UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

P525/1 CHEMISTRY

SCORING GUIDE

FOR THE SAMPLE PAPER

Turn Over

P525/1 CHEMISTRY THEORY
SECTION A
ITEM 1
To attain the highest level of achievement, a *candidate is expected to;*

- *demonstrate understanding of relevant chemical principle(s)/theory(ies), /law(s) and clearly explains factors affecting chemical systems.*
- *analyze and interprets chemical data correctly/ performs calculations accurately /energy changes and draws a conclusion.*
- *apply concept(s) correctly to predict chemical behavior/ optimizes industrial conditions logically and recommendations.*

Possible responses

a) Heat produced from the bio-digester.
The reaction in the bio-digester is;
$C_6H_{12}O_{6(s)} \longrightarrow 3CH_{4(g)} + 3CO_{2(g)}$
Heat of reaction = $\sum DH_f^{\theta}$ of products - $\sum DH_f^{\theta}$ Reactants
; (3 x-394) + (3 x-74.9) –(-1273.3)
= $-133.4 kJmol^{-1}$

$^{-}133.4KJmol^{-1}$ of heat is produced in the bio-digester from the above reaction. The heat produced in the bio digester pit was because the decomposition of glucose to methane and carbon-dioxide is exothermic (gives off heat).

Amount of gas produced reduced with time taken to add more waste material.
This is because the amount (concentration) of waste material reduces with time taken to add more waste. This decreases the concentration of reactant glucose molecules, thereby reducing the rate of formation of the products (methane and carbondioxide).

Reduction in the amount of gas produced increased the cooking time.
Increased cooking time was caused by reduced rate of combustion due to decreased amount of gas (methane) that was being burnt.
OR; Increased cooking time was caused by reduction in amount of heat produced due to decreased amount of gas (methane) that was being burnt.

b) Let;
Rate = $K[CH_4]^a\ [O_2]^b$
Considering A and C
$5.0 \times 10^{-4} = K\ (0.1)^a\ (0.2)^b$ ——— (i)

$40 \times 10^{-4} = K (0.2)^a (0.2)^b$ ——— (ii)

(ii) – (i)
$8 = 2^a$
$a = 3$

Considering B and C
$1.0 \times 10^{-3} = K (0.2)^a (0.1)^b$

$40 \times 10^{-4} = K (0.2)^a (0.2)^b$

$4 = 2^b$

$b = 2$

Rate = $K [CH_4]^3 [O_2]^2$

Increasing the concentrations of both methane and oxygen, increases the rate of the reaction. This in turn increases the amount of heat produced.

So higher concentrations produce high heat energy which can be used for cooking. Therefore, reduction in any one reactant lowers the reaction rate.

For activities that require much heat, the concentration of methane should be kept high by increasing the amount of waste material in the bio-digester.

ITEM 2

To attain the highest level of achievement, a *candidate is expected to;*

- *demonstrate accurate understanding of principle(s)/ law(s)/ theory(ies) of equilibrium/ stoichiometry and clearly explains all conditions/characteristic/ factors affecting the systems.*
- *analyse and interprets data accurately/uses equilibrium constant(s)/phase transition information/ quantities of substances to explain system behavior.*
- *analyse all applications/ uses of chemical systems in real life.*

Possible responses

a) Understands principles/ theories/ laws and factors relating to chemical equilibria/ electrochemistry.
The non-volatile solutes in the juice cause depression of freezing point of water. The dissolved solutes lower the vapour pressure of the solvent and disrupt the formation of solvent crystals thus requiring lower temperatures for the solution/ juice to freeze.

Set A with a higher amount of sugar shows greater depression of freezing point than Set B with a lower amount of sugar. Therefore, to avoid rapid freezing, Set A is recommended for use. Set B freezes faster than Set A, hence the company should use more sugar.

Analyzes and interprets data relating to equilibrium constants/phase transitions/electrochemical systems.

RFM of C_6H_5COONa = 7x12+5+16x2+23

= 144

No. of moles of $C_6H_5COONa = \frac{0.1578}{144}$

$= 1.0958 \times 10^{-3}$ moles

$50cm^3$ of solution contain 1.0958×10^{-3} mole of C_6H_5COONa

$1000cm^{-3}$ contain $\left(\frac{1.0958 \times 10^{-3} \times 1000}{50}\right)$

= 0.0219 moles

Hence $[C_6H_5COONa] = 0.0219M$

RFM of C_6H_5COOH = 7x12+6+16x2

= 122

No. of moles of $C_6H_5COOH = \frac{1.525}{122}$

$= 1.25 \times 10^{-2}$ moles

$50\ cm^3$ of solution contain 1.25×10^{-2}mole of C_6H_5COOH

Therefore, $1000\ cm^3$ contain $\left(\frac{1.25 \times 10^{-2} \times 1000}{50}\right)$ moles

= 0.25 mole

Therefore, $[C_6H_5COOH] = 0.25$ M

pKa = -log Ka

4.2 = -log Ka

Therefore, $Ka = \log^{-1}(-4.2)$

$= 6.3095 \times 10^{-5}$

$$Ka = \frac{[C_6H_5COO^-]\,[H^+]}{[C_6H_5COOH]}$$

$$6.3095 \times 10^{-5} = \frac{0.0219 \times [H^+]}{0.25}$$

$$\text{Therefore, } [H^+] = \frac{6.3095 \times 10^{-5} \times 0.25}{0.0219}$$

$$= 7.20262 \times 10^{-4}$$

$$\text{Therefore, } pH = -\log[H^+]$$

$$= -\log 7.20262 \times 13^{-4}$$

Therefore, pH = 3.14

The pH is below the recommended pH range for the juice. This implies that the juice contains more acid than expected, hence its sour taste.

b) Evaluates the applications/uses of chemical systems in real life.
The additives such as sugar are sources of glucose for energy production in the body, however, too much sugar may lead to diabetes and dehydration or obesity. Buffers such as a mixture of sodium benzoate and benzoic acid preserve juice by maintaining constant pH, however, they being acidic may cause dental erosion and sour juice taste/ulcers.

SECTION B

Part I

ITEM 3

To attain the highest level of achievement, a *candidate is expected to;*

- *demonstrate understanding of all physical properties/complete trends/all processes of radioactive decay*
- *explain reactivity (chemical properties) of substances with all equation(s)/correct calculation on radioactivity with an interpretation.*
- *assess health/environmental/ ethical implication(s) of chemical substance(s)/process(es) of radioactive decay and give recommendation(s)/mitigation(s).*

Possible responses

Silica is a stable solid with high melting point. This is because it has a giant covalent structure with strong covalent bonds between oxygen and silicon

atoms and since glass needs to be strong and should not easily melt when exposed to relatively high temperature, silica is very suitable for its making.

Calcium oxide and magnesium oxide are basic oxides and hence react with the acids in the wastes to form a salt and water and hence neutralize the acidic wastes and therefore control contamination.

$CaO_{(s)} + 2H^{+}_{(aq)} \longrightarrow Ca^{2+}_{(aq)} + H_2O_{(l)}$

OR

$MgO_{(s)} + 2H^{+}_{(aq)} \longrightarrow Mg^{2+}_{(aq)} + H_2O_{(l)}$

OR

$SiO_{2(s)} + CaO_{(s)} \longrightarrow CaSiO_{3(s)}$

Aluminium oxide is amphoteric and hence reacts with acids in the wastes to form a salt and water. However, the salt formed is acidic and hence the acidity of the wastes is not neutralized completely.

$Al_2O_{3(s)} + 6H^{+}_{(aq)} \longrightarrow 2Al^{3+}_{(aq)} + 3H_2O_{(l)}$

OR

$Al_2O_{3(s)} + 3\ SiO_{2(s)} \longrightarrow Al_2\ (SiO_3)_{3(s)}$

The fumes contain oxides of Sulphur and phosphorous and react with water to form acidic solutions which makes water sour or causes death of aquatic organisms.

$P_2O_{3(g)} + H_2O_{(l)} \longrightarrow H_3PO_{3(aq)}$

OR

$P_2O_{5(g)} + H_2O_{(l)} \longrightarrow H_3PO_{4(aq)}$

$SO_{2(g)} + H_2O_{(l)} \longrightarrow H_2SO_{3(aq)}$

OR

$SO_{3(g)} + H_2O_{(l)} \longrightarrow H_2SO_{4(aq)}$

Chlorine as a disinfectant has advantages and disadvantages.

The advantage is that chlorine reacts with water to form an acidic solution which kills germs making water safe for use.

The disadvantage is that, if chlorine is used in excess, it lowers the PH of water significantly causing irritation to the skin/throat if such water is used. This can be mitigated by use of controlled amounts of chlorine tablets to water.

ITEM 4

To attain the highest level of achievement, a *candidate is expected to;*

- *demonstrate understanding of all physical properties/complete trends/all processes of radioactive decay*
- *explain reactivity (chemical properties) of substances with all equation(s)/correct calculation on radioactivity with an interpretation.*
- *assess health/environmental/ ethical implication(s) of chemical substance(s)/process(es) of radioactive decay and give recommendation(s)/mitigation(s).*

Possible responses

a) Iron is a stronger metal than aluminium. So it is more favorable for carrying heavy load than aluminium. This is because iron forms stronger metallic bonds than aluminium, since iron uses more electrons in metallic bond formation than aluminium.

Al - $1s^2\ 2s^2\ 2P^6\ 3s^2\ 3P^1$
Fe - $1s^2\ 2s^2\ 2P^6\ 3s^2\ 3P^6\ 3d^6\ 4s^2$

Iron uses electrons from the 3d orbitals and 4s orbitals in metallic bond formation while aluminium has only 3 electrons available for metallic bond formation.
Iron has a smaller atomic radius than aluminium, therefore, forms stronger metallic bonds than aluminium, and the electrostatic force of attraction between the cation and delocalized electrons is stronger in iron than aluminium.

Being reducing agents, iron and aluminum are slowly oxidized by air to form aluminium oxide, iron(III) oxide / rust.

$4Al_{(s)} + 3O_{2(g)} \longrightarrow 2\ Al_2O_{3(s)}$

$4Fe_{(s)} + 3O_{2(g)} \longrightarrow 2Fe_2O_{3(s)}$

OR

$2Fe_{(s)} + {}^3/_2\ O_{2(g)} + n\ H_2O_{(l)} \longrightarrow Fe_2O_3 . n\ H_2O$

Magnesium is more reactive with oxygen than iron, therefore protects iron from rusting by forming a protective oxide layer.

$2\ Mg_{(s)} + O_{2(g)} \longrightarrow 2\ MgO_{(s)}$

Structurally, beryllium would be better than aluminium because beryllium forms stronger metallic bonds than aluminium due to smaller atomic radius, however, beryllium is toxic so aluminium is a better material than beryllium.

b) Iron is applied in bridge construction to reinforce concrete because its stronger. However, iron rusts in moist air, consequently colouring water and increases iron concentration in water which can kill aquatic organisms.
This can be mitigated by use of stainless steel which is stronger and resistant to rusting than normal iron.

Part II

ITEM 5

To attain the highest level of achievement, a *candidate is expected to;*

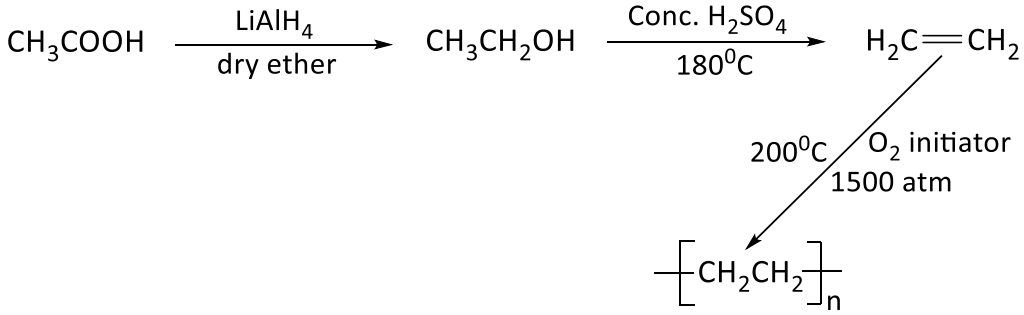
- *demonstrate understanding of physical property(ies) in relation to class(es)/ structure(s)/ nature of organic compound(s) by giving all explanations.*
- *analyse correctly the organic reaction using mechanisms*
- *evaluates correctly the synthetic pathways of organic reactions.*
- *evaluate applications of organic compounds in real-life contexts and clearly explains health/ societal /environmental impacts, proposing appropriate mitigation measures.*

Possible responses

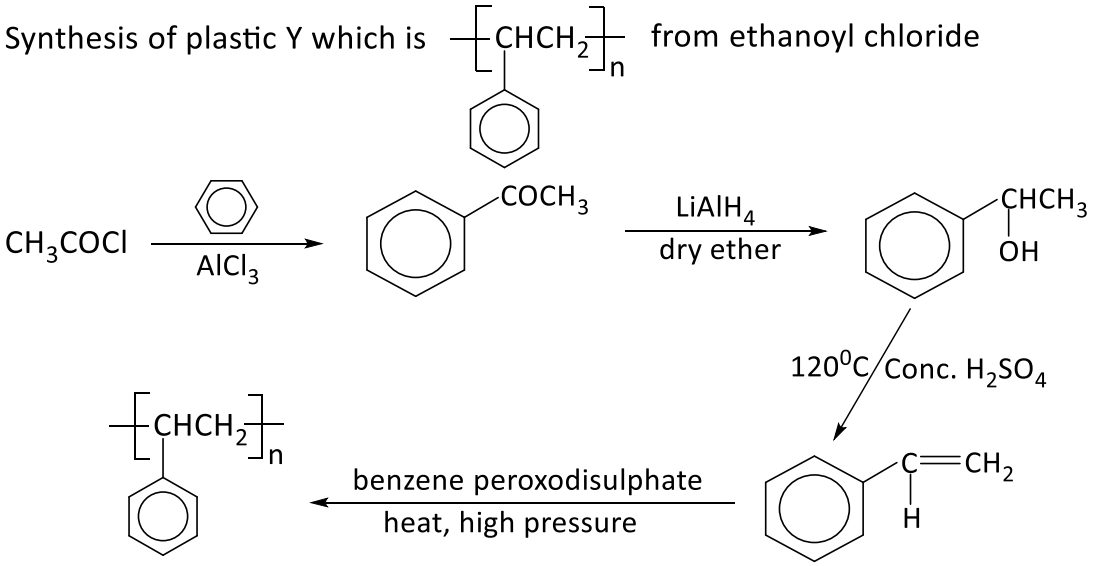
a) Explanation why plastic material does not easily decompose.
   - The material is generally stable due to strong carbon to carbon and carbon to hydrogen covalent bonds.
   - The material is insoluble in water since it is non-polar and yet most reactions occur in solution form.
   - The material has a high tensile strength due to a rigid structure that cannot easily break.

- The material is generally unreactive due to lack of defined functional group(s) and hence cannot be easily attacked by acids and bases in the environment or those produced by micro-organisms.

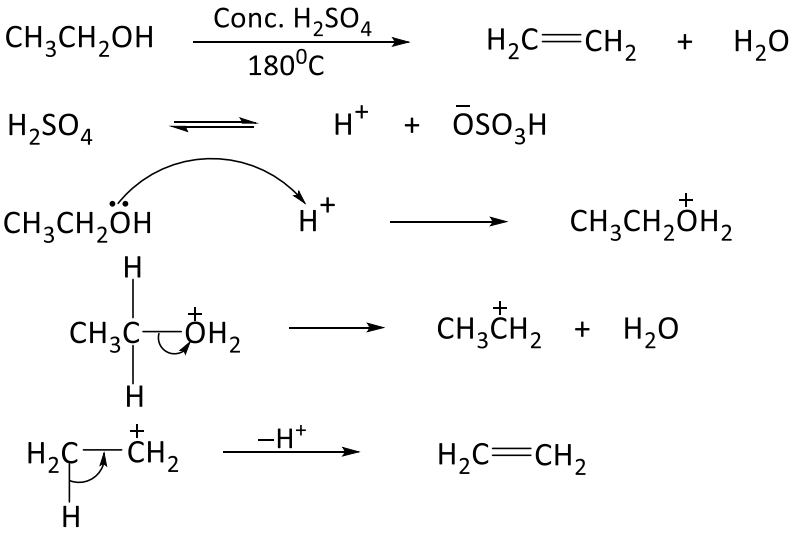
b) Understanding how plastic can be manufactured from vinegar as a raw material.



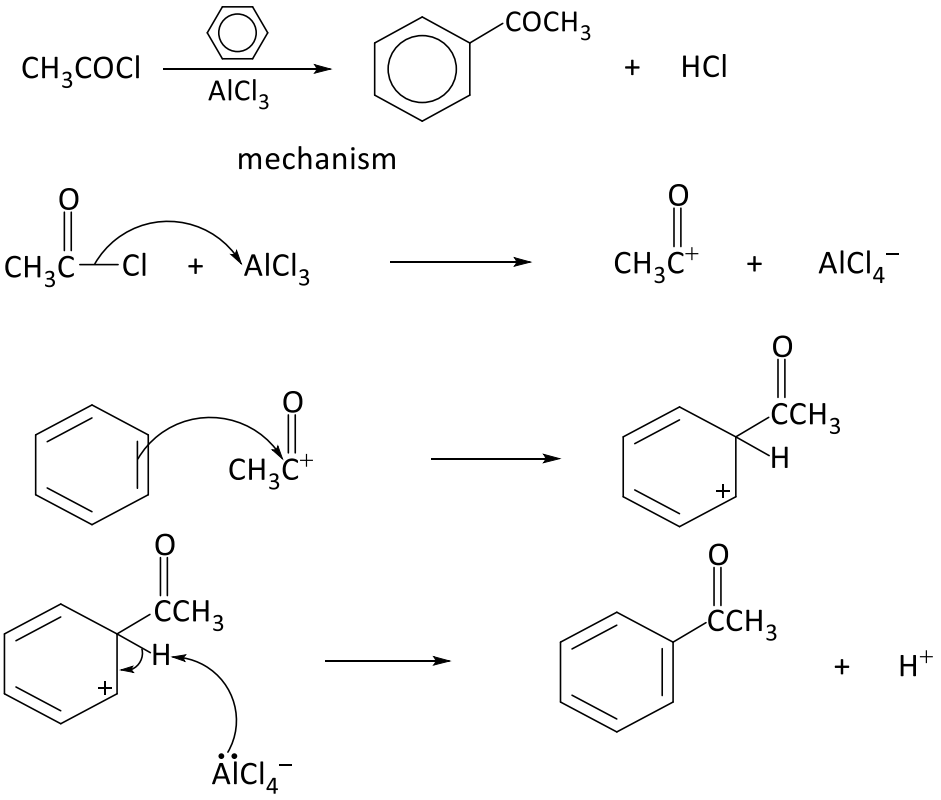
Ethanoic acid in vinegar is reduced to ethanol using lithium aluminium hydride in presence of dry ether.
Ethanol is then dehydrated using concentrated sulphuric acid at a temperature of 180 ^{0}C to form ethane.
Ethane then undergoes additional polymerization process to form polythene when exposed to an oxygen initiator at pressure of 150 atoms (high pressure) and temperature 200^{0}C (high temperature).



Mechanism for the reaction involved in formation of the monomer of plastic Q



Mechanism for the formation of the aromatic ketone



c) Evaluation of the impacts of the use of plastics **Q** and **Y**.

Application/Use/Advantage

The material is light/ of low density hence preferred as packaging material/ carrying items.

The materials have attractive appearance because they can easily be coloured and are used in such applications as wrapping materials for gifts.

Danger 1

They are not porous therefore, do not allow water penetration to occur, thus hindering drainage and water infiltration into soils for soil organisms that may die

Mitigation

The material should be recycled to avoid accumulation in the soil.

Danger 2

When Burnt, the materials release toxic fumes like carbon-monoxide as they have high carbon content and the fumes are toxic, causing suffocation and death.

Mitigation

Use of alternative packing materials that do not burn to release carbon monoxide/or burn the plastics in plentiful of oxygen for complete oxidation.

ITEM 6

To attain the highest level of achievement, a *candidate is expected to;*

- *demonstrate understanding of physical property(ies) in relation to class(es)/ structure(s)/ nature of organic compound(s) by giving all explanations.*
- *analyse correctly the organic reaction using mechanisms*
- *evaluate correctly the synthetic pathways of organic reactions.*
- *evaluate applications of organic compounds in real-life contexts and clearly explains health/ societal /environmental impacts, proposing appropriate mitigation measures.*

Possible responses

a) Compound A:

Cx Hy = 86

C_6 Hy = 86

(6 x 12) + y = 86

y= 14

Compound B:

Cx Hy = 92

C_7 Hy = 92

(7 x 12) + y = 92

y = 8

A is $CH_3CH_2CH_2CH_2CH_2CH_3$ Or Hexane

B is C_7H_8 Or Methylbenzene

Compound C

C_nH_{2n}+ 1OH = 46

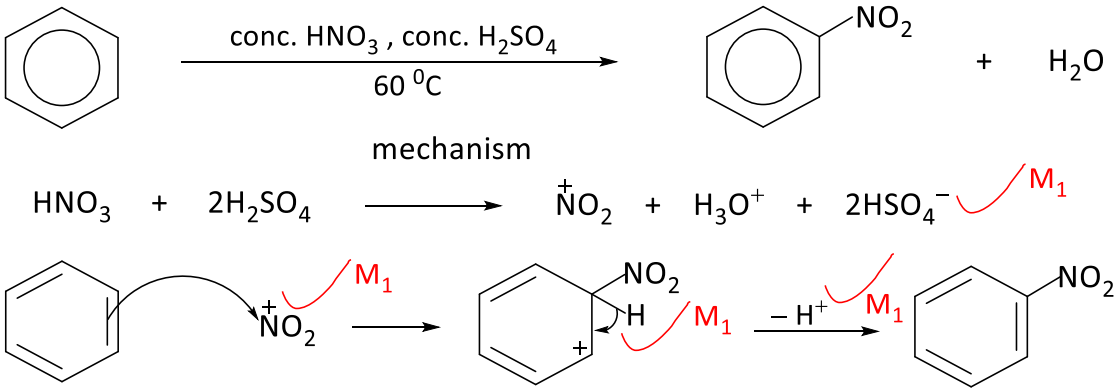
$12_n + 2_n + 1 + 16 + 1 = 46$

n = 2

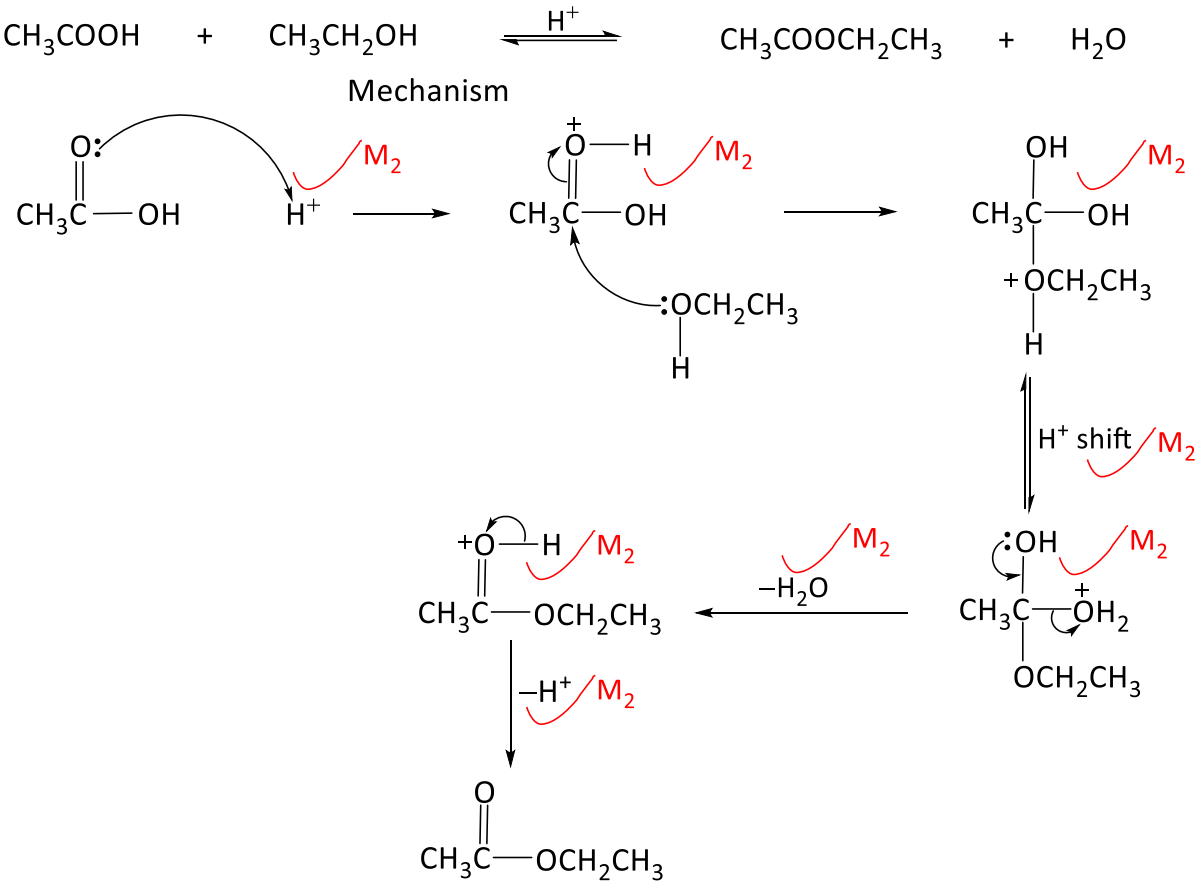
C is CH_3CH_2OH Or Ethanol

Compound **A** (hexane) and Compound **B** (Methylbenzene) are non-volatile polar solvents because there is a smaller difference in the electronegativity of carbon and hydrogen hence dissolve non polar organic compounds.
Compound **C** (Ethanol) is a polar solvent because oxygen is more electronegative than hydrogen hence dissolves polar compounds.
Hexane is the most suitable solvent because it dissolves a wide range of organic compounds and it's non-toxic compared to methylbenzene.

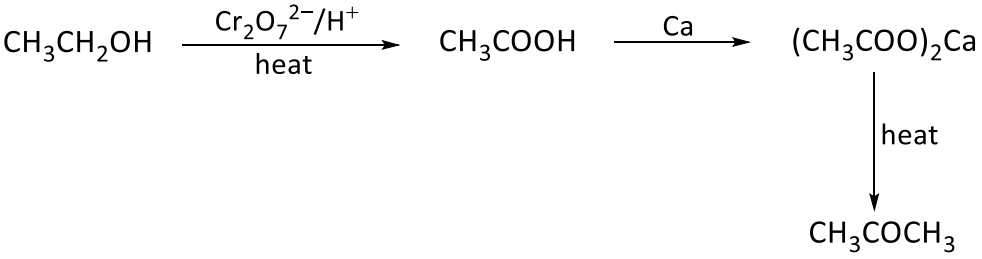
b) Production of nitrobenzene from benzene occurs as follows



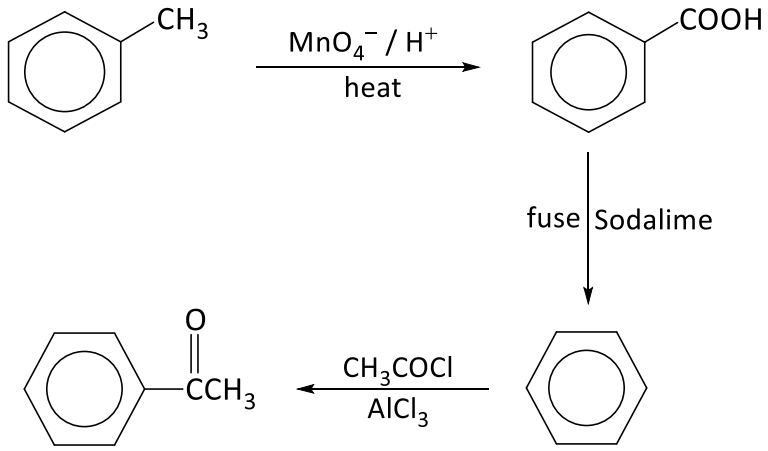
Production of ethyl ethanoate from compound C which is ethanol occurs by the following mechanism



Formation of propanone from ethanol



Formation of phenylethanone from compound B which is methylbenzene



c) Evaluation of the use of the organic compounds in the store.
Benzene and hexane are nonpolar and therefore used as solvents for many non polar organic compounds in the organic laboratories and in the manufacturing industries e.g. varnish.
Ethanol is polar and a common solvent in dissolving organic substances that are polar like drugs.
Dangers
Compound A is highly inflammable and can cause fire outbreaks. This can be mitigated by installing fire extinguishers in the factory to be used to prevent the spread of fires.

Compound B has a benzene ring and when inhaled cause blood cancers since benzene is highly carcinogenic, triggering uncontrolled cell division. This can be mitigated by wearing face masks to prevent inhalation of fumes.

Compound C (Ethanol); it is highly inflammable and can cause fires. This can be mitigated by installing fire extinguishers to be used to prevent spread of fires.