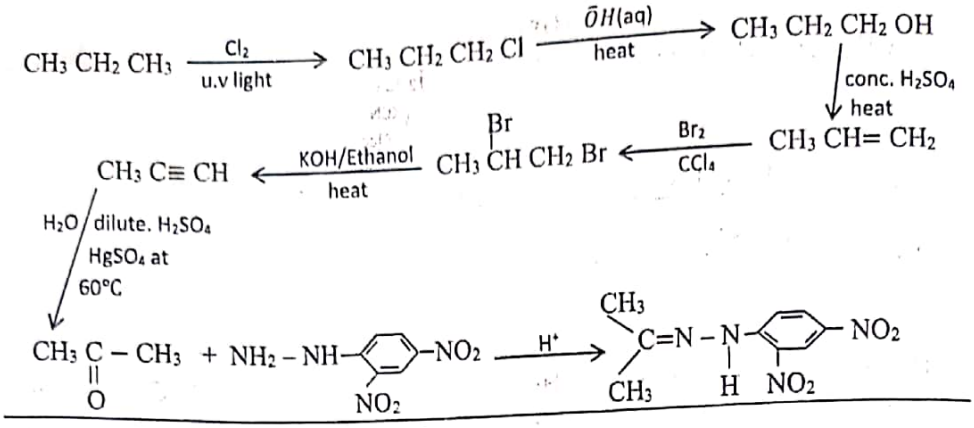
Note; In the above alternative, instead of (Zn-Cu, couple and aqueous alcohol), (Mg/dryether then H_2O/H^+) can be used.

(c)

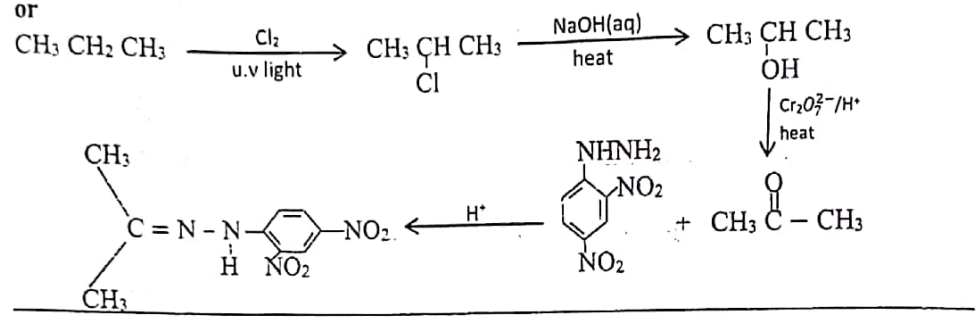


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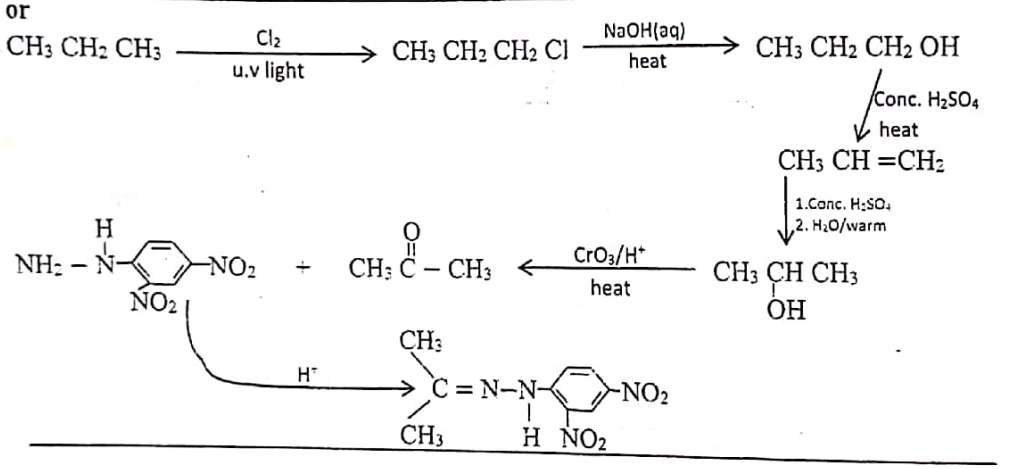
(d)



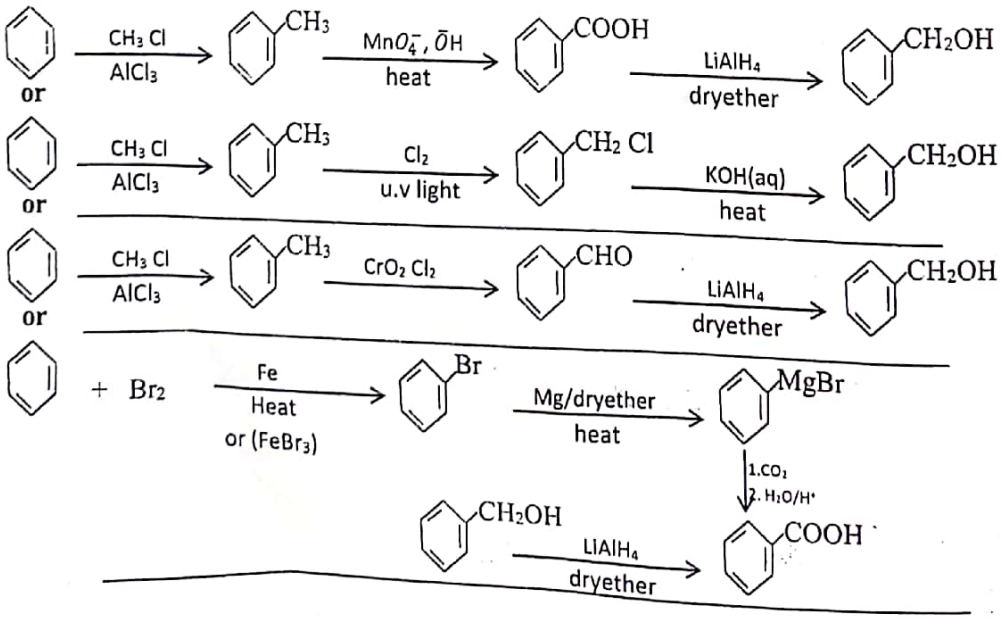
or



or



or



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Question. Six.

(a) **Heated** carbon reacts with **steam** to form **carbon monoxide** and **hydrogen gas.**
$C(s) + H_2O(g) \rightarrow CO(g) + H_2(g)$
Heated silcon reacts with **steam** to form **silicon (IV) oxide** and **hydrogen gas**
$Si(s) + 2H_2O(g) \rightarrow SiO_2(s) + 2H_2(g)$
Germanium and tin **donot** react with water or steam.
Lead reacts with **soft water** in presence of **oxygen** (air) to form lead (II) hydroxide
$2Pb(s) + 2H_2O(l) + O_2(g) \rightarrow 2Pb(OH)_2(s)$

(b) Carbon, silicon and Germanium **do not** react with dilute acids
Tin is **oxidized** by dilute nitric acid to **tin (II) nitrate**, and the acid is reduced to **ammonium nitrate** and **water**.
$Sn(s) + 10HNO_3(aq) \rightarrow 4Sn(NO_3)_2(aq) + NH_4NO_3(aq) + 2H_2O(l)$
Tin reacts with dilute hydrochloric acid and sulphuric acid to form **tin(II) chloride**, tin(II) sulphate respectively and hydrogen gas
$Sn(s) + 2HCl(aq) \rightarrow SnCl_2(aq) + H_2(g)$
$Sn(s) + 2H_2SO_4(aq) \rightarrow SnSO_4(aq) + H_2(g)$
or, $Sn(s) + 2H^+(aq) \rightarrow Sn^{2+}(aq) + H_2(g)$
Lead reacts with dilute hydrochloric acid on **heating** to form **lead(II) chloride** and **hydrogen gas**
$Pb(s) + 2HCl(aq) \rightarrow PbCl_2(aq) + H_2(g)$
Cold dilute hydrochloric acid and dilute sulphuric acid **render lead passive** due to formation of insoluble lead(II) chloride and lead(II) sulphate respectively.

(c) Carbon is **oxidized** by **hot concentrated** sulphuric acid to **carbon dioxide** and the acid is reduced to **sulphur dioxide** and **water**
$C(s) + H_2SO_4(aq) \rightarrow CO_2(g) + 2SO_2(g) + 2H_2O(l)$
Carbon is also **oxidized** by **hot concentrated** nitric acid to **carbon dioxide** and the nitric acid reduced to **nitrogen dioxide** and **water**
$C(s) + 4HNO_3(aq) \rightarrow CO_2(g) + 4NO_2(g) + 2H_2O(l)$
Silicon **does not** react with hydrochloric, nitric and sulphuric acids but reacts with **concentrated hydrofluoric** acid to form **hexafluoro silicic** acid and **hydrogen gas**
$Si(s) + 6HF(aq) \rightarrow H_2SiF_6(aq) + 2H_2(g)$
Germanium is **oxidized** by **hot** concentrated sulphuric acid to **Germanium (IV) oxide** and the acid is reduced to **sulphur dioxide** and **water**
$Ge(s) + 2H_2SO_4(aq) \rightarrow GeO_2(s) + 2SO_2(g) + 2H_2O(l)$
Germanium is **oxidized** by **hot concentrated** nitric acid to **Germanium (IV) oxide** and the acid is reduced to **nitrogen monoxide** and **water**
$3Ge(s) + 4HNO_3(aq) \rightarrow 3GeO_2(s) + 4NO(g) + 2H_2O(l)$
Tin reacts with concentrated hydrochloric acid to form **hydrated tin (II) chloride** and **hydrogen gas**
$2Sn(s) + 2HCl(aq) + 2H_2O(l) \rightarrow SnCl_2 \cdot Sn(OH)_2(s) + 2H_2(g)$
Tin is oxidized by **hot concentrated** sulphuric acid to **tin (IV) sulphate** and the acid is reduced to **sulphur dioxide** and water;
$Sn(s) + 4H_2SO_4(aq) \rightarrow Sn(SO_4)_2(aq) + 2SO_2(g) + 4H_2O(l)$
Lead reacts with **hot concentrated** hydrochloric acid to form **lead (II) chloride** and **hydrogen gas**;
$Pb(s) + 2HCl(aq) \rightarrow PbCl_2(aq) + H_2(g)$
Lead is **oxidized** by **hot concentrated** nitric acid to **lead (II) nitrate** and the acid is reduced to **nitrogen monoxide** and **water**
$3Pb(s) + 8HNO_3(aq) \rightarrow 3Pb(NO_3)_2(aq) + 2NO(g) + 4H_2O(l)$
Lead is **oxidized** by **hot concentrated** sulphuric acid to **lead (II) sulphate** and the acid is reduced to **sulphur dioxide** and **water.**
$Pb(s) + 2H_2SO_4(aq) \rightarrow PbSO_4(s) + SO_2(g) + 2H_2O(l)$

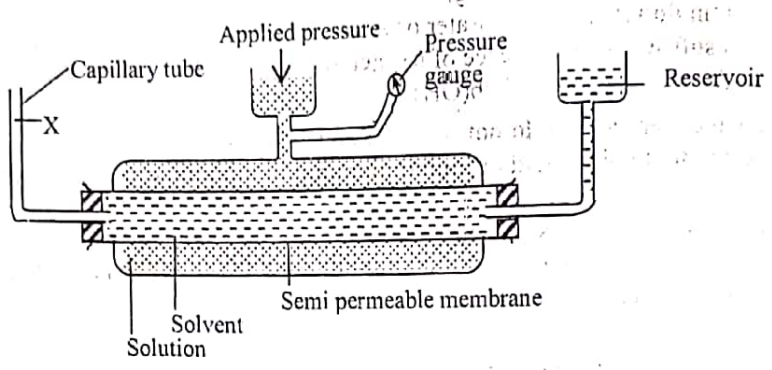
Question. Seven.

(a) (i) The process by which **solvent** molecules move from a less concentrated solution to a more concentrated solution across a **semi permeable membrane**
(ii) The pressure which must be applied to the solution to **balance the flow** of solvent molecules from the solvent to the solution across a **semi permeable membrane**

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(b) In the determination of molecular masses of polymers
Osmosis facilitates water up take through the roots and maintains turgidity in plants.
Osmosis is significant in excretion and gaseous exchange.

(c)



-A solution whose osmotic pressure is to be determined is separated from the solvent by a **semi permeable membrane.**
Pressure is then applied to the solution and the pressure that **maintains the level** of the solvent in the capillary tube at point X is the **osmotic pressure of the solution** and this pressure is read off from the **pressure gauge.**

(d) -When the solution is concentrated
-When the solute particles react chemically with the solvent
-When the solute particles associate or dissociate in solution
-When the solute is volatile

(e) Let the relative molecular mass of polymer = mr

Hence $\pi v = \frac{m}{mr}RT$

$3.1 \times 10^{-3} \times 0.1 = \frac{1.24 \times 0.0821 \times (25+273)}{mr}$

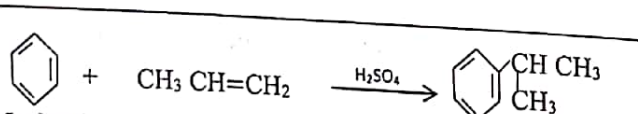
$mr = \frac{1.24 \times 0.0821 \times (25+273)}{3.1 \times 10^{-3} \times 0.1} = 97863.2$

Question. Eight.

(a) $CH_3CH_2CH_2Br + CH_3CH_2\bar{O}Na^+ \longrightarrow CH_3CH_2CH_2OCH_2CH_3$

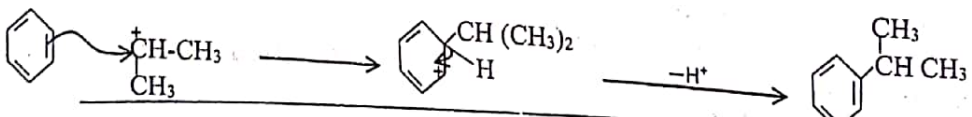
Mechanism;

$CH_3CH_2CH_2 \leftarrow \bar{O}CH_2CH_3$ (Br leaving) $\longrightarrow CH_3CH_2CH_2 - O - CH_2CH_3$

(b) 

Mechanism;

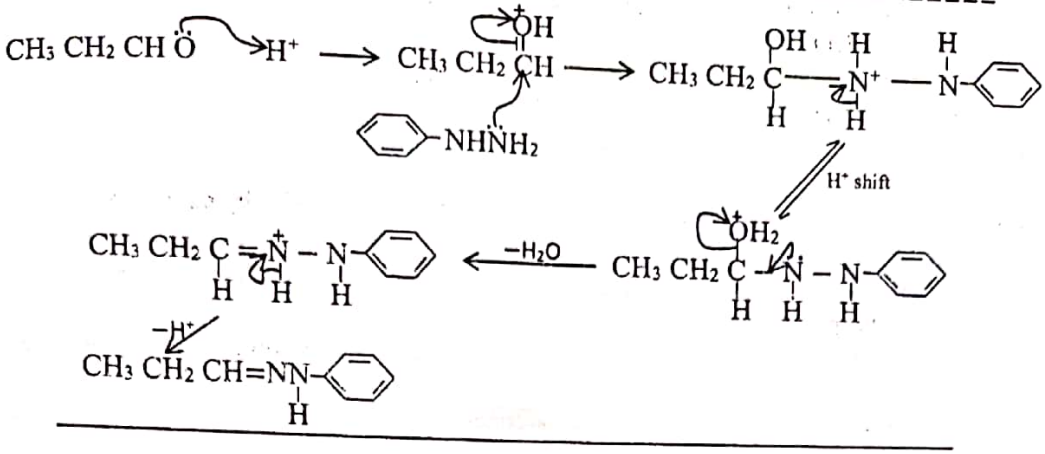
$CH_3C(H)=CH_2 \longrightarrow CH_3\overset{+}{C}HCH_3 + HS\bar{O}_4$ (H–OSO3H)



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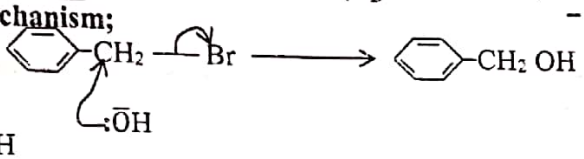
(c) $CH_3CH_2CHO + H_2N-NH-C_6H_5 \xrightarrow{H^+} CH_3CH_2CH=N-NH-C_6H_5$

Mechanism;



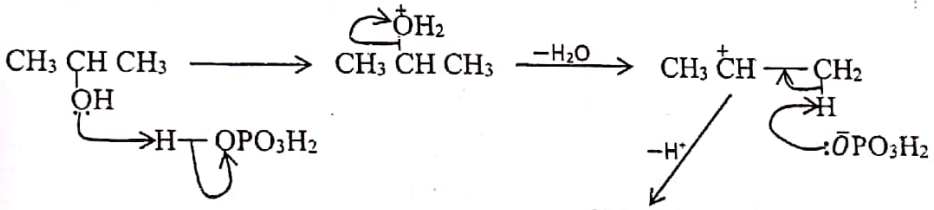
(d) $C_6H_5CH_2Br + \bar{O}H(aq) \xrightarrow{heat} C_6H_5CH_2OH$

Mechanism;



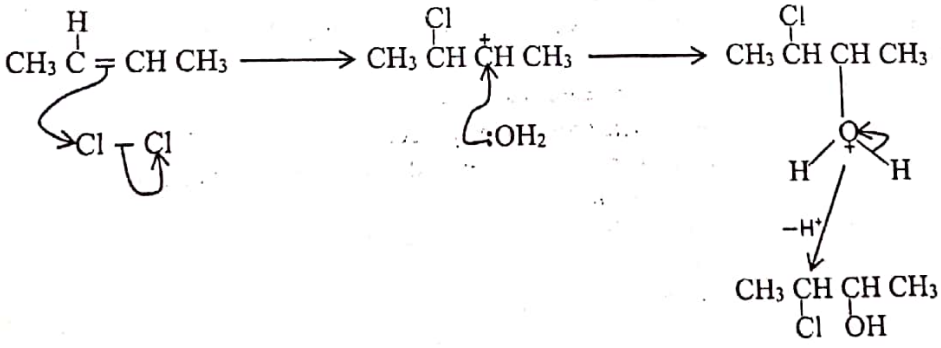
(e) $CH_3CH(OH)CH_3 + \text{conc. } H_3PO_4 \xrightarrow{heat} CH_3CH=CH_2$

Mechanism;



(f) $CH_3CH=CHCH_3 \xrightarrow{Cl_2/H_2O} CH_3CH(Cl)CH(OH)CH_3$

Mechanism;

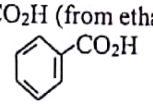


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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1 (P525/1), 2001

1. The osmotic pressure of a solution containing 1.4g of a polymer X per $100cm^3$ of a solution is $1200Nm^{-2}$ at 25°C.
   (a) Calculate the relative molecular mass of X (4 marks)
   (b) Determine the number of monomers in X
   (The molecular mass of the monomers of X is 28) (1 mark)
2. (a) Compare the following equation for the decay of bismuth.
   $^{214}_{83}Bi \longrightarrow {}^{0}_{-1}e +$ ..... (1 mark)
   (b) The half life of bismuth is 19.7 minutes. Determine the time taken for 43% by mass of bismuth to decay. (3 marks)
3. The solubility of calcium phosphate is 0.0011g per 100g water at 25°C. Calculate the solubility product of calcium phosphate at 25°C. (5 marks)
4. (a) A gaseous compound X contains 44.4% carbon, 51.9% nitrogen and hydrogen. Determine the empirical formula of X.
   (b) 50ml of X diffused through a porous plug in 25 seconds. Under similar conditions, the same volume of hydrogen gas diffused in 6.8 seconds.
   Calculate:
   (i) the molecular mass of X. (1½ marks)
   (ii) the molecular formula of X.
5. Name one reagent that can be used to distinguish between each of the following pairs of compounds and in each case, state what would be observed if each member of the pair is treated with the reagent.
   (a) $CH_3\overset{O}{\overset{\|}{C}}CH_3$ and $CH_3\overset{O}{\overset{\|}{C}}-H$ (3 marks)
   (b) C_6H_5COOH and C_6H_5OH (3 marks)
6. The results of the hydrolysis of 2-bromo-2-methylpropane by aqueous sodium hydroxide at 25°C is shown in the table below.

Concentration of $(CH_3)_3CBr$/mol dm^{-3}	Concentration of OH^- ions/mol dm^{-3}	Rate of Hydrolysis/mol dm^{-3}
0.100	0.500	0.0020
0.100	0.250	0.0020
0.050	0.250	0.0010
0.025	0.250	0.0005

   (a) Deduce the order of reaction with respect to
   (i) 2-bromo-2-methylpropane (1 mark)
   (ii) the hydroxide ion (1 mark)
   (b) Write the rate equation for the reaction (1 mark)
   (c) Calculate the rate constant, K, for the reaction and state its units. (2 marks)
7. $100cm^3$ of an aqueous solution containing 20g of W was shaken once with $50cm^3$ of ether.
   (a) Calculate the mass of W extracted by ether.
   (The distribution coefficient, K_D of W between ether and water is 4) (2 marks)
   (b) Calculate the mass of W that would be extracted by shaking the solution twice with 25°C of ether. (4 marks)
8. When $142cm^3$ of a hydro carbon Q, of molecular mass 58 was exploded with excess oxygen and cooled to room temperature, the volume of the residual gas was $694cm^3$
   After addition of concentrated potassium hydroxide, the volume decreased to $126cm^3$.
   (a) Determine the molecular formula of Q. (4 marks)
   (b) Write the names and the structural formulae of all isomers of Q. (2 marks)
9. An acid HA ionizes in water to give a 0.1M acidic solution with pH = 30.
   (a) Write the equation for the ionization of HA. (1 mark)
   (b) Calculate the ionization constant, K_a of the acid. (3 marks)
10. Write equations to show the following compounds can be synthesized
    (a) CH_3CO_2H (from ethane) (3 marks)
    (b)  (from benzene) (3 marks)
    (c) $CH_3CH_2CH=CH_2$ (from ethyne) (3 marks)

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11. (a) State:
(i) the distribution (Partition) law
(ii) the conditions under which the distribution law is valid. (3½ marks)

(b) $100cm^3$ of an aqueous solution containing 10g of a compound Q was shaken with $100cm^3$ of benzene. Q is more soluble in benzene and water is 12.2. Calculate the mass of Q left in the aqueous layer. (1½ marks)

(c) State one application of partition of solutes (3 marks)

12. The bond energies and the atomic numbers of the elements in group VII in the Periodic Table are given in the table below. (1 mark)

Element	F	Cl	Br	I
Bond energy (kJ mol^{-1})	158	242	193	151
Atomic number	9	17	35	53

(a) Define the term bond energy. (2 marks)

(b) (i) Draw a graph of bond energy versus atomic number of the halogens. (3 marks)
(ii) Explain the shape of the graph you have drawn in (b) (i) (4 marks)

13. Complete the following equations and in each case write the accepted mechanism for the reaction.

(a) $CH_3-CH=CHCH_3 \xrightarrow{H^+/H_2O}$ (3 marks)

(b)  $+ CH_3COCl \xrightarrow{AlCl_3}$ (3 marks)

(c) $(CH_3)_3C-Br + CH_3O^-Na \xrightarrow[heat]{CH_3OH}$ (3 marks)

14. (a) Iron (II) sulphate is normally used to standardize a solution of potassium manganate (VII) acidified using sulphuric acid.
(i) Write equation for the reaction between potassium manganate (VII) and iron (II) sulphate. (1½ marks)
(ii) State why hydrochloric acid is not used to acidify potassium manganate (VII) solution (2½ marks)

(b) $25cm^3$ of an acidified solution of 0.02M potassium manganate (VII) reacted exactly with $25cm^3$ of sodium nitrite. Potassium manganate (VII) reacts with sodium nitrite according to the following equation.

$2MnO_4^-(aq) + 5NO_2^-(aq) + 6H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 5NO_3^-(aq) + 3H_2O(l)$.

Calculate the concentration of the sodium nitrite in moles per litre. (4 marks)

15. (a) Define the term a buffer solution (2 marks)

(b) Calculate the mass of sodium ethanoate that should be added to 1 litre of a 0.1M ethanoic acid solution in order to produce a solution of pH = 4.0
(Ka for ethanoic acid = 1.8×10^{-5}) (5 marks)

(c) State what would happen to the pH of the solution in (b) if a small amount of the following were added.
(i) Sodium hydroxide solution (½ mark)
(ii) Hydrochloric acid (½ mark)

(d) State one biological application of a buffer solution. (1 mark)

16. (a) (i) Write an equation for the solubility of silver sulphate in water. (1 mark)
(ii) Determine the molar concentrations of silver and sulphate ions in a saturated solution of silver sulphate at 25°C (3 marks)
(The solubility product, K_{sp}, of silver sulphate is 1.7×10^{-5}mol dm^{-3} at 25°C)

(b) State how the solubility of silver sulphate would be affected if the following substance were added.
(i) Sodium sulphate solution (1 mark)
(ii) Ammonia solutyion (1 mark)

(c) Explain your answer in (b) (3 marks)

17. State the type of polymerization leading to the formation of the polymers given in the table below. In each case, write the name and the structural formulae of the monomers.

polymer	Type of polymerization	Structural formula of monomers	Name of monomers
Polyester			
Polyarnide			
Polysterene			

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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2001

1. (a) From the laws of osmostic pressure;

$$\pi v = \frac{m\,RT}{mr}$$

Hence; relative molecular mass of X; $mr = \frac{mRT}{\pi v}$

$$= \frac{1.4\times8.31\times(25+273)}{1200\times(100\times10^{-6})}$$

$$= 28891$$

(b) Let the number of monomer units $= n$

Hence; $(molar\ mass\ of\ monomer)n = relative\ molecular\ mass\ of\ polymer$

$$(28)n = 28891$$

$$n = \frac{28891}{28} = \mathbf{1032\ monomers}$$

2. (a) $^{214}_{83}Bi \longrightarrow {}^{0}_{-1}e + {}^{214}_{84}Po$

(b) Let λ be the decay constant and t be the time taken for 43% by mass of bismuth to decay, while t½ is the life of Bismuth;

Then; $\lambda = \frac{0.693(In2)}{t\frac{1}{2}}$

$$\lambda = \frac{0.693}{19.7} = \mathbf{0.0352\ minute^{-1}}$$

$$using;\ 2.303\log_{10}\left(\frac{No}{Nt}\right) = \lambda t$$

$$2.303\log_{10}\left(\frac{100}{100-43}\right) = 0.0352\times t$$

$$\therefore t = \frac{2.303\log\left(\frac{100}{57}\right)}{0.0352} = \mathbf{15.97minutes}$$

3. Equation of solubility;

$$Ca_3(PO_4)_2(s) \rightleftharpoons 3Ca^{2+}(aq) + 2PO_4^{3-}(aq)$$

$$Ksp = [Ca^{2+}]^3[PO_4^{3-}]^2$$

$$Formula\ mass\ of\ Ca_3(PO_4)_2 = (3\times40) + (2\times31) + (8\times16)$$

$$= 310$$

$100g\ of\ solution\ contain\ 0.0011g\ of\ calcium\ phosphate$

$\therefore 1000g\ of\ solution\ contain\ \frac{1000\times0.0011}{100}g$ of $calcium\ phosphate.$

$$= 0.011gdm^{-3}$$

$$molar\ concentration\ Ca_3(PO_4)_2 = \frac{0.011}{310} = 3.548\times10^{-5}moldm^{-3}$$

According to the equation of solubility;

$$[Ca^{2+}] = (3\times3.548\times10^{-5})moldm^{-3}$$

$$[PO_4^{3-}] = (2\times3.548\times10^{-5})moldm^{-3}$$

Hence; $ksp = (3\times3.548\times10^{-5})^3\times(2\times3.548\times10^{-5})^2$

$$= 6.072\times10^{-21}mol^5dm^{-15}$$

4. (a) Percentage of hydrogen in $X = 100 - (44.4 + 51.9) = 3.7\%$

Composition of X;

	C		H		N
Number of moles;	$\frac{44.4}{12}$		$\frac{3.7}{1}$		$\frac{51.9}{14}$
	3.7		3.7		3.7
Mole ratio;	$\frac{3.7}{3.7}$		$\frac{3.7}{3.7}$		$\frac{3.7}{3.7}$
	1	:	1	:	1

Emperical formula of X is **CHN**

(c) From Graham's law;

$$\frac{Rate\ of\ diffusion\ of\ H_2}{Rate\ of\ diffusion\ of\ x} = \sqrt{\frac{molecular\ mass\ of\ x}{Molecular\ mass\ of\ H_2}}$$

$$So;\quad \frac{VH_2}{tH_2}\times\frac{tx}{Vx} = \sqrt{\frac{molecular\ mass\ of\ X(Mx)}{Molecular\ mass\ of\ H_2}}$$ (where; v = volume and t = time)

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Thus; $\frac{50}{6.8} \times \frac{25}{50} = \sqrt{\frac{Mx}{2}}$

$$Mx = \left(\frac{25}{6.8}\right)^2 \times 2 = 27$$

(ii) $(HCN)n = 27$

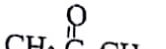
$$(1\times 1)n + (1 \times 12)n + (1 \times 14)n = 27$$

$$n = \frac{27}{27} = 1$$

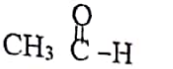
∴ molecular formula of X is HCN.

5. (a) **Reagent**; Ammoniacal silver nitrate **solution**

Observation;



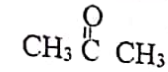
-gives **no observable change**



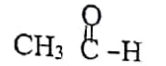
Alternatively; -forms a **silver mirror** on the sides of the test tube

Reagent - Fehling's solution

Observation;



-gives **no observable change**



-gives a reddish brown precipitate

(b) **Reagent** – Sodium carbonate or sodium hydrogen carbonate

Observation; C_6H_5COOH –gives **effervescence** of a **colourless gas**

C_6H_5OH -gives **no observable change**

Alternatively;

Reagent - Iron (III) chloride solution

Observation; C_6H_5COOH – gives a reddish –brown solid

C_6H_5OH – gives a purple or violet colouration

Alternatively;

Reagent - Bromine water

Observation; C_6H_5COOH – gives no observable change

C_6H_5OH – gives a white precipitate

6. (a) (i) When the concentration of sodium hydroxide is **constant** and the concentration of 2-bromo -2-methylpropane **halved**, the rate of hydrolysis also **reduces by half** indicating that the reaction is **first order** with respect to 2 – bromo 2methyl propane.

Or, by calculation;

$$\left(\frac{0.050}{0.100}\right)^x = \frac{0.0010}{0.0020}$$

$$(0.5)^x = (0.5)^1$$

Hence; $x = 1$; Thus order of react with respect to 2-bromo-2-methyl propane is **one.**

(ii) When the concentration of 2-bromo-2-methyl propane is **constant**, the concentration of hydroxide ions **reduces by half** and the rate of hydrolysis **remains the same** hence the order of reaction with respect to hydroxide ions is **zero**

or by calculation;

$$\left(\frac{0.250}{0.500}\right)^y = \left(\frac{0.0020}{0.0020}\right)$$

$$(0.5)^y = 1$$

Thus; $y = 0$; hence the order of reaction with respect to hydroxide ions is **zero**

(b) Rate $= k[(CH_3)_3C - Br]$ *where* $k = rate\ constant$

(c) Rate constant; $k = \frac{Rate}{[(CH_3)_3C-Br]}$

$= \frac{0.0020}{0.100}$ (substitution using the first set of values)

$= 0.02\ second^{-1}$

7. (a) Let; *mass of w extracted by* $50cm^3$ *of ether* $= y\ grams$

Hence; *mass of w left in aqueous (water) layer* $= (20 - y)g$

∴ *concentration of w in ether* $= \frac{y}{50}$ and;

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$$\text{concentration of } w \text{ in aqueous layer} = \frac{(20-y)}{100}$$

$$K_D = \frac{\text{concentration of } W \text{ in ether}}{\text{concentration of } W \text{ in water}}$$

$$k_D = \frac{y}{50} \times \frac{100}{(20-y)}$$

$$4 = \frac{2y}{(20-y)}$$

$$2y = 80 - 4y$$

$$y = \frac{80}{6} = 13.33g$$

(b) let; mass of w extracted by the first 25cm³ portion of ether $= xg$

Mass of w remaining in aqueous layer $= (20-x)g$

$$k_D = \frac{x}{25} \times \frac{100}{(20-x)} \quad \Big| \quad 4 = \frac{4x}{20-x} \quad \Big| \quad x = 10g$$

Thus; mass of w remaining in aqueous layer after first extraction $= (20-10) = 10g$

Let; mass of w extracted by 2nd 25cm³ portion of ether $= z$

Mass of w remaining in aqueous layer after second extraction $= (10-z)g$

$$k_D = \frac{z}{25} \times \frac{100}{(10-z)} \quad \Big| \quad 4 = \frac{4z}{10-z} \quad \Big| \quad \therefore z = 5g$$

Therefore; total mass of w extracted by ether $= (10+5) \quad = \mathbf{15g}$

8. (a) Let the molecular formula of the hydro carbon Q be; $Cx\,Hy$

Equation of combustion of Q.

$$Cx\,Hy(g) + \left(x + \frac{y}{4}\right)O_2(g) \longrightarrow xCO_2(g) + \frac{y}{2}H_2O(l)$$

$$142cm^3 \qquad 142\left(x + \frac{y}{4}\right)cm^3 \qquad (142x)\,cm^3$$

Volume of CO_2 formed $= 694 - 126 = 568cm^3$

Hence; $142x = 568$

$$\therefore x = \frac{568}{142} = 4$$

But; $Cx\,Hy = molecular\ mass\ of\ Q$

$$(4 \times 12) + (y \times 1) = 58$$

$$y = 58 - 48 = 10$$

∴ molecular formula of Q is $\mathbf{C_4H_{10}}$

(b) $CH_3\,CH_2\,CH_2\,CH_3$ Butane

$CH_3\,CH(CH_3)\,CH_3$ 2-methyl propane

9. (a) $HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$

or $HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$

(b) $$pH = -\log_{10}[H^+]$$

$$[H^+] = 10^{-pH}$$

$$[H^+] = 10^{-3} = 0.001moldm^{-3}$$

But; $[H^+] or\ [H_3O^+] = [A^-] = 0.001moldm^{-3}$

$$[HA] = 0.1moldm^{-3}$$

$$Ka = \frac{[H_3O^+][A^-]}{[HA]} \text{ or } Ka = \frac{[H^+][A^-]}{[HA]}$$

$$= \frac{(0.001)^2}{0.1} = 1.0 \times 10^{-5}moldm^{-3}$$

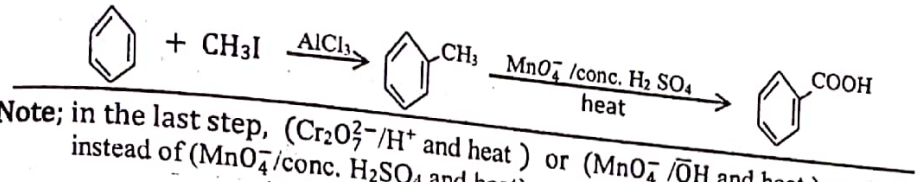
10. (a) $H_2C = CH_2 \xrightarrow[2.\ H_2O/warm]{1.\ conc.\ H_2SO_4} CH_3\,CH_2\,OH \xrightarrow[(MnO_4^-/conc.\ H_2SO_4)\ heat]{(CrO_3/H^+)\ or\ (Cr_2O_7^{2-}/H^+)\ or} CH_3\,COOH$

Alternatively;

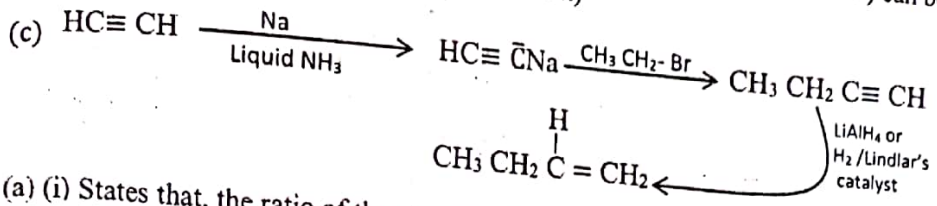
$H_2C = CH_2 \xrightarrow{HBr} CH_3\,CH_2\,Br \xrightarrow[heat]{NaOH(aq)} CH_3\,CH_2\,OH$

$CH_3\,CH_2\,OH \xrightarrow[conc.\ H_2SO_4\ heat]{MnO_4^-} CH_3\,COOH$

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(b) 

Note; in the last step, $(Cr_2O_7^{2-}/H^+$ and heat) or $(MnO_4^-/\bar{O}H$ and heat) can be used instead of $(MnO_4^-$/conc. H_2SO_4 and heat)

(c) 

11. (a) (i) States that, the ratio of the concentrations of a solute in two **immiscible solvents** in **contact** is a **constant** at a **particular temperature.**

(ii) Constant temperature
No association of solute in solution
No dissociation of solute in solution
Solute should not chemically react with any of the solvents
Solute should not saturate any of the solvents

(b) Let; mass of Q extracted by $100cm^3$ of benzene $= xg$
Hence; mass of Q left in aqueous layer $= (10 - x)g$

Concentration of Q in benzene $= \frac{x}{100}$

Concentration of Q in aqueous layer $= \frac{10-x}{100}$

$$K_D = \frac{\text{Concentration of Q in benzene}}{\text{Concentration of Q in aqueous layer}}$$

$$K_D = \frac{x}{100} \times \frac{100}{(10-x)} = 12.2$$

$$\frac{x}{10-x} = 12.2$$

$$x = 122 - 12.2x$$

$$13.2x = 122$$

$$x = 9.24g.$$

$\therefore$ mass of Q left in the aqueous layer $= 10.0 - 9.24 = 0.76g$

(c) Chromatography
Solvent extraction

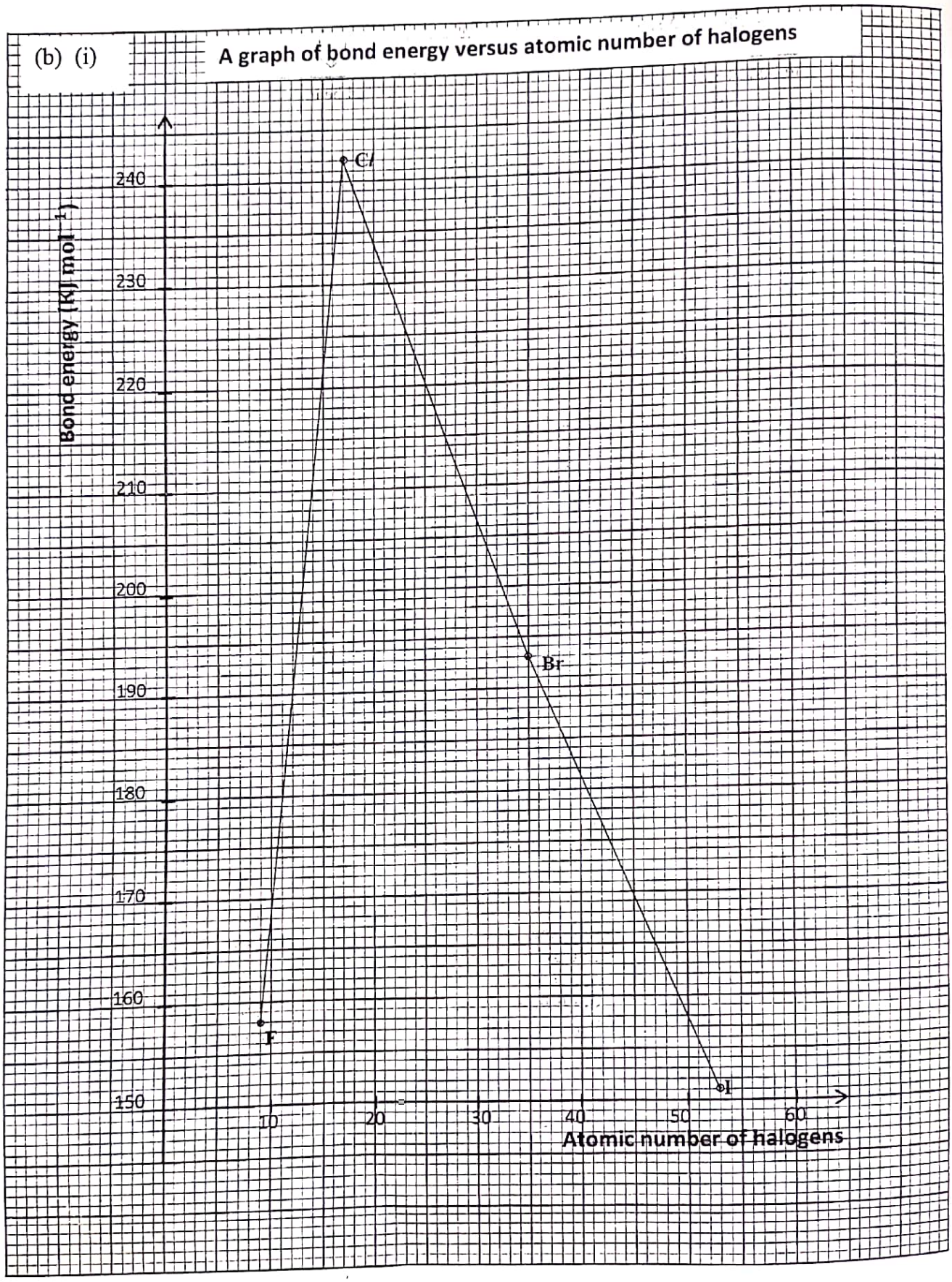
12. (a) Energy **evolved** when a **covalent bond** is formed between two free **atoms** in **gaseous state.**
Or; Energy **required** to break a **covalent** bond between two free **atoms** in **gaseous state**

(b) (i) See graph next page

(ii) Bond energy **rises sharply** from **fluorine to chlorine** and then **decreases** with increase in atomic number from **chlorine to iodine.** From chlorine to iodine, **atomic radius increases** which results into **less effective overlap** of **orbitals.**
However, the unexpectedly low energy of fluorine is due to the **very small atomic radius** of fluorine which results into a **small fluorine –fluorine distance** (small bond length).
This **increases the inter nuclear repulsions** and **the electron –electron repulsions** between the lone pairs of the two fluorine atoms which **weaken the bond.**

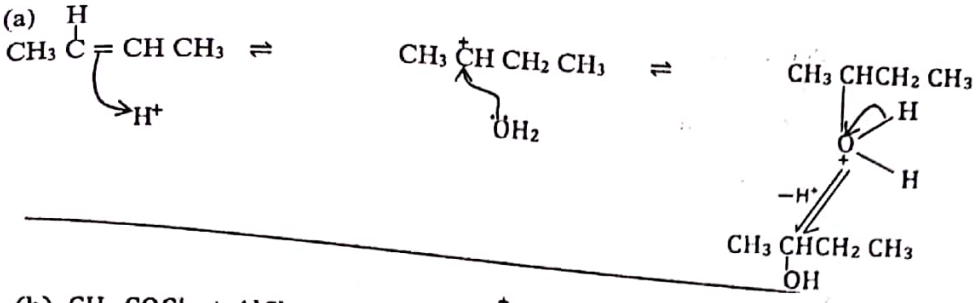
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(b) (i) A graph of bond energy versus atomic number of halogens

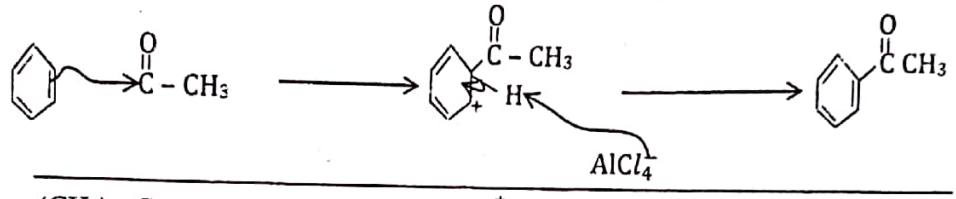


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13. (a)



(b) $CH_3COCl + AlCl_3 \longrightarrow CH_3\overset{+}{C}O + AlCl_4^-$



(c) $(CH_3)_3C-Br \rightleftharpoons (CH_3)_3\overset{+}{C} + Br^-$



14. (a) (i) $5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \longrightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$

(ii) Hydrchloric acid is **oxidized** by manganate (VII) ion to **chlorine**

$2MnO_4^-(aq) + 10Cl^-(aq) + 16H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 5Cl_2(aq) + 8H_2O(l)$

(b) Moles of MnO_4^- in $25cm^3 = \frac{25}{1000} \times 0.02 moles = 5 \times 10^{-4} moles$

$2MnO_4^-(aq) + 5NO_2^-(aq) + 6H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 5NO_3^-(aq) + 3H_2O(l)$

2 moles of MnO_4^- react with 5 moles of NO_2^-

5×10^{-4} moles of MnO_4^- react with $\left(\frac{5}{2} \times 5 \times 10^{-4}\right)$ moles

$25cm^3$ of the nitrite solution contain $\left(\frac{5\times5\times10^{-4}}{2}\right)$ moles of NO_2^-

$\therefore$ $1000cm^3$ of the nitrite solution contain $\left(\frac{1000\times5\times5\times10^{-4}}{2\times25}\right)$ mole of NO_2^-

Concentration of sodium nitrite $= 0.05 moll^{-1}$

15. (a) A buffer solution is a solution which **resists** change in pH when a **small amount** of acid or **base** is added.

(b) $Ka = \frac{[CH_3CO\bar{O}][H^+]}{[CH_3COOH]}$

$[CH_3CO\bar{O}] = [CH_3COONa]$ and $[CH_3COOH] = 0.1M$

$[H^+] = 10^{-pH}$ (since $pH = -\log[H]^+$)

$= 10^{-4.0}$

Hence; $Ka = \frac{[CH_3COONa]\ [H^+]}{[CH_3COOH]}$

$[CH_3COONa] = \frac{1.8\times10^{-5}\times0.1}{(10^{-4.0})} = 0.0182M$

Formula mass of $CH_3COONa = (2 \times 12) + (3 \times 1) + (2 \times 16) + (1 \times 23) = 82$

Mass of CH_3COONa that must be added $= 0.0182 \times 82$ **$= 1.49g$**

Alternatively;

Using $pH = PKa + \log\frac{[salt]}{[acid]}$

$4 = -\log_{10}(1.8 \times 10^{-5}) + \log\frac{[salt]}{0.1}$

$4 = 4.74 + \log\frac{[salt]}{0.1}$

$\log\frac{[salt]}{0.1} = -0.74$

$[salt] = 0.182 \times 0.1 = 0.0182M$

Mass of $CH_3COONa = (0.0182 \times 82) = 1.49g$

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(c) (i) The pH would not change

(ii) The pH would not change

(d) Keeping the pH of blood constant

16. (a) (i) $Ag_2SO_4(s) \rightleftharpoons 2Ag^+(aq) + SO_4^{2-}(aq)$

or, $Ag_2SO_4(s) + (aq) \rightleftharpoons 2Ag^+(aq) + SO_4^{2-}(aq)$

(ii) Let the solubility of Ag_2SO_4 be, S $moldm^{-3}$

$$Ksp = [Ag^+]^2[SO_4^{2-}]$$

$$1.7 \times 10^{-5} = (2S)^2 \times (S) = 4S^3$$

$$S = \sqrt[3]{\left(\frac{1.7\times10^{-5}}{4}\right)}$$

$$= 1.62 \times 10^{-2}\ moldm^{-3}$$

Hence; molar concentration of $Ag^+ = 2 \times 1.62 \times 10^{-2}$

$= 3.24 \times 10^{-2}$ $moldm^{-3}$

Molar concentration of $SO_4^{2-} = 1.62 \times 10^{-2} moldm^{-3}$

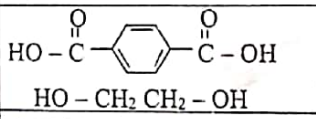
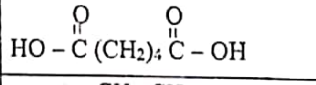
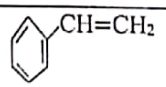
(b) (i) Solubility would decrease

(ii) Solubility would increase

(c) (i) Addition of sodium sulphate **increases the concentration of sulphate ions** as sodium sulphate is a **strong electrolyte**. Therefore the excess sulphate ions in solution **react** with silver ions to form **solid silver sulphate** and hence **solubility decreases.**

(ii) The ammonia solution added **reacts** with silver ions to form a **soluble complex** of diammine silver (I) ion. This **reduces the concentration of silver ions** in the solution. Therefore, silver sulphate **dissolves** to restore the equilibrium.

17.

Polymer	Type of polymerization	Structural formula of monomers	Name of monomer
Polyester	**Condensation**	 $HO-CH_2CH_2-OH$	**Benzene-1-4 dioic acid** **Ethane-1,2-diol**
Polyamide	**Condensation**	$H_2N(CH_2)_6NH_2$ 	**Hexa-1,6-diamine** **Hexane-1,6-dioic acid**
Polystyrene	**Addition**		**Phenylethene (styrene)**

QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2 (P525/2), 2001

1. (a) Define the term relative atomic mass (2 marks)

(b) Explain how relative atomic mass can be determined by the mass spectrometer (10 marks)

(c) The mass spectrum of an element, A, contained four lines at mass charge of 54, 56, 57 and 58 with relative intensities 3.84, 91.68, 2.17 and 0.31 respectively

(i) Explain what the term relative intensities mean (2 marks)

(ii) Calculate the relative atomic mass of A. (2 marks)

(d) Explain why the values of relative atomic mass have no units (1 mark)

(e) Thorium decays according to the following equation

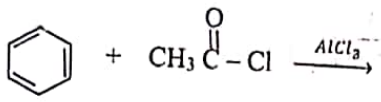
$$^{232}_{90}Th \xrightarrow{\alpha} X \xrightarrow{\beta} Y \xrightarrow{\beta} Z$$

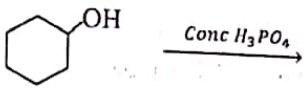
Determine the mass numbers of X, Y and Z (3 marks)

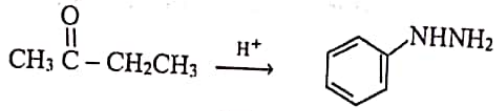
2. Complete the following equations and each case write a mechanism for the reaction

(a) $CH_3CH_2CHO + NH_2NH_2 \xrightarrow{H^+}$ (4 marks)

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(b)  (4 marks)

(c)  (3½ marks)

(d)  (5½ marks)

(e) $(CH_3)_2C = CH_2 + I_2 \xrightarrow{CCl_4}$

3. (a) Define the term eutectic mixture (3 marks)

(b) The table below shows the melting points of various mixtures of lead and tin (3 marks)

% Tin	0	20	40	70	80	100
Melting point /°C	327	280	234	193	206	232

(i) Draw a fully labelled diagram for the tin-lead system (5 marks)

(ii) Determine the eutectic temperature and the compostion of the eutectic mixture. (3 marks)

(c) Describe the changes that would take place when a liquid mixture of the above system containing 40% tin is cooled from 400°C to 100°C (6 marks)

(d) (i) State one application of the tin-lead eutectic mixture (1 mark)

(ii) Name one other pair of metals which can give a similar phase diagram as in (b)(i) (1 mark)

4. (a) Describe how sodium hydroxide can be prepared on a large scale (6 marks)

(b) Sodium hydroxide solution was added to 25cm^3 of 0.1M ethanoic acid and pH of the solution was measured at intervals. The results are given in the table below

volume of sodium hydroxide (cm^3)	0	4	8	12	16	20	22	22.5	23	24	28
pH of the mixture	2.8	3.5	4.0	4.5	5.1	5.8	7.0	9.0	10.5	11.4	12.3

(i) Plot a graph of pH against volume of sodium hydroxide (3 marks)

(ii) Explain the shape of the curve (4 marks)

(iii) Determine the pH at the end point (1 mark)

(iv) Calculate the molarity of the sodium hydroxide (3 marks)

(c) Determine the dissociation constant, K_a, of the ethanoic acid (3 marks)

5. Write equations to show how the following compounds can be synthesized

(a) Benzoic acid from benzene (2 ½ marks)

(b) Hexane from 1-bromompentane (1 mark)

(c) Ethyne from ethanol (4 ½ marks)

(d) Propanoic acid from bromoethane (2 marks)

(e) Aminoethane from ethene (5 ½ marks)

(f) Methylethanoate from bromoethane (4 ½ marks)

6. (a) Define then following terms

(i) Hydration energy

(ii) Lattice energy

(iii) Enthalpy of solution (6 marks)

(b) State two factors that can affect the magnitude of lattice energy and explain how they affect the lattice energy (4 marks)

(c) Some thermochemical data are given below

The standard enthalpy of formation of $CaCl_2$ is $-795\ KJmol^{-1}$

The standard enthalpy of atomization of calcium is $+177\ KJmol^{-1}$

The first ionization energy of calcium is $+590\ KJmol^{-1}$

The second ionization energy of calcium is $+1100\ KJmol^{-1}$

The standard enthalpy of atomization of chlorine is $+121\ KJmol^{-1}$

The first electron affinity $-364\ KJmol^{-1}$

Calculate the lattice energy of calcium chloride (2 marks)

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(d) The lattice and hydration energies of salts AX and BX are given in the table below

	Lattice energy / $KJmol^{-1}$	Hydration energy / $KJmol^{-1}$
AX	+880	−860
BX	+790	−800

(i) Calculate the enthalpy of solution for each salt (3 marks)

(ii) Which of the two salts is more soluble in water at a given temperature? Give a reason (2 marks)

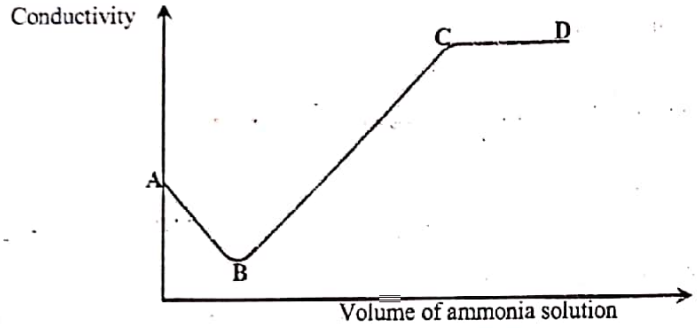
(f) Explain why hydrated copper(II) sulphate crystals dissolve endothermically whereas anhydrous copper(II) sulphate dissolves exothermically. (3 marks)

7. (a) Define the following terms

(i) conductivity (3 marks)

(ii) molar conductivity

(b) The graph below shows the change in conductivity when 0.01M methanoic acid is titrated with 0.1M ammonia solution



Explain the shape of the graph (7 marks)

(c) At 25°C the molar conductivity of silver nitrate, potassium nitrate and potassium chloride are 133.4, 145.0 and 149.9$\Omega^{-1}cm^2$ mol^{-1} respectively.

At the same temperature the conductivity of a saturated solution of silver chloride is $3.41 \times 10^{-6}\Omega^{-1}cm^{-1}$

(i) Calculate the solubility of silver chloride in mol dm^{-1} at 25°C (4 marks)

(ii) Determine the solubility product of silver chloride at 25°C (3 marks)

(d) The ionic conductivities of rubidium and sodium ions are 78.3 and 50.1 $\Omega^{-1}cm^{-2}$ mol^{-1} respectively.

Explain why the ionic conductivity of rubidium ion is higher than that of sodium ion (3 marks)

8. (a) With reference to transition metals, explain what is meant by the following terms

(i) complex ion formation (5 marks)

(ii) catalytic activity (3 marks)

(iii) coloured ion formation (5 marks)

(b) State what would be observed when dioxovanadium(V) ion, VO_2^+ is reacted with

(i) sodium hydroxide solution (1 mark)

(ii) sulphuric acid (1 mark)

(c) The standard electrode potentials for some systems are given below:

$Mn^{3+}(aq)/Mn^{2+}(aq)$ $+1.5E^{\circ}/V$

$V^{3+}(aq)/V^{2+}(aq)$ $-0.26E^{\circ}/V$

(i) Write the conversion for the cell formed by combining the two systems (1 mark)

(ii) Write the overall equation for the cell reaction (1½ marks)

(iii) Calculate the e.m.f of the. State whether the reaction is possible or not and give a reason for your answer (2½ marks)

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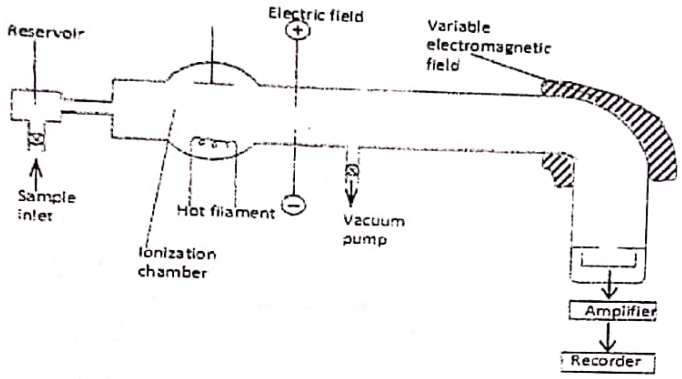
SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2 (P525/2), 2001

Question. One.

(a) Relative atomic mass is the ration of the mass of an atom of an element to a twelveth of the mass of the carbon-12isotope

or; The number of times the mass of an atom of an element is greater than a twelveth of the mass of carbon-12 isotope.

(b) **Diagram of a mass spectrometer**



-The mass spectrometer is first **evacuated** inorder to **remove air molecules** that can interfere with gaseous sample of the material

-The sample whose atomic mass is to be determined is **vapourised** and the vapour led into the ionization chamber where it **collides with a beam of first moving electrons** from the hot filament **to form positively charged ions**

-These positively charged ions are **accelerated** by a strong electric field inorder for the ions to enter the magnetic field with **same kinetic energy**

The ions are then **deflected** according to mass and charge of the ion where the lighter ions are deflected more than the heavier and highly charged ions

-The strength of the magnetic field is varied such that the collector detects the ions of a given mass

-The ions give up their charges to the ion collecter which then passes them to the amplifer and turns them into sizeable electric currents

-The amount of each detector current is proportional to the intensity of the ion producing it.

These detector currents are recorded on the photographic plate as a series of lines or peaks called the **mass spectrum** and this represents the relative abundance of each ion or isotope in the sample

-The relative atomic mass is then calculated as the sum of the relative abundances of the constituent isotopes multiplied by their respective isotopic masses then divided by the sum of the relative abundances

ie. Relative atomic mass $= \frac{\Sigma(isotopic\ mass \times relative\ abundance)}{\Sigma(relative\ abundance)}$

(c) (i) Relative intensities is the proportion or fraction of each isotope in a given sample.

I.e relative intensities represent the relative abundance of the different isotopes of a given element.

(ii) Relative atomic mass of A $= \frac{\Sigma(isotopic\ mass \times relative\ abundance)}{\Sigma(relative\ abundance)}$

$$= \frac{(54\times5.84)+(56\times91.68)+(57\times2.17)+(58\times0.31)}{5.84+91.68+2.17+0.31}$$

$$= 55.91$$

(d) Relative atomic mass has no units because it is ratio or fraction of masses

(e) Let the atomic number of X be (a) and mass number be (b)

Hence; $^{232}_{90}Th \longrightarrow {}^{b}_{a}X + {}^{0}_{-1}e\ (\beta)$

$90 = a - 1$

$\therefore a = 91$

Also; $232 = b + 0$

Hence; $b = 232$.

Let atomic number of Z be y and mass nuber be w; hence

$^{232}_{91}X \longrightarrow {}^{w}_{y}Z + {}^{0}_{-1}e$

Thus; $91 = y - 1$

$y = 91 + 1 = 92$

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Also; $232 = w + o$

Hence; $w = 232$

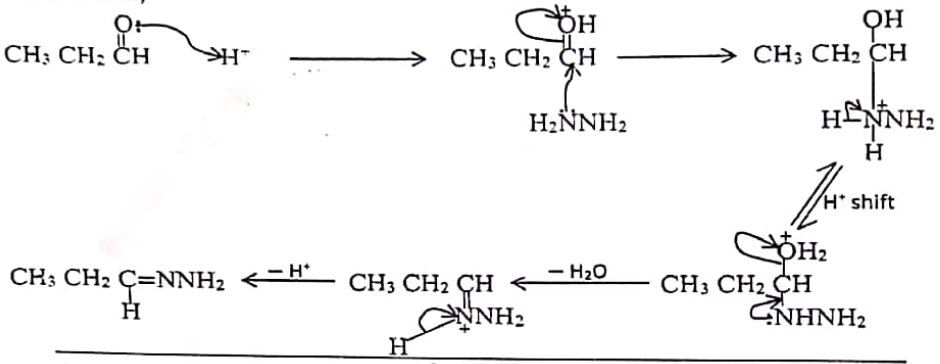
Therefore; Atomic number of X is **91** and mass number is **232.**

Atomic number of Z is **92** and mass number is **232.**

Question. Two.

(a) $CH_3CH_2CHO + NH_2NH_2 \xrightarrow{H^+} CH_3CH_2C(H)=NNH_2 + H_2O$

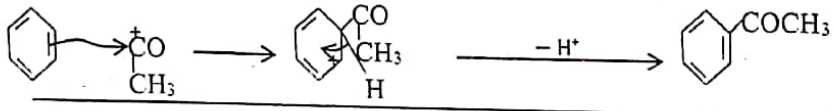
Mechanism;

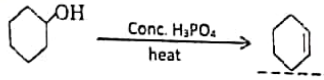


(b) $C_6H_6 + CH_3COCl \xrightarrow{AlCl_3} C_6H_5COCH_3 + HCl$

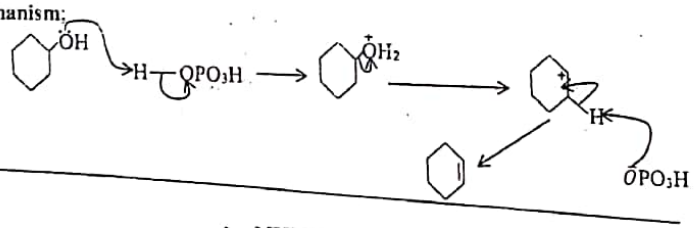
Mechanism;

$CH_3COCl + AlCl_3 \rightleftharpoons CH_3\overset{+}{C}O + AlCl_4^-$



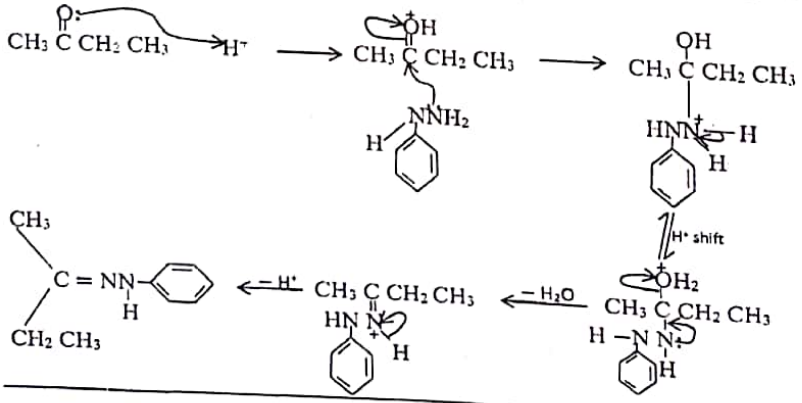
(c) 

Mechanism;



(d) $CH_3CO CH_2CH_3 + C_6H_5NHNH_2 \xrightarrow{H^+} CH_3C(CH_2CH_3)=NNHC_6H_5$

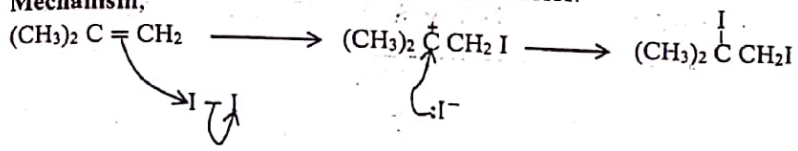
Mechanism;



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(e) $(CH_3)_2C = CH_2 + I_2 \xrightarrow{CCl_4} (CH_3)_2\overset{I}{\underset{|}{C}}CH_2I$

Mechanism;



Question. Three.

(a) A liquid mixture which at **constant temperature** and **pressure** solidifies to form a solid of the **same compositition.**

or A solid mixture which melts at a **constant temperature** and pressure to give aliquid of the **same composition.**

(b) (i) See graph next page

(ii) Eutectic temperature is **180°C**

Composition of eutectic mixture is **62% tin** and **38% lead**

(c) From the diagram: The liquid mixture **cools** from 400°C (point W) up to 255°C (point X) **without change in phase and composition.** At this point X, **pure solid lead begins to crystallize** and hence the **composition of Tin** in the **liquid mixture increases** and this causes a **further decrease in melting temperature of lead along XY**

At point Y, 180°C, **solid tin also begins to crystallize** out from the mixture and the temperature (180°C) **remains constant,** until all the liquid has crystallized. The solid (lead and Tin) then cools to 100°C

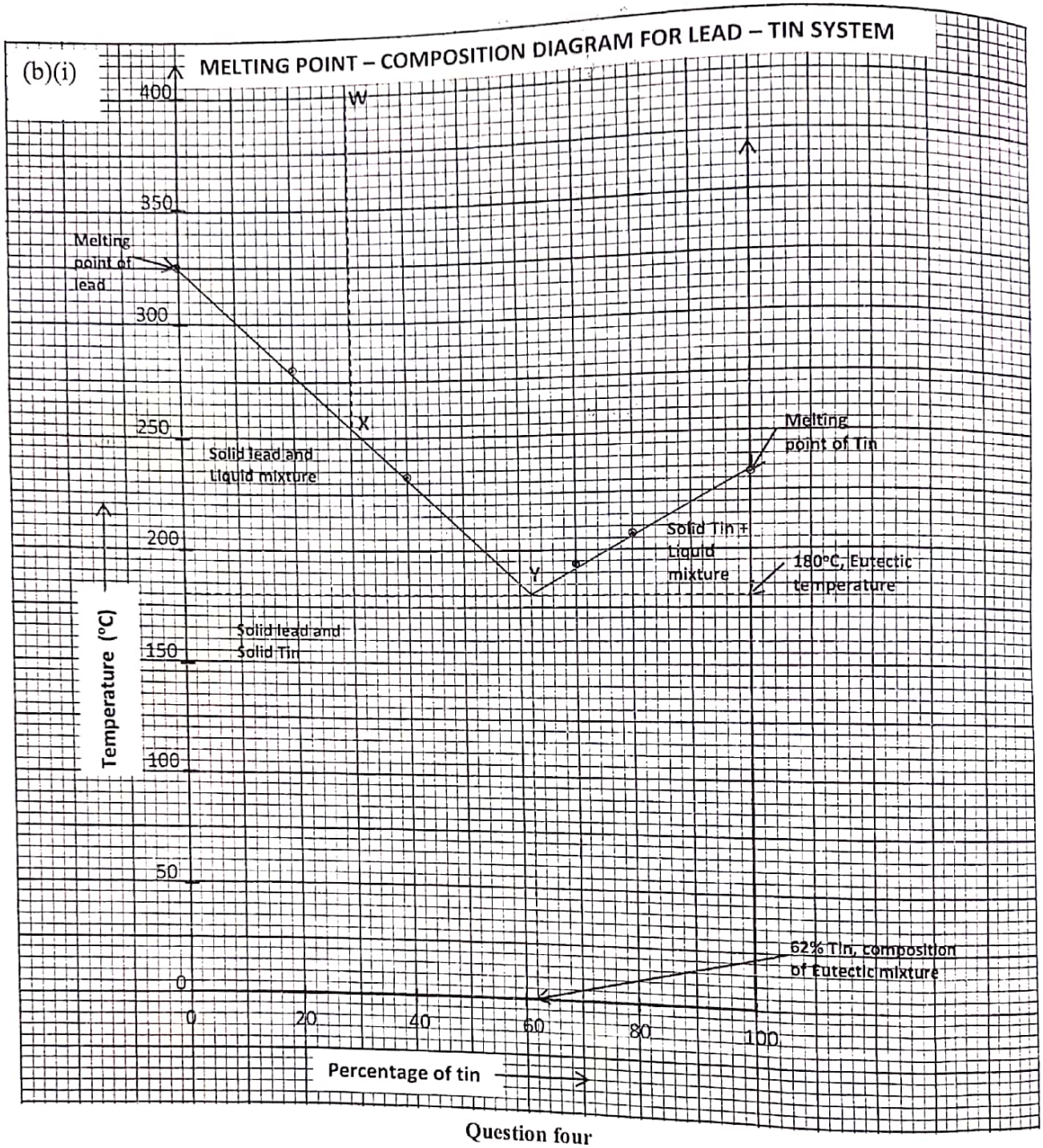
(d)(i) The Tin-lead mixture is used to make an **alloy of solder** which is important in electronic industry.

(ii) Zinc and cadmium
Magnesium and calcium
Tin and Bismuth
Bismuth and cadmium

(iii) Both have a fixed melting point at constant pressure.
Both show similar cooling curves.

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(b)(i)



Question four

(a) See diagram from solution to question 8. (a) 2014 P2

Sodium hydroxide is prepared on a large scale by **electrolysis of brine** (concentrated sodium chloride solution) using a **mercury cathode** and **graphite anode** in a mercury cathode cell.(see diagram)
The sodium ions are **discharged at the cathode** to form **sodium** which **combines with the mercury** to form **sodium amalgam**

$Na^+(aq) + e \longrightarrow Na(l)$ Then; $Na(l) + Hg(l) \longrightarrow Na\text{-}Hg(l)$ (sodium amalgam)

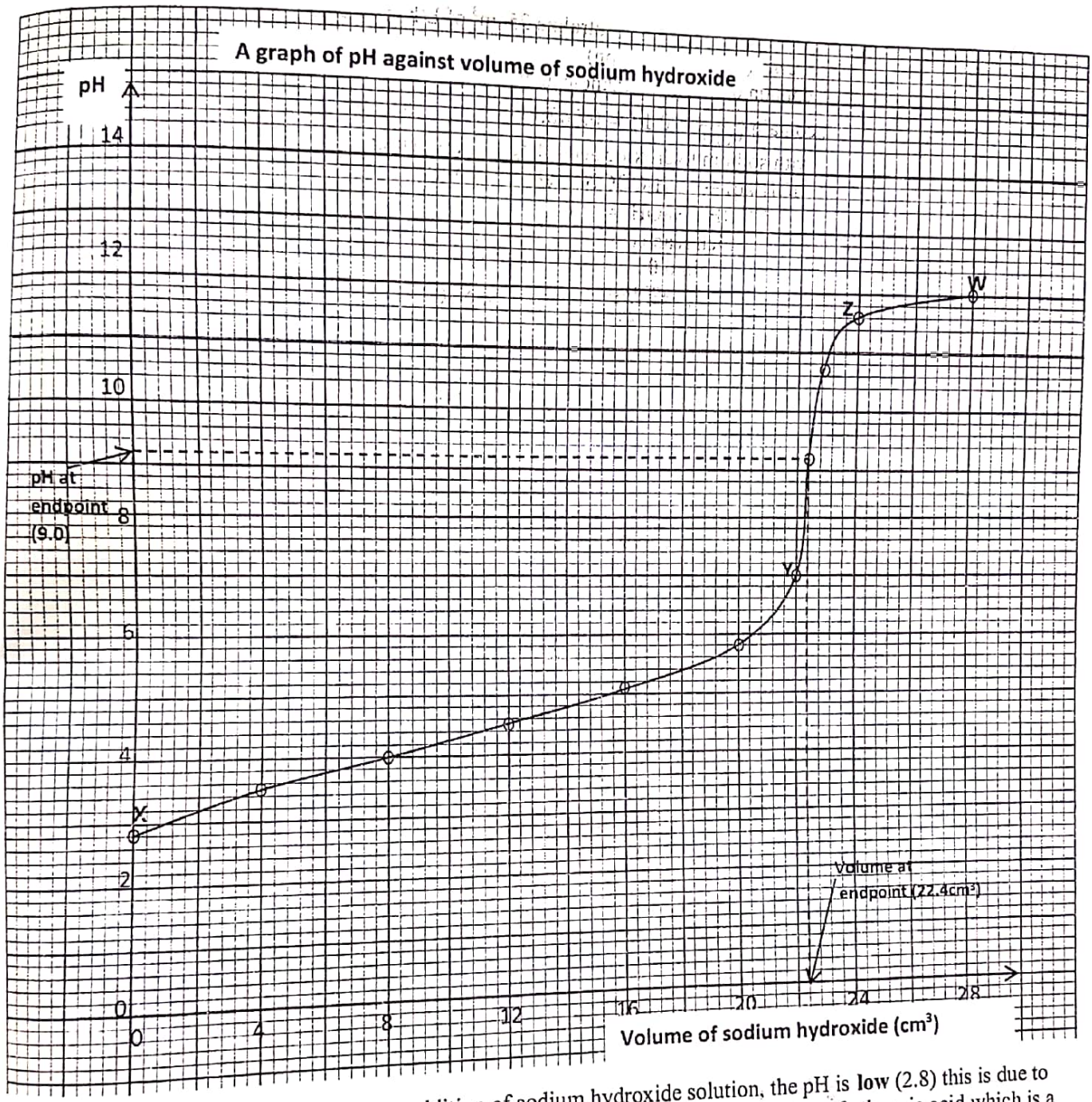
The sodium amalgam is then **dissolved in water** to form sodium hydroxide solution

$Na\text{-}Hg(l) + H_2O(l) \longrightarrow NaOH(aq) + Hg(l) + \frac{1}{2}H_2(g)$

The sodium hydroxide solution is then **evaporated** to dryness to obtain solid sodium hydroxide.

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(b) (i)



(ii) Initially, at point X, before the addition of sodium hydroxide solution, the pH is **low** (2.8) this is due to the **low concentration of hydrogen ions** produced by the **slight ionization** of ethanoic acid which is a **weak acid.**

The **pH increases gradually** along XY because the **acid** is **being neutralized** by the sodium hydroxide solution added, but the acid is still in excess and so the excess acid and the **sodium ethanoate salt** formed constitute a **buffer solution** which also resists change in pH.

At end point, the **pH rises sharply** along YZ as a very small amount of sodium hydroxide solution is added because all the **acid is completely neutralized** and the sodium hydroxide added is **strong base** which **completely dissociates** producing a **large concentration of hydroxide ions**

The pH at end point is **9.0,** hence greater than 7 because the sodium ethanoate salt formed **undergoes hydrolysis** to produce **hydroxide ions** that make the solution at end point **alkaline.**

ie;

$CH_3CO\bar{O}(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + \bar{O}H(aq)$

The pH then **increases gradually** along Zw because of **excess sodium hydroxide** solution added.

(iii) pH at end point is **9.0**

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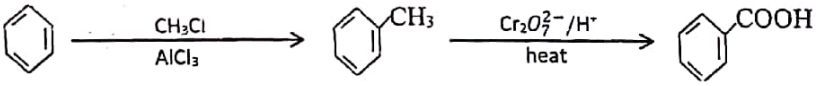
(iv) Volume of sodium hydroxide required to neutralize $25cm^3$ of Ethanoic acid
$= 23.4cm^3$ (Read from graph)
$1000cm^3$ of solution contain 0.1mole of ethanoic acid
$\therefore 25cm^3$ of solution contain $\left(\frac{25}{1000} \times 0.1\right) = 0.0025 moles\ of\ ethanoic\ acid$
Ethanoic acid reacts with sodium hydroxide according to the equation;
$CH_3COOH(aq) + NaOH(aq) \longrightarrow CH_3COONa(aq) + H_2O(l)$
Hence; mole ratio of $CH_3COOH : NaOH = 1:1$
Therefore; moles of NaOH which reacted $= 0.0025 moles$
Hence; $23.4cm^3$ of solution contain 0.0025moles of NaOH
Thus; $1000cm^3$ of solution contain $\left(\frac{1000 \times 0.0025}{23.4}\right)$moles of NaOH
Molarity of sodium hydroxide $= 0.11 moldm^{-3}$

(c) When the volume of NaOH(aq) added is 0.0, the pH of Ethanoic acid $= 2.8$
(see table or graph)
But; $pH = -\log_{10}[H^+]$
Hence; $[H^+] = 10^{-pH} = 10^{-2.8} = 1.585 \times 10^{-3}\ moldm^{-3}$
Equation of ionization of Ethanoic acid is
$CH_3COOH(aq) \rightleftharpoons CH_3CO\bar{O}(aq) + H^+(aq)$
Hence; from the above equation;

$$Ka = \frac{[CH_3CO\bar{O}][H^+]}{[CH_3COOH]}$$

But $[CH_3CO\bar{O}] = [H^+]$ and $[CH_3COOH] = 0.1\ moldm^{-3}$
Thus; $Ka = \frac{[H^+]^2}{0.1} = \frac{(1.585 \times 10^{-3})^2}{0.1} = 2.512 \times 10^{-5}\ moldm^{-3}$

Question five

(a) 

Note In step 2; $(MnO_4^-/\text{conc.}H_2SO_4)$ can be used instead of $(Cr_2O_7^{2-}/H^+)$.
Also $(MnO_4^-/\bar{O}H$ and then $H^+)$ can be used instead.

(b) $2CH_3CH_2CH_2Br + 2Na \xrightarrow{dry\ ether} CH_3CH_2CH_2CH_2CH_2CH_3 + 2NaBr$

(c) $CH_3CH_2OH \xrightarrow[Heat(or\ 170°C)]{Conc.\ H_2SO_4} CH_2=CH_2 \xrightarrow[CCl_4]{Cl_2} CH_2CH_2Cl \xrightarrow[heat]{KOH,\ Ethanol} HC\equiv CH$
(Cl)

(d) $CH_3CH_2Br \xrightarrow[reflux]{KCN/Ethanol} CH_3CH_2CN \xrightarrow[heat]{H_2O/H^+} CH_3CH_2COOH$
or
$CH_3CH_2Br \xrightarrow[dryether]{Mg} CH_3CH_2MgBr \xrightarrow[2.\ H_2O/H^+]{1.CO_2} CH_3CH_2COOH$

(e) $CH_2=CH_2 \xrightarrow{HCl} CH_3CH_2Cl \xrightarrow[heat]{NaOH(aq)} CH_3CH_2OH$
$CH_3CH_2OH \xrightarrow[heat]{MnO_4^-/\text{conc. } H_2SO_4} CH_3COOH$
$CH_3COOH \xrightarrow[2.\ Heat]{1.\ (NH_4)_2CO_3} CH_3CONH_2 \xrightarrow[warm]{NaOH/Br_2} CH_3NH_2$

or
$CH_2=CH_2 \xrightarrow[2.\ H_2O/warm]{1.conc.\ H_2SO_4} CH_3CH_2OH \xrightarrow[heat]{Cr_2O_7^{2-}/H^+} CH_3COOH$
$CH_3COOH \xrightarrow{PCl_5} CH_3COCl$
$CH_3COCl \xrightarrow{NH_3} CH_3CONH_2 \xrightarrow[warm]{NaOH/Br_2} CH_3NH_2$

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or

$$CH_2 = CH_2 \xrightarrow[2.\ H_2O/warm]{1.conc.\ H_2SO_4} CH_3CH_2OH \xrightarrow[heat]{Cr_2O_7^{2-}/H^+} CH_3COOH$$

$$CH_3COOH \xrightarrow[heat]{Soda\ lime\ or\ (NaOH(s),\ CaO(s))} CH_4 \xrightarrow[u.v\ light]{Cl_2} CH_3Cl \xrightarrow[Heat\ in\ a\ sealed\ tube]{NH_3} CH_3NH_2$$

(f) $CH_3CH_2Br \xrightarrow[heat]{\bar{O}H(aq)} CH_3CH_2OH \xrightarrow[heat]{MnO_4^-/conc\ H_2SO_4} CH_3COOH \xrightarrow[conc H_2SO_4,\ warm]{CH_3OH} CH_3CO_2CH_3$

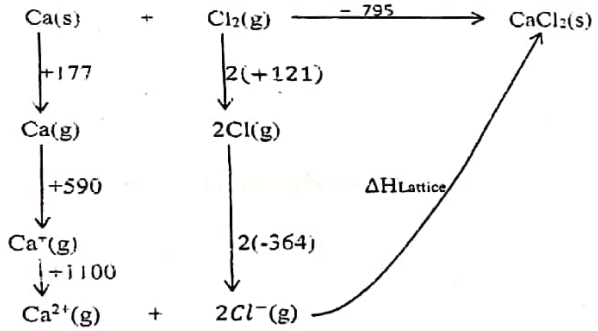
Question Six

(a) (i) **Energy liberated** when **one mole** of **gaseous ions** is completely surrounded by water molecules to form an infinitely dilute solution with **no change in pH**

(ii) Energy **required** to break **one mole** of an **ionic** crystal into its constituent **gaseous** ions.
or Energy **liberated** when **one mole** of an **ionic** crystal is formed from its constituent **gaseous ions.**

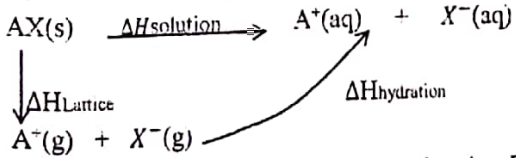
(iii) **Heat change** when **one mole** of an **ionic** compound is dissolved in water to form an **infinitely dilute solution** such that any further dilution causes no more heat change

(b) **-Ionic charge**
When the ions have a **high charge**, they approach one another **more closely** due to **strong attraction** between them (oppositely charged ions) which leads to **strong ionic bonds** and thus **higher lattice energy.**
-Ionic radius
When the ions of opposite charge have **small ionic radius** they **approach each other more closely** due to **strong attraction** between them. This results into **strong ionic bonds** and hence higher **lattice energy.**

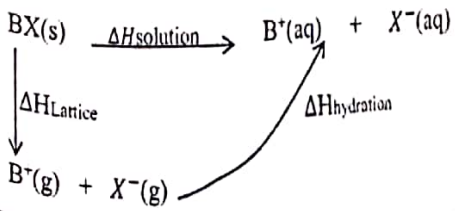


From Hess's law;
$-795 = 177 + 590 + 1100 + 2(121) + 2(-364) + \Delta H\text{lattice energy}$
$\Delta H\text{lattice energy of } (CaCl_2) = -2176KJmol^{-1}$

(c) (i) Using the born haber cycle,



Thus; $Ethalpy\ of\ solution\ of\ salt\ AX = lattice\ Energy + hydration\ Energy$
$= +880 + (-860)$
$= +20KJmol^{-1}$



Thus; $Ethalpy\ of\ solution\ of\ salt\ BX = lattice\ Energy + hydration\ Energy$
$= +790 + (-800)$
$= -10KJmol^{-1}$

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(ii) Salt BX is **more soluble** in water because its enthalpy of solution is negative (exothermic) while that of salt AX is positive (endothermic)

(d) **Note**; when a salt is dissolved in water, there are two energy changes that occur ie **lattice energy** and **hydration energy.** When the lattice energy of the salt is greater than its hydration energy, the salt **dissolves endothermically**.
However, if the hydration energy of the salt is greater than its lattice energy, the salt will dissolve **exothermically in water**.
Answer
In hydrated copper (II) sulphate, the ions are **already partially hydrated** and so when hydrated copper (II) sulphate is dissolved in water its **lattice** energy becomes greater than the further hydration energy that occurs hence making it dissolve endothermically.
However, in anhydrous copper (II) sulphate, the ions are **not hydrated at all** and so the hydration energy of the salt is high and hence outweighs the lattice enrgy of the salt making it **dissolve exothermically**.

Question seven

(a) (i) The conductance of an **aqueous solution** of an electrolyte contained between two electrodes of unit cross-sectional area and a unit distance apart.
or The reciprocal of resistivity
(ii) The conductance of an **aqueous** solution containing **one mole** of an electrolyte contained between two electrodes of unit cross-sectional area and unit distance apart.

(b) Initially at point A, the **conductivity is low** because of the **few hydrogen ions** produced by the **slight ionization** of methanoic acid which is a **weak acid**
The **conductivity decreases** along AB, because the hydrogen ions are being neutralized by the ammonia solution added and as a result the fast moving hydrogen ions are being replaced by slow moving ammonium ions of the ammonium methanoate salt formed.
Further more, conductivity decreases along AB also because the ionization of methanoic acid is being **suppressed** by the **methanoate ions** from the ammonia methanoate salt formed which is a strong electrolyte.
The conductivity increases along BC due to **increase in the number of conducting ions** from the **ammonium methanoate salt formed** which is a strong electrolyte.
Point C is the end point of the titration and at this point, the conductivity is **high** still because of the formation of **ammonium methanoate** salt which is a strong electrolyte.
Conductivity is **almost constant** along CD because the ionization of ammonia solution added is **suppressed** by the ammonium ions from the ammonium methanoate salt which is a strong electrolyte.

(c) (i) Equation leading to formation of silver chloride;
$AgNO_3(aq) + KCl(aq) \longrightarrow KNO_3(aq) + AgCl(s)$
Hence; From Kohlrausch's law

$$\Lambda(AgCl) = \Lambda(AgNO_3) + \Lambda(KCl) - \Lambda(KNO_3)$$
$$= 133.4 + 149.9 - 145.0 = 138.3\Omega^{-1}cm^2mol^{-1}$$

Electrolytic conductivity; $K(AgCl) = Ksolution - Kwater$
$= 3.14 \times 10^{-6} - 1.6 \times 10^{-6} = 1.81 \times 10^{-6}\Omega^{-1}cm^{-1}$

From; $\Lambda = \frac{K}{C} \times 10^3 (since\ 1dm^3 = 1000cm^3)$

Hence; concentration or solubility of AgCl (c) $= \frac{K \times 10^3}{\Lambda}$

$$= \frac{1.81 \times 10^{-6} \times 10^3}{138.3} = 1.31 \times 10^{-5}\ moldm^{-3}$$

(ii) Equation of solubility of AgCl; $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$
Hence; solubility/ concentration of AgCl $= [Ag^+] = [Cl^-]$
Hence; solubility product; $Ksp(AgCl) = [Ag^+][Cl^-]$
$= (1.31 \times 10^{-5})^2 = 1.72 \times 10^{-10}mol^2dm^{-6}$

(d) Sodium ion has a **smaller ionic radius** and thus a **hiher charge density** than the rubidium ion. Therefore in aqueous solution, sodium ion attracts **many water molecules** and hence the ion becomes **heavier** with a **lower mobility** and hence a **lower ionic conductivity than** rubidium ion.

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Question eight

(a) (i) Complex ion formation is a process when a transition metal cation forms **dative** or **co-ordinate bonds** with atoms, ions or molecules with lone pair(s) electrons. The atoms, ions or molecules with lone pair(s) of electrons are called **ligands.**
Complex ion formation is possible because the transition metal cations have accessible **vacant 3d-orbitals** in which the lone pairs of electrons of the ligand molecules can be accommodated.
Also; Transition metal cations have **high charges** and **small ionic radius** and hence **high charge density** that makes them to **strongly attract** ligands hence favouring formation of complexes.
The complex ions formed can either be **positive** or **negative.**

(ii) Catalytic activity is an **alternative way** in which the rate of the reaction is changed (for example **increased**) by a Transition metal (catalyst) which provides an alternative reaction pathway of **lower activation energy** than the uncatalysed reaction. This is due to the fact that transition metals have **variable oxidation states.**
During the reaction, the transition metals (catalysts) **absorb the reactants on their surfaces.** eg; Iron is used as a catalyst in the manufacture of ammonia.

(iii) A characteristic property of transition metal ions whereby because of having **partially filled 3d-orbitals**, there is movement (transitions) of unpaired electrons in the 3d-orbitals **from lower energy 3d-orbitals to higher energy empty 3d-orbitals**. The energy that causes these electron transitions is absorbed from the visible light as it falls on the metal ion. However some of the energy from visible light is not absorbed and hence is **reflected** and this reflected light energy corresponds to the colour of the complex ion. eg hydrated copper (II) sulphate appears blue because of the blue light that it **reflects.**

(b) (i) No significant observable change
or: Yellow solution changes into a dark **yellow solution**

(ii) Solution remains yellow.

(c) (i) $Pt(s) \mid V^{2+}(aq), V^{3+}(aq) \mid\mid Mn^{3+}(aq), Mn^{2+}(aq) \mid Pt(s)$

(ii) $V^{2+}(aq) + Mn^{3+}(aq) \longrightarrow V^{3+}(aq) + Mn^{2+}(aq)$

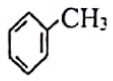
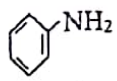
(iii) Emf cell $= E^{\theta}_{cathode} - E^{\theta}_{anode} (or\ Emf\ cell = E^{\theta}_{R.H.E} - E^{\theta}_{L.H.E})$
$= +1.5 - (-0.26)$
$= +1.76 volts$
Hence; the cell reaction is **feasible** because the Emf cell is **positive**

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QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1(P525/1), 2000

1. Complete the following equations:
   (a) $CH_3CHOHCH_3 \xrightarrow{CrO_3/H^+}$ (1 mark)
   (b) $CH_3CH_2Br \xrightarrow[\text{ethanol}]{Zn-Cu\ couple}$ (1 mark)
   (c) $C_6H_6 + CH_3Cl \xrightarrow{AlCl_3}$ (1 mark)
   (d) $(CH_3)_2CHOH \xrightarrow[\text{heat}]{Conc.H_2SO_4}$ (1 mark)
2. (a) (i) What is meant by the term ionization energy of an element? (2 marks)
   (ii) Write equation to show first ionization of magnesium (1 mark)
   (b) The second and third ionization energies of magnesium are 1450kJ mol^{-1} and 7730kJ mol^{-1} respectively. Give a reason for the large difference between the second and the third ionization energies of magnesium. (2 marks)
3. The second dissociation constant of a dibasic acid is $4.39\times 10^{-5} mol^2 dm^{-6}$ at 25°C.
   (a) Calculate the degree of a 0.01M solution of the acid.
   (b) Sketch a diagram to show the degree of dissociation varies with dilution. (2 marks)
4. (a) (i)Write the electronic configuration of aluminium. (1½ marks)
   (ii) State the type of bonding that exists in aluminium fluoride. (1 mark)
   (b) By using equations only, explain why aqueous solution of aluminium chloride is acidic. (1½ marks)
5. (a) Draw and name the structure of the following compounds.

	Structure	Name	
(i)	NCl_3	.....	(1½ marks)
(ii)	PCl_5	.....	(1½ marks)

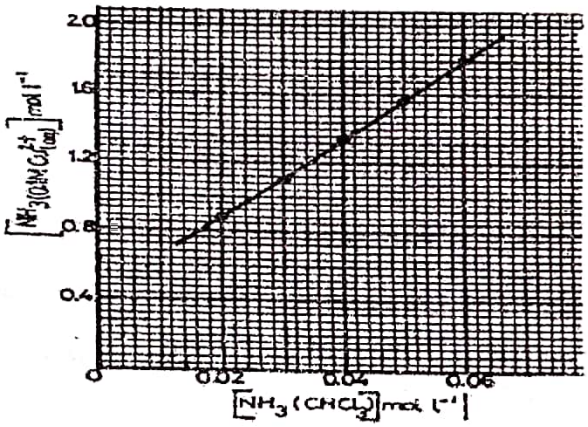
   (b) Write equation for the reaction between nitrogen trichloride and boron trichloride. (1½ marks)
6. Name one reagent that can be used to distinguish between each of the following pairs of compounds and in each case, state what would be observed if each member of the pair is treated with the reagent.
   (a) $CH_3CH_2\underset{\displaystyle OH}{\underset{|}{C}}H\,CH_3$ and $CH_3CH_2CH_2OH$ (3 marks)
   (b) $(CH_3CH_2)_2NH$ and $CH_3CH_2NH_2$ (3 marks)
7. Ethanol decomposes according to the equation:
   $CH_3CHO(g) \rightleftharpoons CH_4(g) + CO(g) \qquad \Delta H = -Ve$
   (a) Write an equation for the equilibrium constant, k_p for the reaction. (1 mark)
   (b) Explain how k_p would be affected if:
   (i) the temperature is increased (2 marks)
   (ii) pressure is increased (2 marks)
8. Write equation to show how benzene can be converted to
   (a)  (2 marks)
   (b)  (2 marks)
9. 1.00dm^3 of aqueous solution contains 5.00g of butanoic acid. Calculate the mass of butanoic extracted when the solution was shaken:
   (a) with 50cm^3 of a solvent Q. (3 marks)
   (b) twice with 25cm^3 of solvent Q. (4 marks)
10. (a) Name two types of polymerization reactions (2 marks)
    (b) State the structural requirements for the formation of polymers by each of the two reactions you have named in (a) (2 marks)
    (c) Write the name and structural formulae of:
    (i) two naturally occurring polymers (3 marks)
    (ii) the monomers of the polymers named in (c) (i) above. (2 marks)

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11. (a) Write the formula of an ore of aluminium. (1 mark)
(b) During the extraction of aluminium, the ore is first treated with sodium hydroxide, followed by aluminium hydroxide.
(i) State the purpose of adding sodium hydroxide (1 mark)
(ii) Write equation for the reaction between the ore and sodium hydroxide. (1½ marks)
(iii) What is the purpose of adding aluminium hydroxide? (1 mark)
(c) Briefly explain how aluminium can be obtained after the ore has been treated as in (b). (3 marks)
(d) Carbon dioxide was used instead of aluminium hydroxide in (b). Write equation for the reaction that took place. (1½ marks)

12. (a) Write equation for the solubility of silver bromide in water at 25°C. (1 mark)
(b) If the solubility product of silver bromide at 25°C is $5.0\times 10^{-13} mol^2 dm^{-6}$. Calculate the solubility in gdm^{-3} at 25°C of silver bromide in:
(i) Water (3 marks)
(ii) 0.1M hydrobromic acid (State any assumptions made.) (3 marks)
(c) State two methods that can be used to determine solubility product. (2 marks)

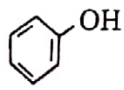
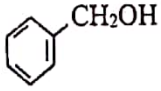
13. The graph below shows the distribution of ammonia between aqueous layer of 0.1M copper (II) ions and chloroform.

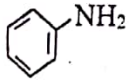


(a) (i) Determine the distribution coefficient, K_D of ammonia between aqueous copper (II) ions and chloroform. (3 marks)
(ii) State what the value of K_D you have determined indicate about the distribution of ammonia. (2 marks)
(b) The graph does not pass through the origin because ammonia reacts with copper (II) ions:
(i) Determine the number of moles of ammonia that reacts with copper (II) ions (2½ marks)
(ii) Write equation for the reaction between ammonia and copper (II) ions. (1½ marks)

14. (a) Write the structural formulae and names of all possible isomers of an organic compound having the molecular formula C_3H_8O. (3 marks)
(b) When one of the isomers, P, in (a) above was reacted with acidified potassium dichromate compound Q was formed. Q reacted with phosphorus pentachloride to form compound R and hydrogen chloride gas. Identify: P, Q and R (3 marks)
(c) Write equation and indicate a mechanism for the reaction between P and concentrated sulphuric acid. (3 marks)

15. Name a reagent that can be used to distinguish between each of the following pairs of compounds. State what would be observed if the compounds are treated with the reagent:

(a)  and  (3 marks)

(b)  and $CH_3CH_2CH_2CH_2CH_2CH_2NH_2$ (3 marks)

(c) $CH_3CH_2CH{=}CH_2$ and $CH_3CH_2C{\equiv}CH$. (3 marks)

16. (a) State three characteristics of chromium as a transition metal. (3 marks)
(b) A solution of potassium dichromate (VI) was added to an acidified solution of iron(II) sulphate.
(i) State what was observed. (1 mark)
(ii) Write the ionic equation for the reaction that took place. (1½ marks)

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(c) (i) Write the structural formulae of the isomers of chromium(III) chloride $CrCl_3 \cdot 6H_2O$ (3 marks)
(ii) State one way of distinguishing the isomers (3 marks)

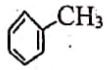
17. When 0.155g of an organic compound T was burned in oxygen 0.220g of carbon dioxide and 0.135g of water were formed.
(a) Determine the empirical formula of T. (3 marks)
(b) When 0.225g of T was vaporized at 127°C and 760mmHg it occupied a volume of 119.11cm^3. (molar volume of gas at s.t.p is 22.4dm^3)
(i) Calculate the molecular mass of T (2½ marks)
(ii) Determine the molecular formula of T (1½ marks)
(c) T reacts with acidified potassium dichromate to form ethane-1, 2-dioc acid. Write the formula and the IUPAC name of T. (1½ marks)

END

SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 1 (P525/1), 2000

1. (a) $CH_3CHOHCH_3 \xrightarrow{CrO_3/H^+} CH_3\overset{O}{\overset{\|}{C}}-CH_3$

(a) $CH_3CH_2Br \xrightarrow[\text{ethanol}]{Zn-Cu\ couple} CH_3\ CH_3$

(b) $C_6H_6 + CH_3Cl \xrightarrow{AlCl_3}$  $+ HCl$

(c) $(CH_3)_2\ CHOH \xrightarrow[\text{heat}]{Conc.H_2SO_4} CH_3\ CH{=}CH_2 + H_2O$

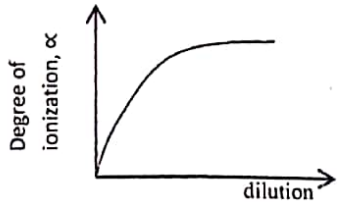
2. (a) (i) Amount of energy **required** to remove an electron completely from a **gaseous** atom or ion to form a positively charge ion
or Energy required to remove **one mole** of electrons from **one mole** of gaseous atoms or ions to form **one mole** of positively charged ions
(ii) $Mg(g) \longrightarrow Mg^+(g) + e$

(b) Electronic configuration of magnesium is $1s^2\ 2s^2\ 2p^6\ 3s^2$. The third electron is removed from an **inner 2p sub shell** which is **completely filled with electrons** and therefore **thermo dynamically stable**, and thus more energy is required to move the third electron than the second which is removed from an **outer 35 – subshell.**

3. (a) **Equation of ionization of the dibasic acid; H_2X**
$H_2X\ (aq) \rightleftharpoons H^+(aq) + HX^-(aq)$
$HX^-(aq) \rightleftharpoons H^+(aq) + X^{2-}(aq)$
Second dissociation constant; $Ka = \frac{[H^+][X^{2-}]}{HX^-}$
Hence; $Ka = \frac{\propto c \cdot \propto c}{c(1-\propto)}$

$$Ka = \frac{\propto^2 C}{1-\propto} \text{ (where } C = concentration\ of\ acid \text{ and } \propto = \text{degree of dissociation)}$$

However, $\propto$ *is very small, hence* $1-\propto \simeq 1$
Therefore $Ka = \propto^2 C$
and so; $\propto = \sqrt{\frac{Ka}{C}} = \sqrt{\frac{4.39\times10^{-5}}{0.01}} = 6.625 \times 10^{-2}$ *or* 6.625%

(b) 

Note; Degree of ionization increases with dilution.

4. (a) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2 3p^1$.
(ii) ionic bonding or electrovalent bonding

(b) $AlCl_3(aq) \longrightarrow Al^{3+}(aq) + 3Cl^-(aq)$
$Al^{3+}(aq) + 6H_2O(l) \longrightarrow Al(H_2O)_6^{3+}(aq)$

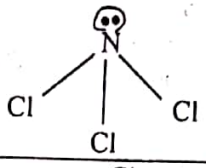
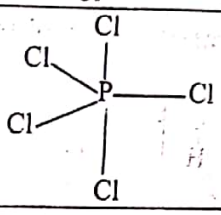
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$Al(H_2O)_6^{3+}(aq) + H_2O(l) \rightleftharpoons [Al(H_2O)_5OH]^{2+}(aq) + H_3O^+(aq)$

or, $AlCl_3(aq) + H_2O(l) \longrightarrow Al(OH)_3(s) + 3HCl(aq)$

or, $Al^{3+}(aq) + 3H_2O(l) \longrightarrow Al(OH)_3(s) + 3H^+(aq)$

5. (a)

		Structure	Name
(i)	NCl_3		Trigonal pyramidal
(ii)	PCl_5		Trigonal bi pyramidal

(b) $NCl_3 + BCl_3 \longrightarrow Cl_3N \longrightarrow BCl_3$

6. (a) Reagent – solution of concentrated hydrochloric acid and anhydrous zinc chloride.

Observation;

$CH_3CH_2\underset{\underset{OH}{|}}{C}HCH_3$ - forms a **cloudy solution** or two layers within **5-10minutes** at **room temperature.**

$CH_3CH_2CH_2OH$ - gives **no observable change** at **room temperature**

Alternatively;

Reagent – Aqueous iodine and sodium hydroxide solution

Observation;

$CH_3CH_2\underset{\underset{OH}{|}}{C}HCH_3$ - gives a **yellow precipitate**

$CH_3CH_2CH_2OH$ - gives **no observable change**

(b) Reagent – solution of concentrated hydrochloric acid and sodium nitrite at 0 to 5°C

Observation; $(CH_3CH_2)_2NH$ forms a **yellow oily solution**

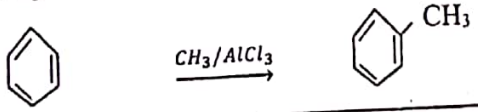
$CH_3CH_2NH_2$ gives **effervescence** of a **colourless gas** and **colourless solution**

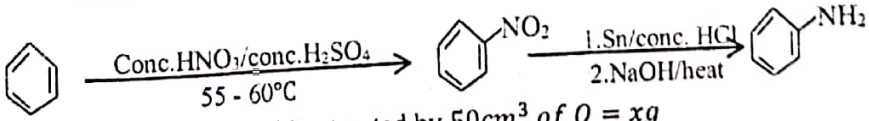
7. (a) $Kp = \frac{P_{CH_4} \times P_{CO}}{P_{CH_3CHO}}$ **or** $Kp = \frac{(P_{CH_4}) \cdot (P_{CO})}{(P_{CH_3CHO})}$

(b)(i) Kp value would **decrease.** This is because increase in temperature **shifts the equilibrium position from right to left** since the **back ward reaction is endothermic.** This results into **increase in the partial pressure (amount) of CH_3CHO** and **decrease in amount of CH_4 and CO** and hence the ***Kp* decreases.**

(ii) Kp value would **not change**

Increase in pressure **shifts the equilibrium position from right to left** since the backward reaction proceeds with a decrease in volume. The **partial pressures** of CH_4 and CO **decrease** while that of CH_3CHO **increases** but **proportionately** thus maintaining the ***Kp* constant.**

8. (a) 

(b) 

9. (a) Let; mass of butanoic acid extracted by $50cm^3$ *of* $Q = xg$

Hence; mass of butanoic acid remaining in aqueous layer $= (5.00 - x)g$

So; concentrated of butanoic acid in $Q = \frac{x}{50}$

and; concentration of acid in aqueous layer $= \left(\frac{5.00-x}{1000}\right)$

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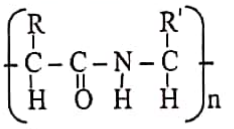
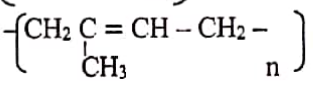
But; $K_D = \frac{\text{concentration of butanoic acid in Q}}{\text{concentration of butanoic acid in aqueous layer}}$

Note – The question lacked the partition coefficient; K_D and so, the candidates would not proceed with the calculation. Thus part (b) also could not be worked out.

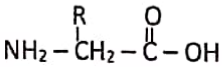
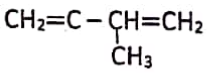
10. (a) Addition polymerization and condensation polymerisation

(b) Addition polymerization, the monomer should be **unsaturated** ie should contain atleast a carbon –carbon **double bond** or carbon –carbon **triple bond** ie (C= C or C≡C)
For condensation polymerization, the monomer should be **bi functional** ie should contain **two functional groups** in the smame molecule

(c) (i)

Name	**Structural formula**
Protein	
Rubber	
Carbohydrate	$(C_6H_{10}O_5)_n$

(ii)

Polymer	**Name of monomer**	**Structural formula**
Protein	Amino acid	
Rubber	2-methylbuta-1, 3-diene or isoprene	
Carbohydrate	Glucose	$C_6H_{12}O_6$

11. (a) $Al_2O_3.2H_2O$

(b)(i) To purify the ore by removing it from silica and iron (II) oxide impurities.

(ii) $Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \longrightarrow NaAl(OH)_4(aq)$
or $Al_2O_3(s) + 2\bar{O}H(aq) + 3H_2O(l) \longrightarrow Al(OH)_4^-(aq)$
or $Al_2O_3(s) + 2\bar{O}H(aq) \longrightarrow 2AlO_2^-(aq) + H_2O(l)$

(iii) To precipitate aluminium hydroxide

(c)The **purified ore** is **heated** with **molten cryolite**. The ore is heated to **obtain pure aluminium oxide** and the cryolite **lowers the melting point** of the ore and serves as the **electrolyte.**
The molten ore is **electrolysed** between the **graphite electrodes** where molten aluminium is obtained at the cathode by the reaction;
$Al^{3+}(l) + 3e \longrightarrow Al(l)$

(d) $2Al(OH)_4^-(aq) + CO_2(g) \longrightarrow 2Al(OH)_3(s) + CO_3^{2-}(aq) + H_2O(l)$
or $2NaAl(OH)_4(aq) + CO_2(g) \longrightarrow 2Al(OH)_3(s) + Na_2CO_3(aq) + H_2O(l)$

12. (a) $AgBr(s) \rightleftharpoons Ag^+(aq) + Br^-(aq)$
or, $AgBr(s) + (aq) \rightleftharpoons Ag^+(aq) + Br^-(aq)$

(b)(i) Let the solubility of AgBr in water = (S) moldm^{-3}
According to the equation of solubility; $[AgBr] = [Ag^+] = [Br^-] = s$
$Ksp = [Ag^+][Br^-] = 5.0 \times 10^{-13}$
$Therefore;\ S \times S = 5.0 \times 10^{-13}$
$S^2 = 5.0 \times 10^{-13}$
$hence;\ S = \sqrt{5.0 \times 10^{-3}} = 7.07 \times 10^{-7}$ moldm^{-3}
$Formula\ mass\ of\ AgBr = (1 \times 108) + (1 \times 80) = 188g$
$1 mole\ of\ AgBr\ weigh\ 188g$
$\therefore 7.07 \times 10^{-7}\ mole\ of\ AgBr\ weigh\ 7.07 \times 10^{-7} \times 188g$
$thus;\ solubility\ of\ AgBr = 1.33 \times 10^{-4} gdm^{-3}$

(ii) Let the solubility of AgBr in hydrobromic acid = x moldm^{-3}
Assumptions;
Concentration of $Ag^+ = x$moldm^{-3}
Concentration of $Br^- = x + 0.1 = 0.1$moldm^{-3} $(since\ x\ is\ very\ small)$
Therefore; $Ksp = [Ag^+][Br^-]$

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$5.0 \times 10^{-13} = x \times 0.1$

$\therefore x = \frac{5.0 \times 10^{-13}}{0.1} = 5.0 \times 10^{-12} \text{mold}m^{-3}$

Thus; solubility of AgBr in $\text{gd}m^{-3} = 5.0 \times 10^{-12} \times 188 = 9.4 \times 10^{-10} gdm^{-3}$

(c) - conductivity measurements
- by titration method

13. (a) (i) Hint; The distribution co efficient; K_D of ammonia between aqueous copper (II) ions and chloroform equals to the slope of the graph

Thus; $K_D = slope = \frac{1.68-0.8}{0.054-0.017} = 23.78$

(ii) The K_D is **large** indicating that ammonia **distributes itself more in water than chloroform**(ammonia is **more soluble in water** than chloroform)

(b) (i) Hint; The moles of ammonia that reacted with 0.1M copper (II) ions is obtained by extra polating the graph until it touches the vertical axis and the intercept on the vertical axis equals to the number of moles of ammonia that reacted with 0.1M copper (II) ions;

Thus; from the graph, this is 0.4moles

Hence; 0.1mole of copper (II) ion reacted with 0.4moles of NH_3

$\therefore 1 mole\ of\ copper\ (II) ions\ reacted\ with\ \frac{0.4}{0.1} = 4 moles\ of NH_3$

(ii) $Cu^{2+}(aq) + 4NH_3(aq) \longrightarrow Cu(NH_3)_4^{2+}(aq)$

14. (a) $CH_3\ CH_2\ CH_2\ OH$ Propan -1-ol

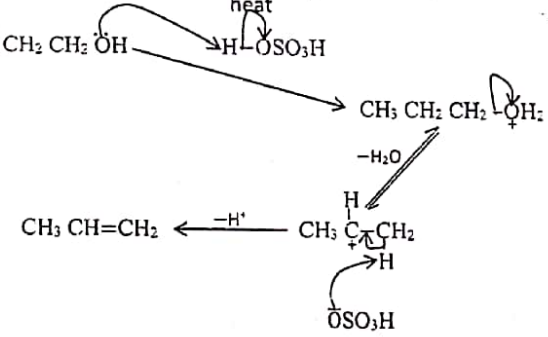
$CH_3\ CH(OH)\ CH_3$ Propan -1-ol

$CH_3\ CH_2\ O\ CH_3$ Methoxyethane

(b) P $CH_3\ CH_2\ CH_2\ OH$ or Propan -1-ol
Q $CH_3\ CH_2\ COOH$ or Propanoic acid
R $CH_3\ CH_2\ COCl$ or Propanoylchloride

(c) $CH_3\ CH_2\ CH_2\ OH \xrightarrow[\text{heat}]{\text{Conc. } H_2SO_4} CH_3\ CH{=}CH_2$

Mechanism



15. (a) Reagent – Neutral iron (III) chloride solution

Observation;



-Gives a **violet** or **purple colouration**



-Gives no observable change

(b) Reagent – solution of concentrated hydrochloric acid and sodium nitrite

Observation;



-gives a **colourless solution**

$CH_3\ CH_2\ CH_2\ CH_2\ CH_2\ CH_2\ NH_2$ – gives **effervescence** of a **colorless gas** and **a colurless solution.**

(c) Reagent – Ammoniacal silver nitrate **solution**

Observation ; $CH_3\ CH_2\ CH{=}CH_2$ –gives **no observable change**

$CH_3\ CH_2\ C{\equiv}CH$ - gives a **white precipitate**

Alternatively;

Reagent – Ammonical copper (I) chloride solution

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Observation; $CH_3CH_2CH{=}CH_2$ –gives **no observable change**

$CH_3CH_2C{\equiv}CH$ - forms a **red precipitate**

16. (a) -Forms coloured compounds
-Chromium forms ions with variable oxidation states
-Forms complexes
-Can be used a catalyst
-Chromium is Paramagnetic

(b) (i) The **orange** solution of potassium dichromate (VI) turned **green**

(ii) $Cr_2O_7^{2-}(aq) + 6Fe^{2+}(aq) + 14H^+(aq) \longrightarrow 2Cr^{3+}(aq) + 6Fe^{3+}(aq) + 7H_2O(l)$

(c) (i) $CrCl_3 \cdot 6H_2O$, $Cr(H_2O)_6Cl_3$, $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O]$, $[Cr(H_2O)_4Cl_2]Cl \cdot 2H_2O$

(ii) Addition of silver nitrate solution or precipitation method
Electrical conductivity measurement.

17. (a) Mass of carbon in $T = \frac{12}{44} \times 0.220 = 0.06g$.

Mass of hydrogen in $T = \frac{2}{18} \times 0.135 = 0.015g$

Mass of oxygen in $T = 0.155 - (0.06 + 0.015) = 0.08g$.

Composition of T;	C	H	O
Moles;	$\frac{0.06}{12}$	$\frac{0.015}{1}$	$\frac{0.08}{16}$
	0.005	0.015	0.005
Mole ratio;	$\frac{0.005}{0.005}$	$\frac{0.015}{0.005}$	$\frac{0.005}{0.005}$
	1 :	3 :	1

Emperical formula of T is CH_3O

(b)(i) Using; $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$volume\ of\ T\ at\ stp;\ V_2 = \frac{P_1V_1T_2}{P_2\ T_1}$

$= \frac{760\times119.11\times273}{760\times(127+273)} = 81.29cm^3$

Thus; $81.29cm^3$ of T weigh 0.225g

$\therefore 22400cm^3$ of T weigh $\frac{22400\times0.225}{81.29}g$

Hence; molecular mass of T is **62**g.

(ii) $(CH_3O)_n = 62$

$(1\times12)n + (3\times1)n + (1\times16)n = 62$

$31n = 62$

$n = \frac{62}{31} = 2$

$Therefore\ molecular\ formula\ of\ T\ is\ C_2H_6O_2.$

(c) $HO - CH_2CH_2 - OH$ Ethane-1, 2-diol

QUESTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2 (P525/2), 2000

1. Explain each of the following observations
(a) Dimethylamine is a stronger base than phenlyamine
(b) The dfirst ioniosation energy of aluminium is less than that of magnesium (5 marks)
(c) The pH of a solution of chrtomium(III) sulphate in water is less than 7 (5 marks)
(d) 1-bromohexane undergoes nucleophilic substitution reaction whereas bromobenzene does not (3 marks)
(e) When solid lead(IV) chloride is added to water, white are observed and a brown solid is formed. (5 marks)

2. (a) Determine the sp[ectrum of hydrom atom. Use diagtrams to illustrate your answer (2 marks)
(b) Explain how the spectrum of hydrogen atom;
(i) is formed (7 marks)
(ii) provides evidence for energy levels in atoms (4 marks)
(c) The frequency of hydrogen at the point of ionization is 32.8×10^{14}Hz. Calculate the ionisation energy of hydrogen (Planks constant = 6.6×10^{-34} Js) (7 marks)

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3. (a) Write equations to show how the following compouinds can be prepared
(i) Phenylamine (aniline)
(ii) Aminoethane (ethylamine) (4 marks)
(b) Which one of phenylamine and ethylamine is a stronger base? Explain your answer. (3 marks)
(c) Write equations for each of the following compounds, phenlyamine and ethylamine reacting with
(i) ethanoyl chloride (CH_3COCl) (2 marks)
(ii) acidified solutions of sodiumnitrite at 5°C (2 marks)
(d) (i) Write a mechanism for the reaction ethanolyl chloride with ethylamine (3 marks)
(ii) How can the reaction in (c)(i) above be be used to distinguish between phenlyamine and ethylamine? (1 mark)
(e) Phenylamine can be converted to benzene diazonium chloride



$N^+ \equiv NCl^-$. Write equations (reagents and conditions to be given) for the conversion of diazonium salt into:
(i) iodo benzene (1 mark)
(ii) benzoic acid (4 marks)

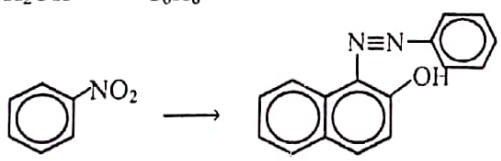
4. (a) The melting point of 4-nitrophenol is much higher than that of 2-nitrophenol. The two compounds can be separated by steam distillation .
(i) Explain why the mealting point of 4-nitrophenol is higher than 2-nitrophenol. (5 marks)
(ii) Explain the principle of steam distillation (5 marks)
(iii) Describe how a mixture of 2-nitrophenol and 4-nitrophenol can be separetd by steam distillation (6 mks)
(b) When substance Y was distiulled at 93°C aand 750mmHg, the distillate contained 55% of Y by mass. Calculate the relative molecular mass of Y. (The partial vapour pressure of water is 654 mmHg) (4 marks)

5. The atomic number number and the melting points of some elements in Period 3 or the Pderiodic Table are shown below:

Elements	Na	Mg	Al	Si	P
Atomic number	11	12	13	14	15
Melting point(°C)	98	650	660	1410	44

(a) (i) Plot a graph of melting pouint against atiomic number. (3 marks)
(ii) Explain the shape of the graph in (i) (6 marks)
(b) Describe and explain how the oxidation states magnesioumj, aluminium and silicon react with:
(i) sodium hydroxide
(ii) hydrochloric acid (9 marks)
(c) State the type of bonding in the oxides of sodium and phosphorus (2 marks)

6. Write equations to show how the following conversions can be effected.
(a) $CH_3CH_2I \longrightarrow CH_3CH_2COOH$ (3 marks)
(b) $CH_3CH_2CH_2OH \longrightarrow CH_3\overset{O}{\overset{\|}{C}}-CH_3$ (5 marks)
(c) $C_6H_5CH_2OH \longrightarrow C_6H_6$ (3 marks)
(d)



(5 marks)
(e) $CH_3\underset{\underset{Br}{|}}{C}HCH_3 \longrightarrow CH_3-\overset{\overset{OH}{|}}{\underset{\underset{CH_3}{|}}{C}}-SO_3^-Na^+$ (4 marks)

7. (a) Explain what is meant by the term ore (2 marks)
(b) Describe two ways in which ores can be concentrated by:
(i) physical method
(ii) chemical method (iluustrate your answer with suitable examples (12 marks)
(c) A copper ore was dissolved in excess concentrated ammonia and the solution made upto 1 dm^3. The resultant solution was shaken with trichloromethane and left to settle. 50cm^3 of organic layer neede 25cm^3 to 0.05M hydrochloric acid for neutralization. 25cm^3 of the aqueous layer was neutralized by 40cm^3 of 0.5M

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hydrochloric acid. Calculate the concentration of copper(II) ions in moles dm^{-3}. (The distribution coefficient between water and trichloromethane is 25) (6 marks)

8. (a) Explain what is meant by the term melting point (1 mark)

(b) State the factors which affect melting point of :

(i) metals (1 mark)

(ii) molecular substances (1 mark)

(c) Explain the trend in the melting points of the elements in group (II) and grfoup (IV) of the Periodic Table (8 marks)

(d) Explain why the transition metals of Period 4 tend to have higher melting points tghan non transition metals of the same Period (2 marks)

(e) The table below shows melting points of some compounds

Compound	**melting points/K**
Aluminium oxide	2290
Aluminium chloride	451
Calcium oxide	2850
Calcium chloride	1051

Explain why:

(i) the melting point of aluminium chloride is abonormally low compared to that of aluminium chloride (2 marks)

(ii) the melting point of calcium oxide is much higher than that of calcium chloride. (2 marks)

(f) Determine the freezing point depression for a solution containing 0.025g of sodium chloride in 200g of water. [molar freezing point comstant of constant of water, Ksp = 1.86°C mol^{-1} Kg^{-1}, Na =23, Cl = 35.5] (3 marks)

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SOLUTIONS TO 'A' LEVEL CHEMISTRY; PAPER 2 (P525/2), 2000

Question. One.

(a) The basic strength of amines depends on the **availability of the lone pair of electrons** on the nitrogen atom. In amino benzene (Phenylamine) the lone pair of electrons on the nitrogen atom **interacts with delocalized or pie electrons** of the benzene ring. Hence the lone pair of electrons in phenyl amine is **not easily available** for reaction with acid or proton
Di methylamine has **two methyl groups** attached to the nitrogen atom and these are **electron releasing** (have a positive inductive effect).
These methyl groups **increase the availability of the lone pair of electrons** on the nitrogen atom

(b) Electronic configuration of Al is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ and that of Mg is $1s^2\ 2s^2\ 2p^6\ 3s^2$.
The first ionization energy of aluminium involves removing an electron from a **partially filled** 3p-subshell which is **shielded by a full 3s-subshell** hence giving aluminium a low first ionization energy
However, the first ionization energy of magnesium involves removing an electron from a **full 3s-subenergy** which is **energetically stable**, hence giving magnesium a **high** first ionization energy

(c) The solution of chromium (III) sulphate contains **hydrated chromium (III) ion** which undergoes **hydrolysis** to produce **hydroxonium ions** that make the solution **acidic** hence with a **pH less than seven.**
$[Cr(H_2O)_6]^{3+}(aq) + H_2O(l) \rightleftharpoons [Cr(H_2O)_5OH]^{2+}(aq) + H_3O^+(aq)$

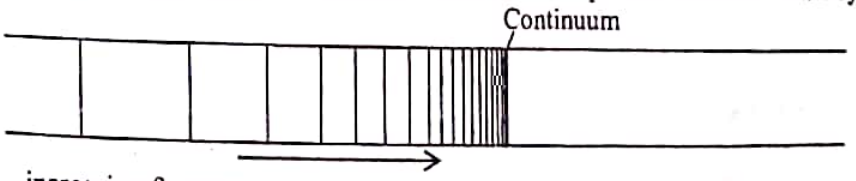
(d) In bromo benzene the lone pair of electrons on the bromine atom **interacts with the delocalized electrons** of benzene ring. This **strengthens the carbon-bromine bond** and so the bromine atom is **not easily replaced.**
In 1-bromohexane, the bromine atom is **more electronegative** than the carbon atom, hence the **bonding electrons are more attracted to the bromine atom**
This makes the bromine acquire a **partial negative charge,** while the carbon acquires a **partial positive charge**, this makes the carbon –bromine bond to be **more polar** and hence **weaker,** thereby allowing displacement of the bromine by a nucleophile.

(e) Lead (IV) chloride is **hydrolyzed** by water to form **Lead (IV) oxide** which is an **insoluble** brown solid and **hydrogen chloride gas**

$$PbCl_4(l) + 2H_2O(l) \longrightarrow PbO_{2(s)} + 4HCl(g)$$

Question. Two.

(a) The spectrum of hydrogen atom consists of a **series** or groups of lines. These series are in the **visible** and some in the **invisible** spectrum
In each series, the spacing between adjacent lines decreases inwards the continuum or as the frequency of the waves giving the lines increases or as wave length deceases.
In each series there is a **continuum.** (The series of lines are separated from each other by a continuum)



(b) (i) When an electric discharge is passed through hydrogen atoms, **electrons absorb energy** and jump to exited states. They fall back to the ground or lower state, and they emit light or radiations of definite amount of energy giving an emission spectrum recorded on the photographic paper

or

Absorption spectrum is formed when light is shone through hydrogen atoms. electrons jump from ground state to excited states after absorbing energy of definite amount and hence give an absorption spectrum recorded on a photographic plate

(ii) Hydrogen has **one electron** yet it provides a spectrum containing **many lines.** These series of lines include balmer, lyman series etc
- The spacing between adjacent lines in each series differs
- There is a continuum in each series of lines
- The number of lines in the spectrum series increases with increasing resolving power used.
- The light giving each line is of definite energy or frequency.

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(c) Ionization energy (E) = *Plank's constant* (h) × *frequency* (f)

Hence; $E = hf$

$= 6.6 \times 10^{-34} \times 32.8 \times 10^{14}$

$= 2.1648 \times 10^{-18} Joules$

or; $E = hf$

$= 6.6 \times 10^{-34} \times 32.8 \times 10^{14}$

$= 2.1648 \times 10^{-18} \times 10^{-3}$

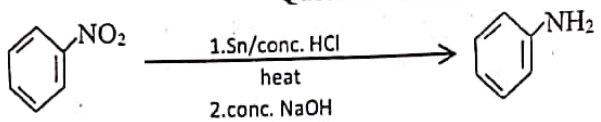
$= 2.1648 \times 10^{-21} KJ$

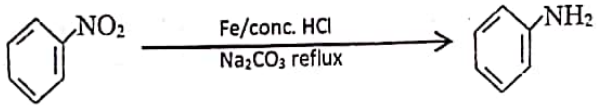
or; $E = (hf) \times Avogadro's constant\ (NA)$

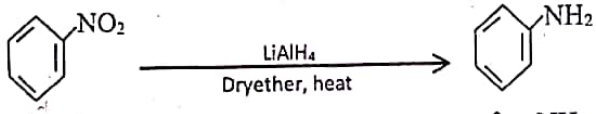
$= 2.1648 \times 10^{-21} \times 6.02 \times 10^{23}$

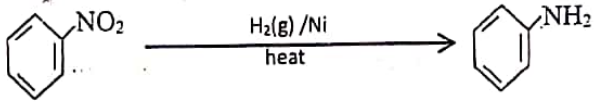
$= 1303 KJmol^{-1}$

Question. Three.

(a) (i) 

or 

or 

or 

(ii) $CH_3CH_2Br \xrightarrow[\text{heat in a sealed tube}]{\text{Conc. } NH_3} CH_3CH_2NH_2$

---

or $CH_3CH_2\overset{O}{\overset{\|}{C}}-NH_2 \xrightarrow[\text{warm}]{Br_2/\bar{O}H} CH_3CH_2NH_2$

---

or $CH_3CH_2OH + NH_3 \xrightarrow[\text{heat}]{\text{Alcohol, pressure}} CH_3CH_2NH_2$

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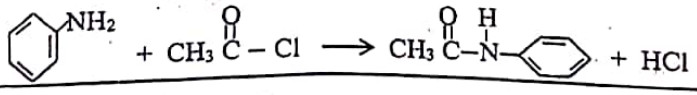
or $CH_3CH_2OH + NH_3 \xrightarrow[\text{pressure}]{Al_2O_3, 400°C} CH_3CH_2NH_2$

(b) Ethyl amine is a **stronger base** than phenyl amine

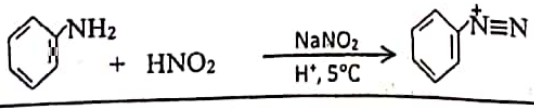
In phenyl amine, the **lone pair of electron** on the nitrogen atom **interacts with the delocalized electrons** of the benzene ring hence making the lone pair of electrons in the phenyl amine **less available** for reaction with acids (or protons)

In ethyl amine, the **ethyl group releases electrons** to the nitrogen atom making the lone pair more available to react with an acid (or proton)

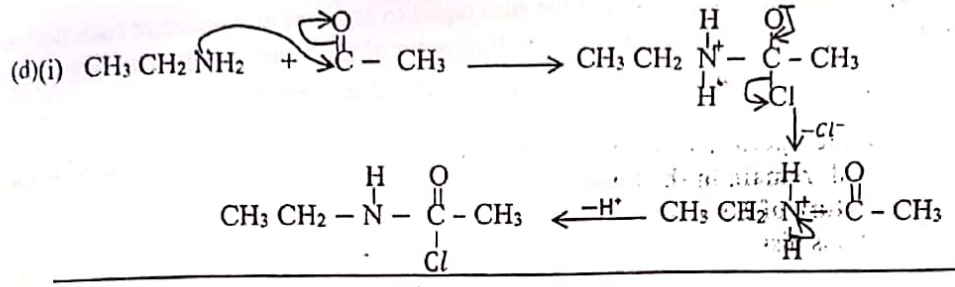
(c) (i) $CH_3CH_2NH_2 + CH_3\overset{O}{\overset{\|}{C}}Cl \longrightarrow CH_3\overset{O}{\overset{\|}{C}}-\overset{H}{\underset{|}{N}}-CH_2CH_3 + HCl$



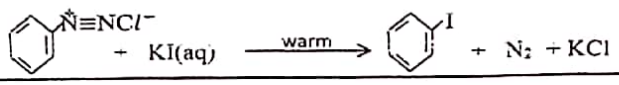
(ii) $CH_3CH_2NH_2 + HNO_2 \xrightarrow[H^+, 5°C]{NaNO_2} CH_3CH_2OH + N_2 + H_2O$

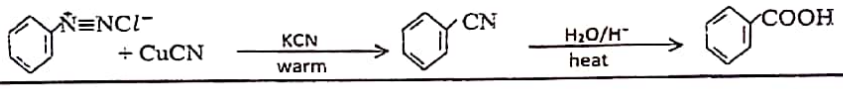


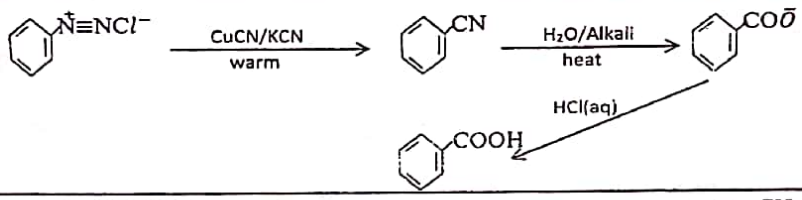
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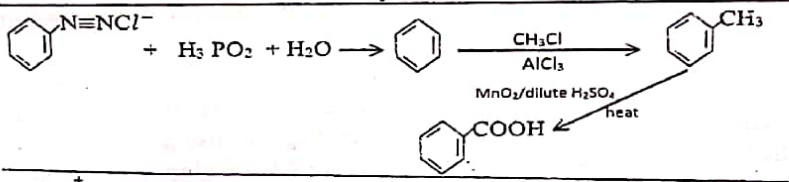
(d)(i) 

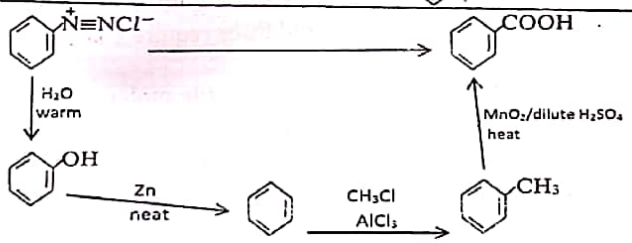
(ii) Ethyl amine forms bubbles of a **colourless gas** but phenyl amine shows **no observable change**

(e) (i) 

(ii) 

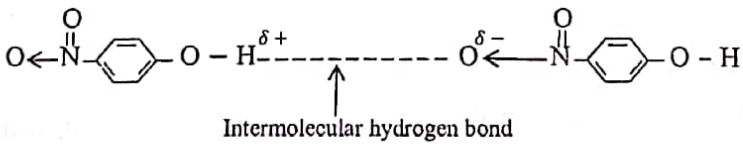
or 

or 

or 

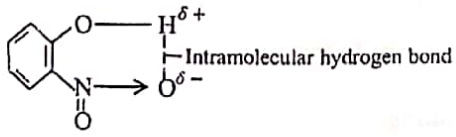
Question. Four.

(a) (i) In 4-nitrol phenol the **two functional groups are wide apart** and form **intramolecular hydrogen bonds**

Ie 

In 2-nitro phenol, the **two functional groups are close** and **cause intramolecular hydrogen bonds**. This produces **less intermolecular hydrogen bonds** and hence the molecules of 2-niro phenol are held together by **weak vander waal's forces**. These vander waal's forces are easier to break than the intermolecular hydrogen bonds.

Hence 4-nitro phenol has a higher melting point than 2-nitro phenol.



(ii) The substance to be steam distilled is **immiscible with water**

The two substances **contribute vapour pressure independent of each other**

The vapour pressure above the mixture is the sum of the two vapour pressures of the individual components.

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on heating, the vapour pressure increases and the sum equal to atmospheric pressure such that the **mixture boils at a temperature lower** than the boiling point of the either component liquids

(iii) **Steam** is passed into a **heated** mixture of 4-nitro phenol and 2-niro phenol.
2-niro phenol is **immiscible with water**
The mixture **boils at a temperature lower than that of water** such that **4-niro phenol** with a much higher boiling point will **remain in the flask**
The **distillate is a mixture of 2-nitro phenol and water**
The mixture (distillate) is dissolved in ether to make a solution of 2-nitro phenol in ether. Water is removed by use of a separating funnel and the 2-nitro phenol is obtained by distilling off the ether, the vapour is condensed to give a distillate which contains 2-nitro phenol.
4-nitro phenol is **miscible** with water

(b) Vapour pressure of $Y = 950 - 654 = 96mmHg$

$$\%\ of\ water\ in\ distillate = 100 - 55 = 45\%$$

$$\frac{\%\ of\ Y\ in\ distillate}{\%\ of\ H_2O\ in\ distillate} = \frac{v.pressure\ of\ Y \times relative\ molecular\ mass\ of\ Y}{v.pressure\ of\ H_2O \times molecular\ mass\ of\ H_2O}$$

$$\frac{55}{45} = \frac{96 \times relative\ molecular\ mass\ of\ Y}{654 \times 18}$$

$$relative\ molecular\ mass\ of\ Y = \frac{55 \times 654 \times 18}{96 \times 45} = 149.9$$

Question. Five.

(a) (i) See graph next page

(ii) Melting point increases from sodium to silicon and **then sharply decreases from silicon to phosphorus.**
From sodium to aluminium, **strong metallic bonds** have to be broken, the strength of the metallic bonds increases from sodium to aluminium because of **increase in number of electrons contributed per atom** to the charge cloud towards metallic bonding and also due to the **decrease in the atomic radius.** Silicon has the highest melting point because it has a **giant atomic structure** in which the silicon atoms are joined by **strong covalent bonds** and thses require a large amount of energy to be broken
Phosphorus has the lowest melting point because it has a **simple molecular structure** and the phosphorus molecules are held together by **weak vander waal's forces** which can **easily be broken**

(b) (i) Magnesium oxide **does not react** with sodium hydroxide because it is **basic**
Aluminium oxide reacts with **hot concentrated** sodium hydroxide solution to form sodium aluminate because it is **amphoteric**

$Al_2O_3(s) + 2\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_4^-(aq)$
or $Al_2O_3(s) + 6\bar{O}H(aq) + 3H_2O(l) \longrightarrow 2Al(OH)_6^{3-}(aq)$
or $Al_2O_3(s) + 2\bar{O}H(aq) \longrightarrow 2AlO_2^-(aq) + H_2O(l)$

Silicon (IV) oxide is **acidic** and reacts with sodium hydroxide solution on **heating** to form **sodium silicate** and **water**

$SiO_2(s) + 2\bar{O}H(aq) \longrightarrow SiO_3^{2-}(aq) + H_2O(l)$

(ii) Magnesium oxide is **basic** and so reacts with **dilute** hydrochloric acid to form **magnesium chloride solution** and **water**

$MgO(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2O(l)$
$MgO(s) + 2H^+(aq) \longrightarrow Mg^{2+}(aq) + H_2O(l)$

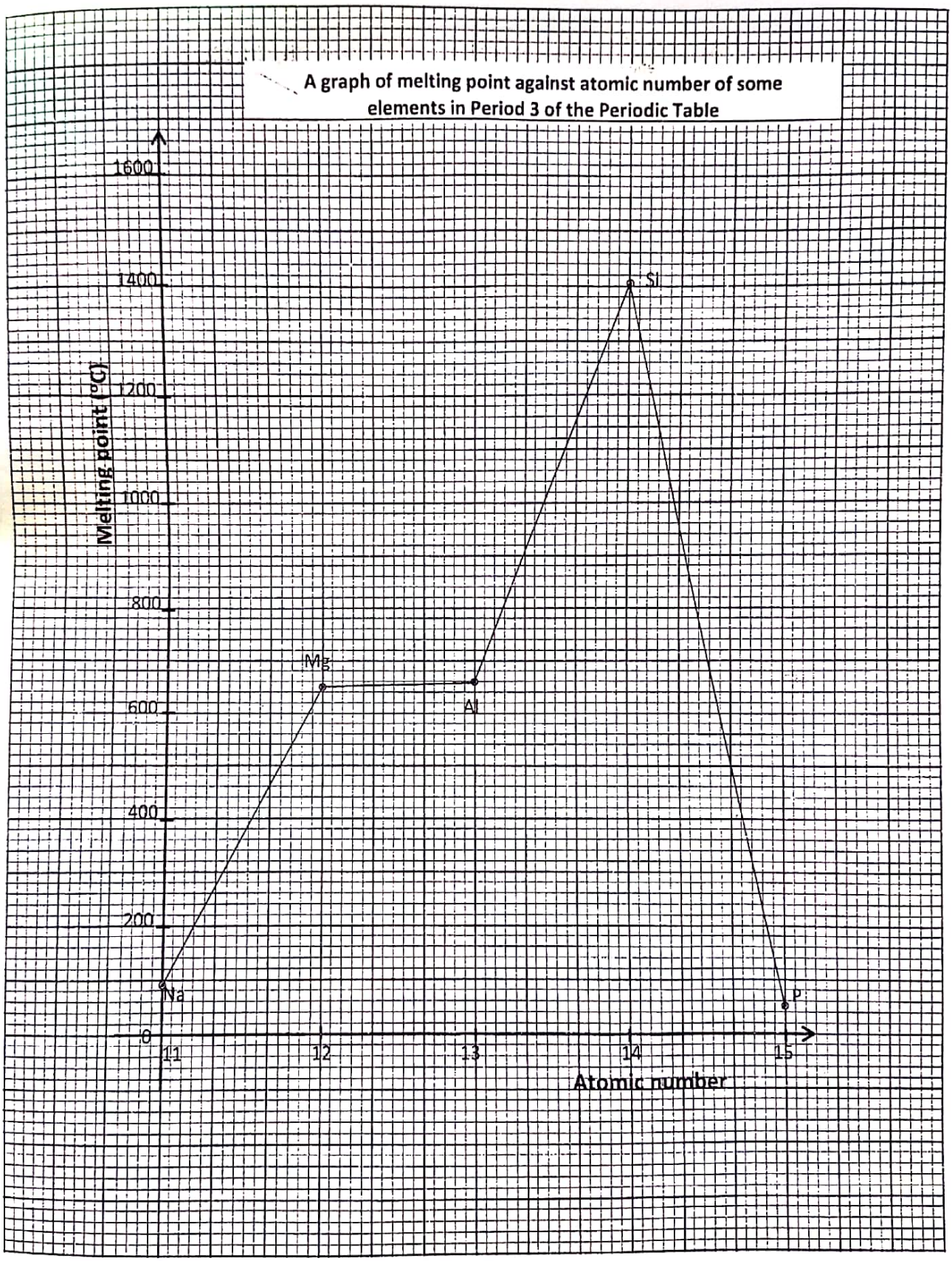
Amphoteric aluminium oxide reacts with **dilute** hydrochloric acid to form **aluminium chloride** and **water**

$Al_2O_3(s) + 6HCl(aq) \longrightarrow 2AlCl_3(aq) + 3H_2O(l)$
$Al_2O_3(s) + 6H^+(aq) \longrightarrow 2Al^{3+}(aq) + 3H_2O(l)$

Acidic silicon (IV) oxide **does not react** with hydrochloric acid

(c) Bonding in oxides of sodium is **ionic bonding**
Bonding in oxides of phosphorus is **covalent bonding**

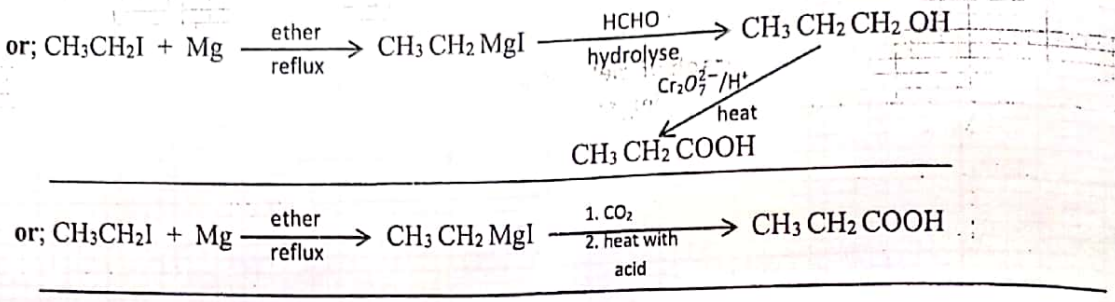
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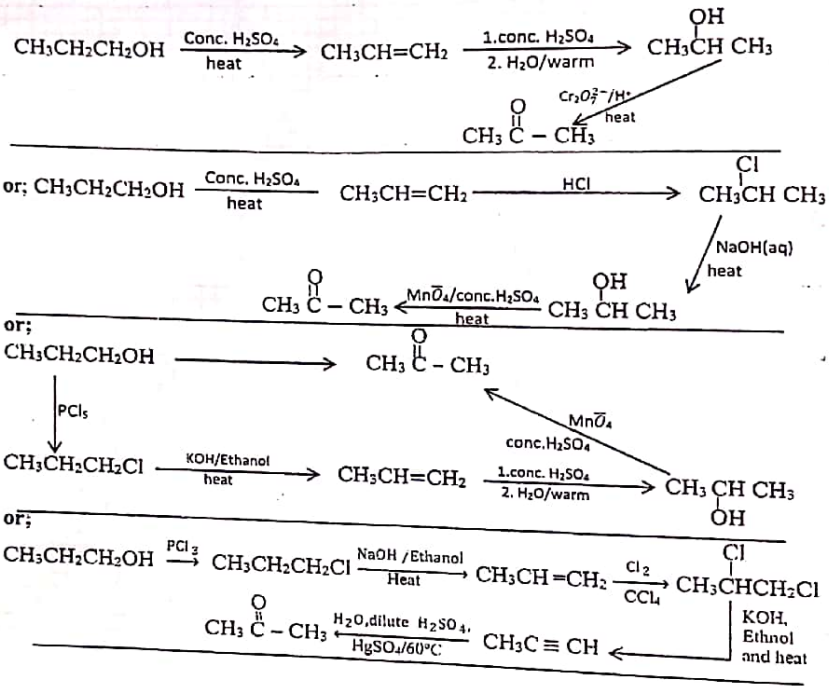
Question. Six.

(a) $CH_3CH_2I \xrightarrow[\text{reflux}]{KCN/Alcohol} CH_3CH_2CN \xrightarrow[\text{heat}]{H_2O/H^+} CH_3CH_2COOH$

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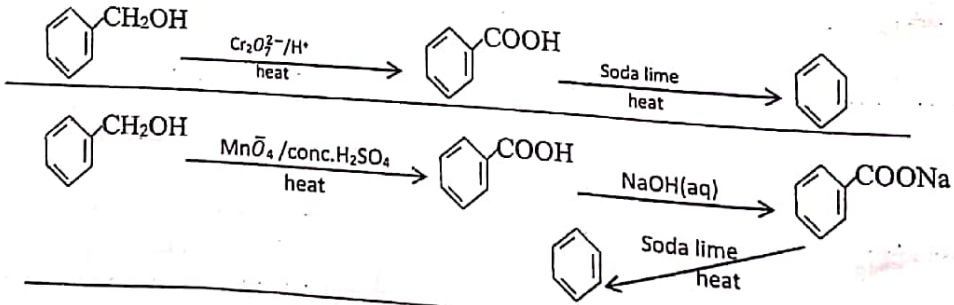


(b)

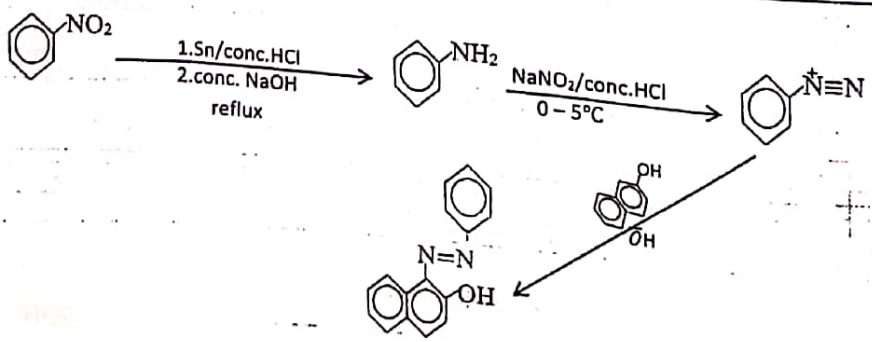


(c)

or

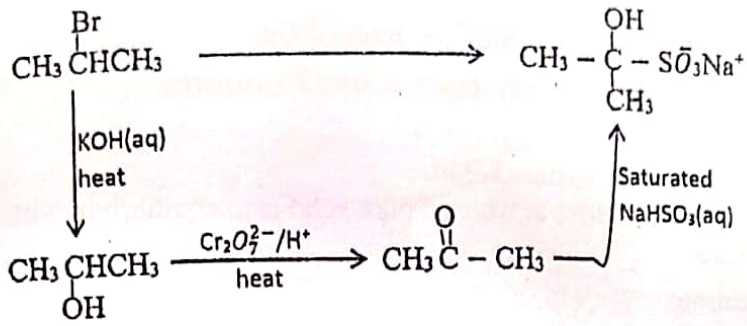


(d)



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(e)



Question. Seven.

(a) A **naturally occurring** substance from which an element can be extracted using a suitable method

(b) (i) -Froth flotation;
The ore is pulverized, then water and a frothing agent added. Air is blown into the mixture. Earthy materials are **wetted** and **sink**. The ore, air and frothing agent form a froth. The froth is **skimmed** off eg copper pyrites, zinc blende Etc

-Magnetic separation
A magnet is used to extract a crushed magnetic ore eg wolframite (tungsten) from cassiterite

-Washing
The ores are usually denser than gangue which may be washed away in a stream of water eg galena

(ii) **Leaching with solvents**
Bauxite is crushed or pulverized, digested with sodium hydroxide, seeded and strongly heated

Roasting
The ore is crushed and roasted eg ores like siderite (iron (II) carbonate), Galena (PbS), Iron pyrites, calamine, zinc blende and copper pyrites. For example siderite is roasted in air to give Iron (III) oxide and carbon dioxide gas is given off.

$4FeCO_3(s) + O_2(g) \longrightarrow 2Fe_2O_3(s) + 4CO_2(g)$

(c) Moles of HCl that neutralized ammonia in the organic layer $= \frac{25.0}{1000} \times 0.05 moles$
$= 1.25 \times 10^{-3}$ moles

Hydrochloric acid reacts with ammonia according to the equation;

$HCl(aq) + NH_3(aq) \longrightarrow NH_4Cl(aq)$

Since; mole ratio of $HCl : NH_3 = 1:1$
Hence; moles of NH_3 in organic layer $= 1.25 \times 10^{-3}$ moles
Since; $50cm^3$ of organic layer contain 1.25×10^{-3} moles of NH_3
Therefore; $1000cm^3$ of organic layer contain $\frac{1000 \times 1.25 \times 10^{-3}}{50}$ moles of NH_3
Thus;
Concentration of NH_3 in organic layer $= 0.025 moldm^{-3}$
Moles of HCl which reacted with NH_3 in aqueous layer $= \left(\frac{40}{1000} \times 0.5\right) moles$
Moles of ammonia in $25cm^3$ of aqueous layer $= \left(\frac{40}{1000} \times 0.5\right) moles$
$25cm^3$ of aqueous layer contain $\left(\frac{40}{1000} \times 0.5\right) moles$ of NH_3
$\therefore 1000cm^3$ of aqueous layer contain $\left(\frac{1000 \times 40 \times 0.5}{25 \times 1000}\right) moles$ of NH_3
Therefore; total concentration of NH_3 in aqueous layer $= 0.8 moldm^{-3}$

$$\frac{[NH_3]\ free\ in\ aqueous\ layer}{[NH_3]\ in\ organic\ layer} = K_D$$

Hence; $[NH_3]$ free in aqueous layer $= 25 \times 0.025$
$= 0.625 moldm^{-3}$
$[NH_3]$ fixed in complex $= 0.8 - 0.625 = 0.175 moldm^{-3}$

Formula of the inn complex formed when copper (II) ion reacts with excess aqueous ammonia is $Cu(NH_3)_4^{2+}$
From the formula of the complex;
4moles of NH_3 complex with 1mole of Cu^{2+}

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$\therefore$ 0.175moles of NH_3 complex with $\frac{0.175}{4}$ mole of Cu^{2+}

Thus; concentration of copper (II) ions = $0.04375 moldm^{-3}$

Question. Eight.

(a) Melting point is a **constant temperature** at which a pure solid is in equilibrium with its own pur a given atmospheric pressure

(b) (i) Number of valence electrons
Atomic radius
(ii) Molecular mass
Type of molecular structure

(c) The melting point of group (II) elements **decreases** down the group **from beryllium to barium.** Down the group from one element to the next, **atomic radius increases** which results into a **decreas the strength of the metallic bonds**

The melting point of group (VII) elements **increases** down the group from **fluorine to iodine** Down the group, the **molecular mass** of the **diatomic** molecule of elements **increases,** which results **increase in strength of vander waal's forces** hence increase in melting point

(d) Transition metals can **use electrons from both the 4s and 3d subenergy levels for bonding** hence th metals contribute **more electrons** per atom to the charge cloud during metallic bond formation compa to non transition metals in the same period which contribute **one or two electrons** per atom towards metallic bond formation.
As a result, transition metals have **stronger metallic bonds** than non transition elements in the same period.
Also; transition metals have **smaller atomic radii** than the non transition elements in the same period a hence, this again contributes to formation of stronger metallic bonds compared to the non transition elements.

(e) (i) The chloride ion in aluminium chloride has a **larger ionic radius** than the oxide ion in aluminium o This makes the chloride ion to be **more polarized** by the aluminium ion than the oxide ion
Hence aluminium chloride is **more covalent** in character than ionic hence with a low melting point
Aluminium oxide is **predominantly ionic** hence with **strong ionic bonds** which require **alot of energy** be broken

(ii) The oxide ion has a **smaller ionic radius** and with a high charge of –2 than the chloride ion with a smaller charge of -1; As a result, there **stronger ionic bonds** in calcium oxide than calcium chloride wi **require a lot of heat energy** to be broken.

(f) Formula mass of NaCl = 23 + 35.5 = 58.5g
200g of water dissolved 0.025g of sodium chloride
$\therefore$ 1000g of water dissolved $\left(\frac{1000\times0.025}{200}\right)$ g of sodium chloride
= 0.125g of sodium chloride
58.5g of NaCl cause a freezing point depression of 1.86°C
$\therefore$ 0.125g of NaCl cause a freezing point depression of $\left(\frac{0.125\times1.86}{58.5}\right)$ °C

Hence; freezing point depression of solution = 0.00397°C

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