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UACE chemistry 2020

PAPER 1

DURATION: 2 HOUR 45 MINUTES

Instructions

- This paper consists of two sections A and B
- Section A is compulsory
- Attempt only six questions in section B
- Answers must be written in the spaces provided only.

Where necessary use the following:

Molar gas constant, R = $8.31 \text{ JK}^{-1} \text{ mol}^{-1}$

Molar volume of a gas at stp. = 22.4 litres

Standard temperature = 273K

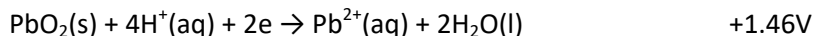
Standard pressure = 10125 Nm^{-2}

For Examiner's Use Only																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

SECTION A

Answer all questions in this section

1. The standard reduction potential for some half-cell are shown below



- (a) Write the overall equation for the cell reaction that would occur when the half cells are combined
- (b) (i) Calculate the emf of the cell (1 ½ marks)
 (ii) State whether the reaction is feasible or not and give a reason for your answer. (01marks)
2. Figure 1

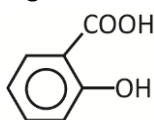
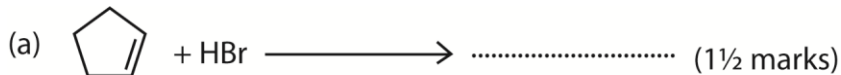


Fig. 1

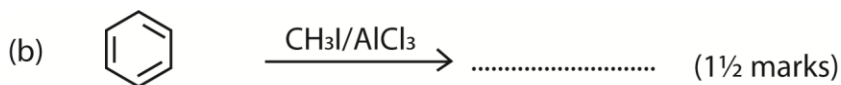
- (a) Identify the functional groups in G (02marks)
 (b) Name the reagent(s) that can be used to identify each of the functional groups you have identified in (a) (02marks)
 (c) State what would be observed when G is treated separately with the reagent(s) you have named in (b) (02marks)
3. Draw the structure and name the shape of each of the following species: (4½ marks)

Species	Structure	Shapes
CrO_4^{2-}		
ClO_3^-		
SF_6		

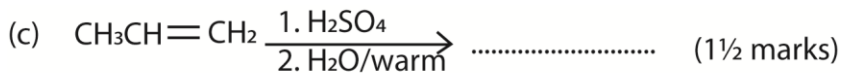
4. (a) Define the term standard enthalpy of formation. (01marks)
 (b) The standard enthalpies of combustion of propan-1-ol, carbon and hydrogen are; -2010, -393 and -286 kJmol⁻¹ respectively.
 Calculate the standard enthalpy of formation of propan-1-ol. (03marks)
 (c) Comment on the stability of propan-1-ol. (1½ marks)
5. Complete the following equations and in each case name the main organic products



Name of the product

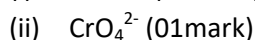
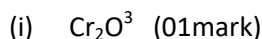


Name of the product:

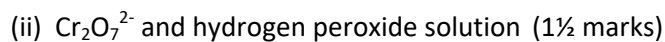
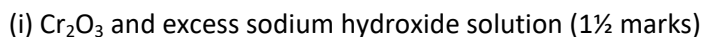


Name of the product:

6. (a) Determine the oxidation state of chromium in each of the following species:



(b) Write an equation to show the reaction between:



7. Ammonium chloride was added to 1.0dm^3 of 0.1M aqueous ammonia to make a solution of pH 8.7. calculate

(a) (i) concentration of hydroxide ions in the solution. (02marks)

($K_w = 1.0 \times 10^{-14} \text{ mol}^2\text{dm}^{-6}$)

(ii) Mass of ammonium chloride used (03marks) (03marks)

(k_b for aqueous ammonia = $1.8 \times 10^{-5} \text{ mol dm}^{-3}$)

(b) (i) State what would happen to the pH of the solution in (a) if small amount of dilute

8. State what would be observed and write an equation for the reaction that would take place when each of the following compounds is mixed with bromine water

(a) $\text{C}_6\text{H}_5\text{OH}$ (2 ½ marks)

Observation

Equation

(b) $\text{CH}_3\text{CH}=\text{CH}_2$

Observation

Equation

9. State the trend in acidity of the hydrides of elements in group (VII) of the Periodic Table (01mark)

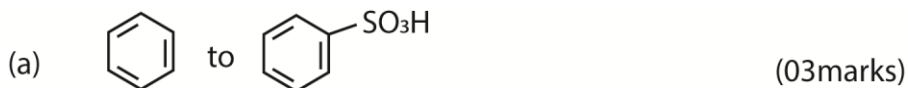
Explain your answer in (a) (04marks)

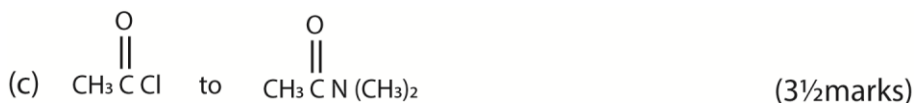
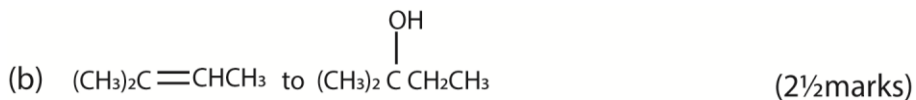
SECTION B (54 MARKS)

Answer any **six** questions from this section

Any additional question(s) answered will **not** be marked

10. Compound A consist of carbon 64.1%, hydrogen 10.3%, the rest being oxygen.
The vapour density of the compound is 29
- Determine the;
 - Empirical formula of A (02marks)
 - Molecular formula of A (01mark)
 - Write the structural formula of all the possible isomers of A (01mark)
 - Compound A reacted with 2,4-dinitrophenylhydroazine to give an orange solid but did not react with ammoniacal silver nitrate solution
 - Identify A ($\frac{1}{2}$ mark)
 - Write the equation and indicate the mechanism for the reaction that occurred between A and 2,4-dinitrophenylhydrazine. ($4\frac{1}{2}$ marks)
11. State what would be observed and write the equation for the reaction that would take place if;
- Propyne is bubbled through ammoniacal copper (I) chloride solution. (02marks)
Observation
Equation
 - Fehling's solution is added to methanoic acid. (02marks)
Observation
Equation
 - Dilute sodium hydroxide solution is added drop-wise until in excess to aqueous nickel (II) ions (02marks)
Observation
Equation
 - Silver nitrate solution is added to aqueous iron (II) Sulphate (03marks)
Observation
Equation
12. (a) Define the term distribution coefficient. (01 mark)
- (b) 1.5g of an impure ore of zinc was dissolved in in 50cm^3 ammonia and the resultant solution shaken with 50cm^3 of trichloromethane. After the layers have settled, 50cm^3 of trichloromethane layer needed 30cm^3 of 0.062M hydrochloric acid for neutralization. 20cm^3 of the aqueous solution were neutralized by 40cm^3 of 0.5M hydrochloric acid. If the partition coefficient between water and trichloromethane at 25°C is 25.0 and the reaction between zinc (II) ions and ammonia is 1:4. Calculate the molar concentration of;
- ammonia in the trichloromethane layer (02marks)
 - free ammonia in the aqueous layer. ($1\frac{1}{2}$ marks)
 - complexed ammonia in the aqueous layer. (02marks)
- (c) Determine the percentage of zinc in the ore ($2\frac{1}{2}$ marks)
13. Write a mechanism to show how each of the following conversion can be effected



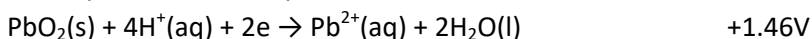
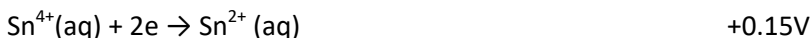


- (c) Compound Z contains 25.6% copper, 12.8% Sulphur, 25.6% oxygen and rest being water
- (a)(i) calculate the empirical formula of Z (02marks)
- (ii) Determine the molecular formula of Z (the formula mass of Z = 250) (1½ marks)
- (b) Concentrated hydrochloric acid was added drop-wise to aqueous Z until in excess.
- (i) State what is observed (1½ mark)
- (ii) Write the equation for the reaction that took place (1½ marks)
- (c) To an aqueous solution of Z was added dilute nitric acid followed by barium nitrate solution
- (i) State what was observed (01mark)
- (ii) Write the equation for the reaction that took place. (1½ marks)
- (d) (a) Carbon and lead are elements in group (IV) of the Periodic Table.
Write the equations to show how carbon dioxide and lead (IV) oxide can react with sodium hydroxide. (03marks)
- (b) write an equation for the reaction between lead (IV) oxide with concentrated solution of;
- (i) hydrochloric acid. (1½ marks)
- (ii) sulphuric acid (1 ½ marks)
- (c) Lead (IV) oxide was strongly heated
- (i) State what was observed (1½ marks)
- (ii) Write the equation for the reaction that took place (1 ½ marks)
- (e) The boiling point of pure water is 100°C at 760 mmHg pressure. At the same pressure, a solution containing 1.576g of potassium chloride in 100g of water boils at 100.11°C.
- (a) Calculate the boiling point constant, K_b for water. (3 ½ marks)
- (b) Explain why;
- (i) the boiling point of potassium chloride solution is higher than that of pure water (2 ½ marks)
- (ii) a 0.1M potassium chloride solution boils at the same temperature as a 0.2M glucose solution (03marks)
- (f) Both chlorine and sodium hydroxide are manufactured by electrolysis of concentrated sodium hydroxide
- (a) Name the substance used as the;

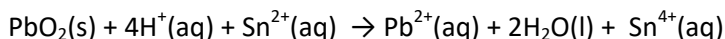
- (i) Cathode (½ mark)
 (ii) Anode (½ mark)
- (b) Write the equations (s) for the reaction(s) leading to the formation of
 (i) Chlorine (01mark)
 (ii) Sodium hydroxide (2½ marks)
- (c) State what would be observed and write the equation(s) for the reaction(s) that would take place if chlorine is bubbled through:
 (i) Sodium iodide solution. (1½ marks)
 (ii) Hot concentrated sodium hydroxide solution (02 marks)
- (d) Give a reason for your answer in (c)(i) (01mark)

Suggested answers

1. The standard reduction potential for some half-cell are shown below



- (a) Write the overall equation for the cell reaction that would occur when the half cells are combined



- (b) (i) Calculate the emf of the cell (1 ½ marks)

$$\begin{aligned} \text{Emf of cell} &= E_{\text{ox.}} - E_{\text{red.}} \\ &= 1.46 - 0.15 \\ &= 1.31\text{V} \end{aligned}$$

- (ii) State whether the reaction is feasible or not and give a reason for your answer. (01marks)

The reaction is feasible because emf is positive

2. Figure 1

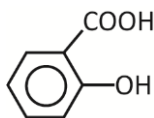


Fig. 1

- (a) Identify the functional groups in G (02marks)

- phenol group
- carboxylic group

- (b) Name the reagent(s) that can be used to identify each of the functional groups you have identified in (a) (02marks)

- phenol group is identified by neutral solution of iron (III) chloride
- carboxylic group is identified by sodium bicarbonate solution

- (c) State what would be observed when G is treated separately with the reagent(s) you have named in (b) (02marks)

- phenol group forms a purple solution
- carboxylic group forms effervesence

3. Draw the structure and name the shape of each of the following species: (4½ marks)

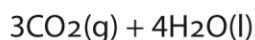
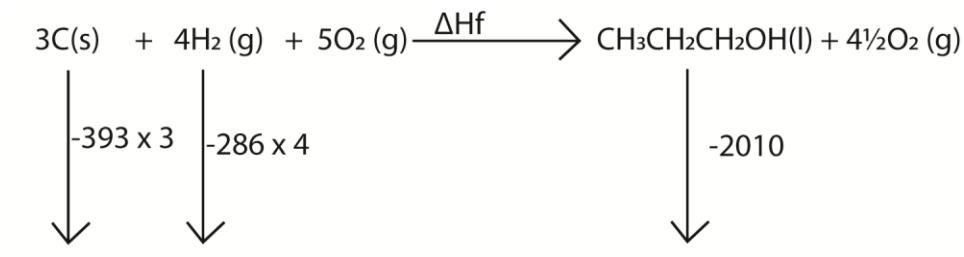
Species	Structure	Shapes
CrO_4^{2-}		tetrahedral
ClO_3^-		Triangular pyramidal
SF_6		octahedral

4. (a) Define the term standard enthalpy of formation. (01marks)

The standard molar enthalpy of formation of a compound is the enthalpy change when 1 mole of the compound is formed from its elements under the standard conditions.

(b) The standard enthalpies of combustion of propan-1-ol, carbon and hydrogen are; -2010, -393 and -286 kJmol^{-1} respectively.

Calculate the standard enthalpy of formation of propan-1-ol. (03marks)



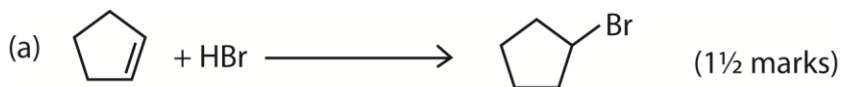
$$-393 \times 3 + (-286 \times 4) = \Delta H_f + (-2010)$$

$$\text{Enthalpy of formation } \Delta H_f = -313\text{kJmol}^{-1}$$

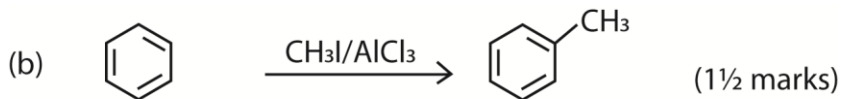
(c) Comment on the stability of propan-1-ol. (1½ marks)

It is stable because enthalpy of formation is negative

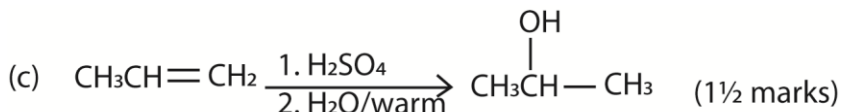
5. Complete the following equations and in each case name the main organic products



Name of the product: Bromocyclopentane



Name of the product: methylbenzene/toluene



Name of the product: propan-2-ol

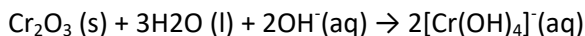
6. (a) Determine the oxidation state of chromium in each of the following species:

(i) Cr_2O_3 (01mark) +3

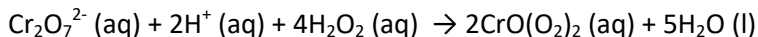
(ii) CrO_4^{2-} (01mark) +6

(b) Write an equation to show the reaction between:

(i) Cr_2O_3 and excess sodium hydroxide solution (1½ marks)



(ii) $\text{Cr}_2\text{O}_7^{2-}$ and hydrogen peroxide solution (1½ marks)



7. Ammonium chloride was added to 1.0dm^3 of 0.1M aqueous ammonia to make a solution of pH 8.7. calculate

(c) (i) concentration of hydroxide ions in the solution. (02marks)

$$(K_w = 1.0 \times 10^{-14} \text{ mol}^2\text{dm}^{-6})$$

$$\text{pH} = 8.7$$

$$[\text{H}^+] = 2 \times 10^{-9} \text{ mol dm}^{-3}$$

$$[\text{OH}^-] = \frac{K_w}{[\text{H}^+]} = \frac{1 \times 10^{-14}}{2 \times 10^{-9}} = 5 \times 10^{-6} \text{ mol dm}^{-3}$$

(ii) Mass of ammonium chloride used (03marks) (03marks)

$$(K_b \text{ for aqueous ammonia} = 1.8 \times 10^{-5} \text{ mol dm}^{-3})$$

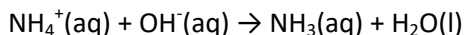
$$[\text{NH}_4\text{Cl}] = [\text{NH}_4^+] = K_b \frac{[\text{NH}_3]}{[\text{OH}^-]} = 1.8 \times 10^{-5} \times \frac{0.1}{5 \times 10^{-6}} = 0.36 \text{ mol dm}^{-3}$$

$$\text{Formula mass of } \text{NH}_4\text{Cl} = 14 + 4 + 35.4 = 53.4$$

$$\text{Mass of ammonium chloride} = 53.4 \times 0.36 = 19.224\text{g}$$

(d) (i) State what would happen to the pH of the solution in (a) if small amount of dilute sodium hydroxide is added to it (01mark)

The pH remains unchanged because the added OH^- are neutralized by ammonium ions

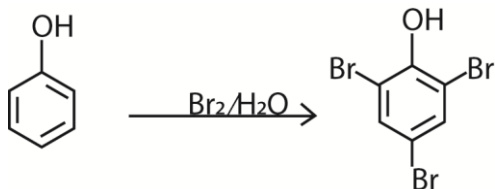


8. State what would be observed and write an equation for the reaction that would take place when each of the following compounds is mixed with bromine water

(g) $\text{C}_6\text{H}_5\text{OH}$ (2 ½ marks)

Observation: Color of bromine is discharged

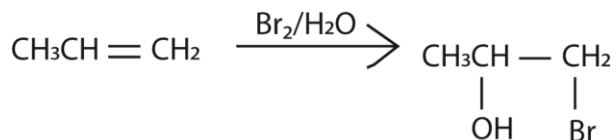
Equation



(h) $\text{CH}_3\text{CH}=\text{CH}_2$ (2 ½ marks)

Observation: yellow bromine color is discharged

Equation



9. (a) State the trend in acidity of the hydrides of elements in group (VII) of the Periodic Table (01mark)

The strengths of these acids decrease in the order $\text{HI} > \text{HBr} > \text{HCl} > \text{HF}$.

(b) Explain your answer in (a) (04marks)

The bond strength decrease in the H-X bond energy in the order $\text{HF} > \text{HCl} > \text{HBr} > \text{HI}$.

SECTION B (54 MARKS)

Answer any **six** questions from this section

Any additional question(s) answered will **not** be marked

10. Compound A consist of carbon 62.1%, hydrogen 10.3%, the rest being oxygen.

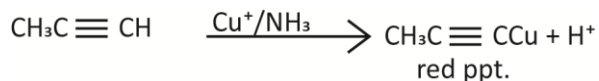
The vapour density of the compound is 29

(a) Determine the;

(i) Empirical formula of A (02marks)

$$\text{Percentage of oxygen} = 100 - (62.1 + 10.3) = 25.6$$

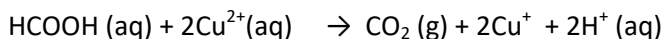
Elements	C	H	O
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- (b) Fehling's solution is added to methanoic acid. (02marks)

Observation: red ppt. is formed

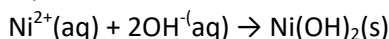
Equation



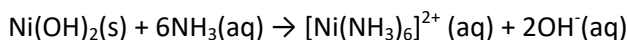
- (c) Dilute sodium hydroxide solution is added drop-wise until in excess to aqueous nickel (ii) ions (02marks)

Observation: green ppt. is formed soluble in excess to a blue/purple solution

Equation



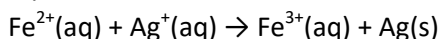
Then



- (d) Silver nitrate solution is added to aqueous iron (II) Sulphate (03marks)

Observation: red yellow solution and black ppt. formed

Equation



12. (a) Define the term distribution coefficient. (01 mark)

Partition coefficient is the ratio of the concentrations of solute in two immiscible solvents at equilibrium

- (b) 1.5g of an impure ore of zinc was dissolved in in 50cm³ ammonia and the resultant solution shaken with 50 cm³ of trichloromethane. After the layers have settled, 50 cm³ of trichloromethane layer needed 30cm³ of 0.062M hydrochloric acid for neutralization. 20cm³ of the aqueous solution were neutralized by 40 cm³ of 0.5M hydrochloric acid. If the partition coefficient between water and trichloromethane at 25^oC is 25.0 and the reaction between zinc (II) ions and ammonia is 1:4. Calculate the molar concentration of;

- (i) ammonia in the trichloromethane layer (02marks)

$$\text{moles of free ammonia in } 50\text{cm}^3 \text{ of trichloromethane} = \frac{30 \times 0.062}{1000} = 0.00186$$

- (ii) free ammonia in the aqueous layer. (1½ marks)

$$\text{From } K_D = \frac{[\text{ammonia in water}]}{[\text{ammonia in trichloromethane}]}$$

$$\text{Free ammonia in } 20\text{cm}^3 \text{ of water} = 0.00186 \times 25 = 0.0465 \text{ moles}$$

- (iii) complexed ammonia in the aqueous layer. (02marks)

$$\text{Moles of ammonia in } 20\text{cm}^3 \text{ of aqueous solution} = \frac{40 \times 0.5}{1000} = 0.02$$

$$\text{Mole of ammonia in } 50\text{cm}^3 \text{ of aqueous solution} = \frac{50}{20} \times 0.02 = 0.05$$

$$\text{Moles of complexed ammonia} = 0.05 - 0.0465 = 0.0035$$

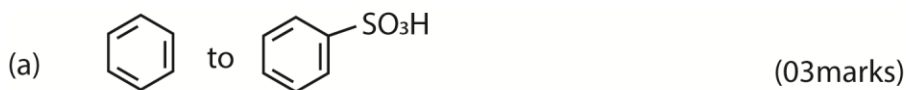
- (c) Determine the percentage of zinc in the ore (2½ marks)

$$\text{Moles of Zn} = \frac{0.0035}{4} = 0.000875 \text{ moles}$$

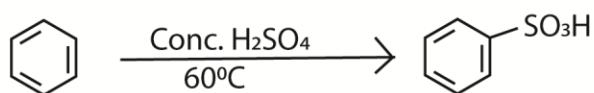
$$\text{Mass of pure zinc} = 0.000875 \times 65.7 = 0.0575\text{g}$$

$$\text{Percentage of zinc in zinc ore} = \frac{0.0575}{1.5} \times 100\% = 3.83\%$$

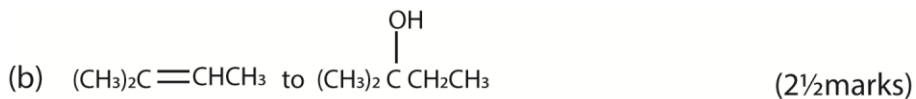
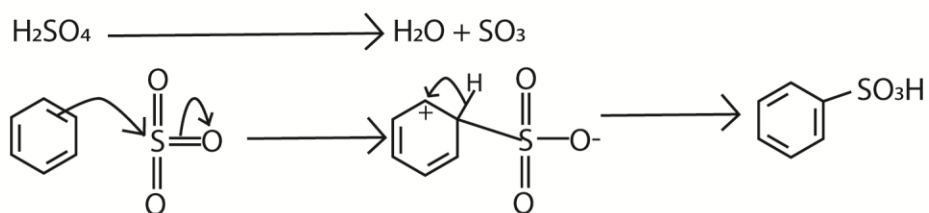
13. Write a mechanism to show how each of the following conversion can be effected



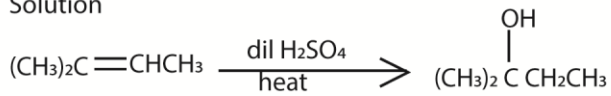
Solution



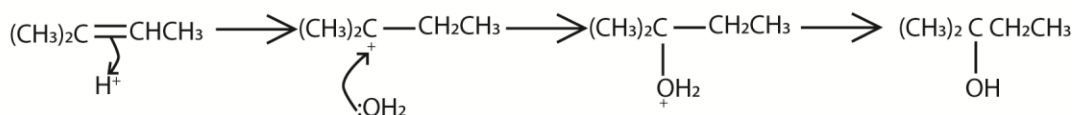
Mechanism

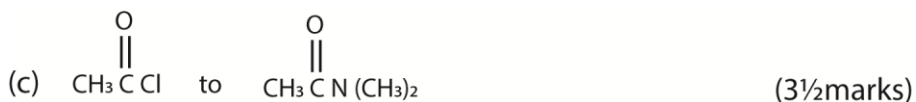


Solution



Mechanism

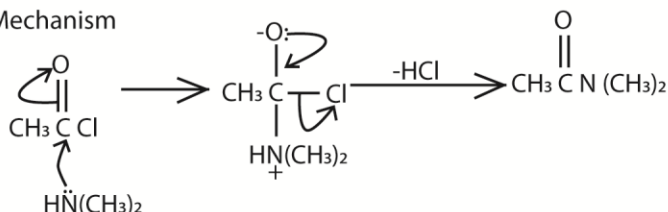




Solution



Mechanism



14. Compound Z contains 25.6% copper, 12.8% Sulphur, 25.6% oxygen and rest being water

(a)(i) calculate the empirical formula of Z (02marks)

Substance	Cu	S	O	H ₂ O
Percentage	25.6	12.8	25.6	36
Molar mass	63.5	32.1	16.0	18
moles	0.4	0.4	1.6	2.0
Mole ratio	1	1	4	5

Empirical formula $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$

(ii) Determine the molecular formula of Z (the formula mass of Z = 250) (1½ marks)

$$[\text{CuSO}_4 \cdot 5\text{H}_2\text{O}]_n = 250$$

$$n(63.5 + 32.1 + 16 \times 4 + 1(2 \times 16)) = 250$$

$$n = 2$$

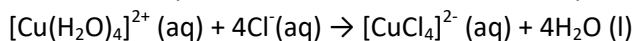
molecular formula = $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$

(b) Concentrated hydrochloric acid was added drop-wise to aqueous Z until in excess.

(i) State what is observed (1½ mark)

A blue solution turns yellow

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

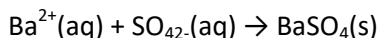


(c) To an aqueous solution of Z was added dilute nitric acid followed by barium nitrate solution

(i) State what was observed (01mark)

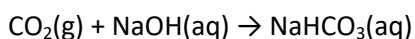
White ppt. formed

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

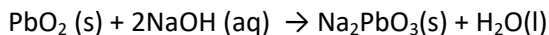
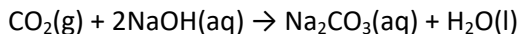


15. (a) Carbon and lead are elements in group (IV) of the Periodic Table.

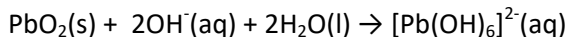
Write the equations to show how carbon dioxide and lead (IV) oxide can react with sodium hydroxide. (03marks)



Or



Or



(b) write an equation for the reaction between lead (IV) oxide with concentrated solution of;

(i) hydrochloric acid. (1½ marks)



(ii) sulphuric acid (1 ½ marks)

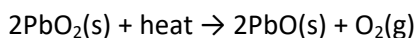


(c) Lead (IV) oxide was strongly heated

(i) State what was observed (1½ marks)

Color change from brown to orange

(ii) Write the equation for the reaction that took place (1 ½ marks)



16. The boiling point of pure water is 100°C at 760 mmHg pressure. At the same pressure, a solution containing 1.576g of potassium chloride in 100g of water boils at 100.11°C.

(c) Calculate the boiling point constant, K_b for water. (3 ½ marks)

$$KCl = 39.1 + 35.4 = 74.4$$

$$\text{Moles of particles in 100g of water} = \frac{2 \times 1.576}{74.5} = 0.0423 \text{ mole}$$

$$\Delta t = 100.11 - 100 = 0.11$$

$$\Delta t = K_b \times \text{moles}$$

$$K_b = \frac{0.11}{0.0423} = 2.6^\circ\text{C mol}^{-1}$$

(d) Explain why;

(i) the boiling point of potassium chloride solution is higher than that of pure water (2 ½ marks)

In potassium chloride solution, K^+ and Cl^- ions occupy part of the surface of solution; this reduces escaping tendency of water molecules in the vapour which reduces the vapour pressure of the solution. The solution has to be heated to a temperature higher than the boiling point of water to make its vapour pressure equal to that of the atmosphere in order to make it boil.

(ii) a 0.1M potassium chloride solution boils at the same temperature as a 0.2M glucose solution (03marks)

KCl ionizes completely in water to produce two particles; therefore 0.1M potassium chloride contains the same number of particles as 0.2M glucose

17. Both chlorine and sodium hydroxide are manufactured by electrolysis of concentrated sodium hydroxide

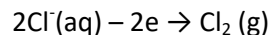
(a) Name the substance used as the;

(i) Cathode (½ mark) Mercury

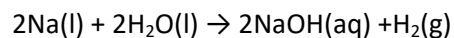
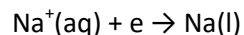
(ii) Anode (½ mark) carbon

(b) Write the equations (s) for the reaction(s) leading to the formation of

(i) Chlorine (01mark)



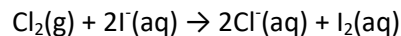
(ii) Sodium hydroxide (2½ marks)



(c) State what would be observed and write the equation(s) for the reaction(s) that would take place if chlorine is bubbled through:

(i) Sodium iodide solution. (1½ marks)

The solution turn brown due to liberation of iodine



(ii) Hot concentrated sodium hydroxide solution (02 marks)

Pale yellow solution formed



(d) Give a reason for your answer in (c)(i) (01mark)

Iodide ions are oxidized to iodine

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Thanks