TERM 2 - 2023
CHEMISTRY – PAPER 1 (233/1)
FORM FOUR (4)
MARKING SCHEME

1. (a) What is radioactivity? (1 mark)

The process where an unstable nuclide breaks up to yield another nuclide of different composition with the emission of radiations and energy.

(b) The half-life of a radioisotope is 2.5 hours. If the initial radioactivity of the radioisotope is 800 counts per minute, how long will it take for the count to fall to 75 counts per minute? (2 marks)

$N=\left(\frac{1}{2}\right)^n N_0$

$75=\left(\frac{1}{2}\right)^n 800$

$\frac{75}{800}=\left(\frac{1}{2}\right)^n$

$Log\left(\frac{75}{800}\right)=Log\left(\frac{1}{2}\right)^n$

$\log\left(\frac{75}{800}\right)=n\log\left(\frac{1}{2}\right)$

$n=\frac{Log\left(\frac{75}{800}\right)}{Log\left(\frac{1}{2}\right)}$

$n=3.415$

$2.5\times3.415=8.54$ hours

2. a) Complete the table below to:
   - deduce the number of protons, electrons and neutrons in the magnesium atom and copper ions shown.
   - identify the atom or ion represented by the final row. (2 ½ marks)

	number of protons	number of electrons	number of neutrons
$^{25}_{12}Mg$	12	12	13
$^{65}_{29}Cu^{2+}$	29	27	36
$^{37}_{17}Cl^-$	17	18	20

(b) Give the meaning of the term **cation.** (½ mark)

A positively charged ion.

3. Calcium reacts with water to form two products. A colourless gas Q and an alkaline solution P.
   (a) Name colourless gas Q. (1 mark)

Hydrogen gas

(b) Give the ions responsible for making solution P alkaline. (1 mark)

Hydroxide ions or OH^-

(c) Write the chemical equation for the reaction. (1 mark)

$Ca\ (s) + 2H_2O\ (l) \rightarrow Ca(OH)_2\ (aq) + H_2\ (g)$

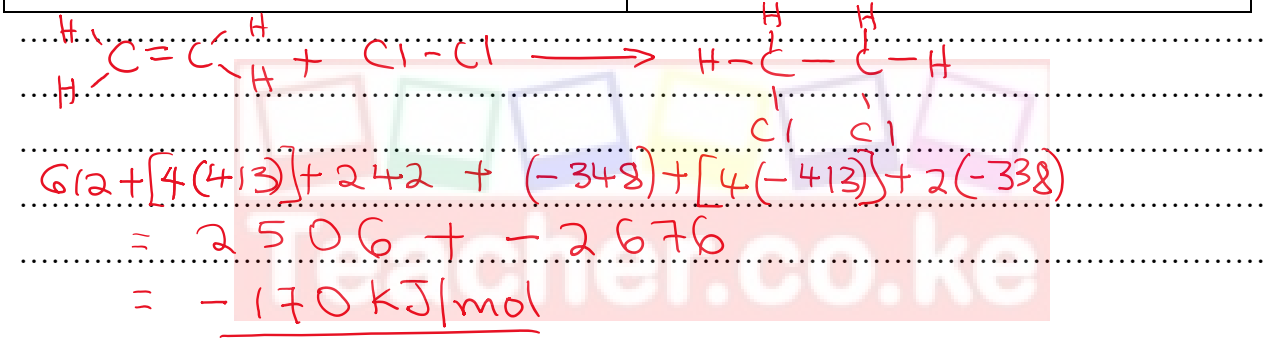
4. (a) Give the meaning of the term enthalpy of formation. (1 mark)

It is the energy change that occurs when one mole of a substance is formed from its constituent elements in their standard state.

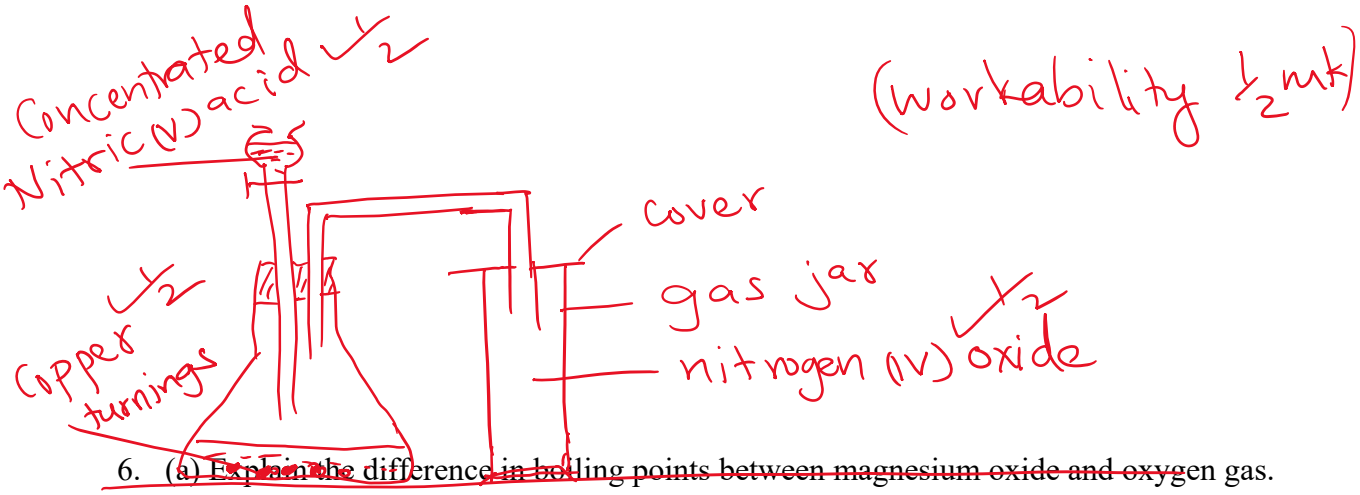
(b) Determine the enthalpy of the following reaction: (2 marks)

$C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$

Bond	Bond energy (kJ/mol)
C-C	348
C = C	612
Cl – Cl	242
C – Cl	338
C - H	413



5. Draw a set-up that can be used to prepare and collect nitrogen (IV) oxide in the laboratory. (2 marks)



6. (a) Explain the difference in boiling points between magnesium oxide and oxygen gas. (2 marks)

Magnesium oxide has a higher boiling point than oxygen gas. Magnesium has strong ionic bonds is a giant ionic structure that require a lot of heat energy to break. Oxygen has weak Van der Waals forces between the molecules that require less heat energy to break.

(b) Give the meaning of the term electron affinity. (1 mark)

It is the energy change that occurs when an atom gains an electron to form a negatively charged ion.

7. (a) Explain why it is not advisable to use potassium sulphate as a salt bridge in an electrochemical cell formed between the following half cells.

Pb(s) | Pb^{2+} (aq) $E^{\theta} = -0.13$ V and Cu (s) | Cu^{2+} (aq) $E^{\theta} = +0.34$ V (1 mark)

Lead (II) ions will react with sulphate ions to form a precipitate of lead (II) sulphate which will reduce the efficiency of the cell.

(b) Calculate the emf of the cell formed by combining the two half cells in (a) above.

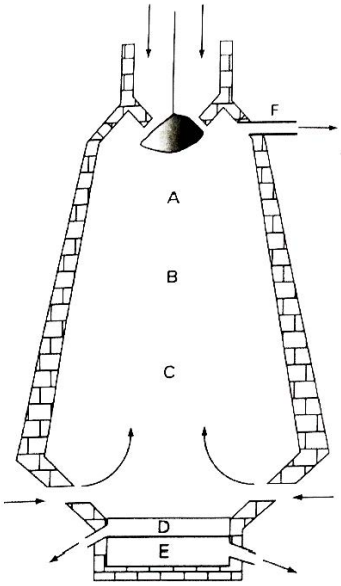
(2 marks)

$E_{cell} = E_{red} - E_{oxy}$

$= +0.34 - (-0.13)$

$= +0.47\ V$

8. The figure below shows the blast furnace for the extraction of iron.



(a) Give the name of the two substances coming from point F. (1 mark)

Carbon (II) oxide and carbon (IV) oxide.

(b) Write the equation for the reaction taking place at point B. (1 mark)

CO_2 (s) + C(s) → 2CO (g)

(c) The iron obtained from the blast furnace is impure. State how the impurities are removed from the molten iron. (1 mark).

Blowing air through the molten iron.

9. (a) Describe how sodium chloride can be prepared in the laboratory using direct synthesis method. (2 marks)

Heat a small piece of sodium metal on a deflagrating spoon until it just begins to burn. Quickly lower it into a gas jar full of chlorine gas. Sodium reacts with chlorine to form sodium chloride. Allow the set–up to cool. Collect the white solid of sodium chloride.

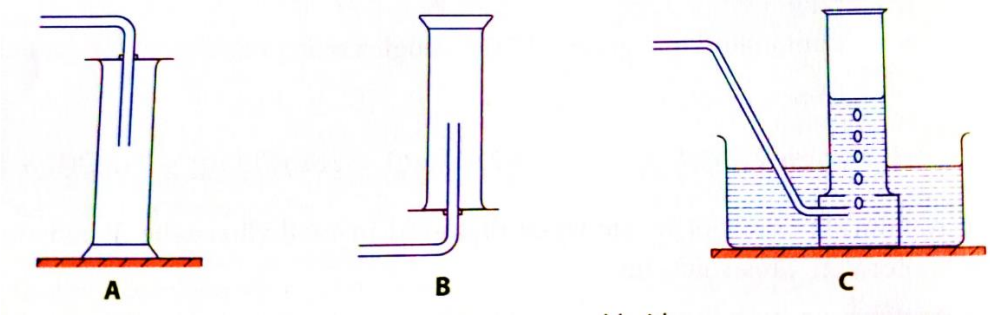
(b) Write an equation for the thermal decomposition of silver nitrate. (1 mark)

$2AgNO_3$ (s) → 2Ag (s) + $2NO_2$ (g) + O_2 (g)

10. When sulphur is heated, it melts into an amber-coloured liquid. On further heating, the liquid darkens and becomes viscous. Explain these observations. (3 marks)

Sulphur is made up of S_8 molecules. On heating the sulphur powder melts due to the breaking of the weak Van der Waal forces between the molecules to form an amber-coloured liquid. On further heating, the molecules break to form long chains that entangle making the liquid viscous and dark.

11. (a) The diagram below shows three methods of gas collection.



Which method of gas collection is most suitable for collecting dry chlorine gas? Explain. (1 mark)

Method A. This is because chlorine is denser than air.

(b) Why was the use of DDT as a pesticide banned? (2 marks)

DDT causes poisoning in animals and affects plants.

It also has a long life span because it is non-biodegradable.

(c) List two uses of hydrochloric acid. (1 mark)

- **Removing rust from metal. For example: de-scaling iron before it is galvanised, other metals before they are electroplated.**
- **Treatment of water (chlorination) at the water works.**
- **Sewage treatment.**
- **Making dyes, drugs and photographic materials such as silver chloride on photographic films.**
- **pH control and neutralisation in industries that require purity.**

12. In a titration, a student added 25.0 cm^3 of 0.200 mol / dm^3 aqueous sodium hydroxide to a conical flask. The student then added a few drops of methyl orange to the solution in the conical flask. Dilute sulphuric (VI) acid is then added from a burette to the conical flask.

The volume of dilute sulphuric (VI) acid needed to neutralise the aqueous sodium hydroxide was 20.0 cm^3.

(a) What is the colour of methyl orange in aqueous sodium hydroxide? (1 mark)

Yellow

(b) Calculate the concentration of sulphuric (VI) acid in mol/dm^3. (2 marks)

0.2 mole $\rightarrow$ $1000cm^3$
? $\rightarrow$ $25cm^3$ ✓½

$\frac{25 \times 0.2}{1000} = 0.005$ mol

Mole Ratio $NaOH : H_2SO_4$
$2 : 1$
$0.005 : x$

$x = \frac{0.005 \times 1}{2}$ ✓½

$= 0.0025$ moles of H_2SO_4

0.0025 moles $\rightarrow 20\ cm^3$
? $\rightarrow 1000\ cm^3$

$\frac{1000 \times 0.0025}{20}$ ✓½ $= 0.125M$

13. Determine the time it would take $300cm^3$ of oxygen to diffuse through a small aperture if it takes $500cm^3$ of nitrogen (I) oxide 475 seconds to diffuse through the same aperture under the same conditions of temperature and pressure. (N = 14, O = 16) (3 marks)

$M_{O_2} = 32$
$M_{N_2O} = 44$

$\frac{t_{O_2}}{t_{N_2O}} = \frac{\sqrt{M_{O_2}}}{\sqrt{M_{N_2O}}}$

$500cm^3 \rightarrow 475$ seconds
$300cm^3 \rightarrow ?$

$\frac{300 \times 475}{500} = 285$ seconds

$\frac{t_{O_2}}{285} = \frac{\sqrt{32}}{\sqrt{44}}$

$t_{O_2} = \frac{\sqrt{32} \times 285}{\sqrt{44}}$

$t_{O_2} = 243.0$ seconds

14. (a) Explain the 'strike back' phenomenon that occurs during the lighting of the Bunsen burner. (2 marks)

Striking back occurs when the Bunsen burner flame ignites from the bottom at the air hole during the lighting of the burner due to low gas pressure. It is dangerous because it may cause a fire accident.

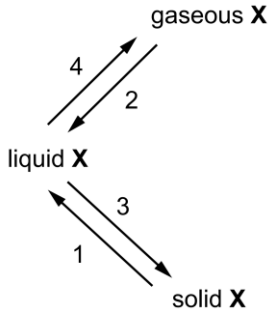
(b) What is the use of an aspirator in the laboratory? (1 mark)

An aspirator is used to pump gases or liquids into apparatus.

15. (a) What is the meaning of the term melting point? (1 mark)

It is the constant temperature at which a solid changes into a liquid.

(b) Element **X** undergoes the following physical changes.



(i) Name each of the numbered physical changes. (2 marks)

1 melting

2 condensation

3 freezing

4 evaporation/ boiling

(ii) Element **X** is a group III metal. Write an equation for the reaction of element X and oxygen gas. (1 mark)

$2X(s) + 3O_2(g) \rightarrow 2X_2O_3(s)$

16. (a) State and explain the observation made when iron nails are left outside the laboratory for two weeks during the rainy season. (2 marks)

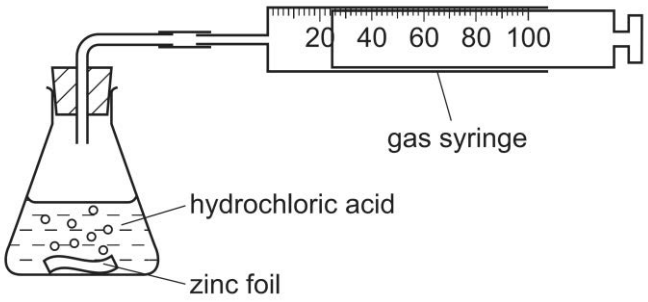
Observation: Iron nails will change to brown/ a brown coating will form on the nails.

Explanation: The nails will rust due to the reaction with moisture and oxygen in air.

(b) Give two uses of oxygen gas. (1 mark)

- **Oxygen mixed with helium is used by mountain climbers and deep sea divers.**
- **Oxygen mixed with acetylene (or hydrogen) is used to produce a very hot flame for welding and cutting metals.**
- **Air enriched with oxygen is used by patients with breathing difficulties.**
- **During steel making, iron is used to remove iron impurities.**
- **Used as one of the reactants in fuel cells.**
- **Used to burn fuels such as rocket fuel to propel rockets.**

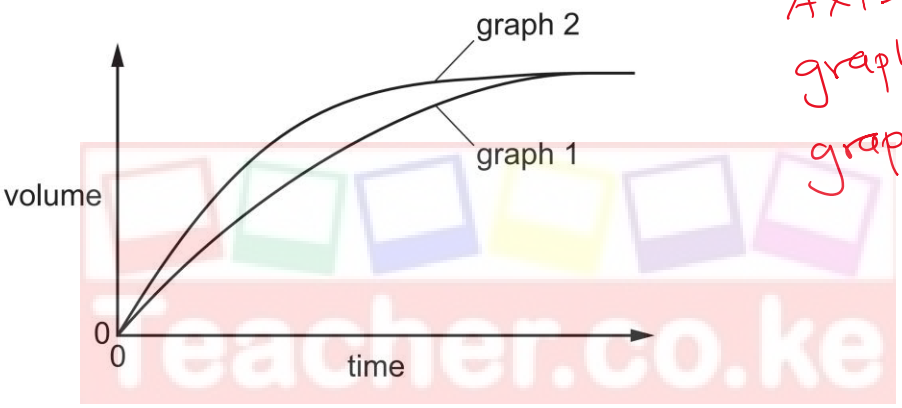
17. The rate of reaction between a metal and an acid can be investigated using the apparatus shown in the figure below.



A piece of zinc foil was added to 50 cm^3 of hydrochloric acid, of concentration 2.0 mol/dm^3. The acid was in excess. The hydrogen evolved was collected in the gas syringe and its volume measured every minute.

(a) Sketch a graph of volume against time for the reaction above. **Label it graph 1**.

(2 marks)



Axis - 1mark
graph 1 - 1mark
graph 2 - 1mark

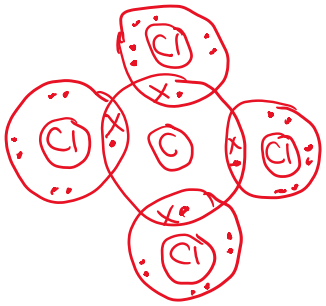
(b) On the same graph, sketch another graph that would be obtained if the experiment was repeated using the same amounts of reagents and copper (II) sulphate crystals added into the mixture. Label it **graph 2**. (1 mark)

18. (a) Suggest the structures and bonds of the following substances. (2 marks)

Substance	**Bonds**	**Structure**
Naphthalene	**Covalent**	**Simple molecular**
Copper	**Metallic**	**Giant metallic**

(b) Draw the dot (.) and cross (x) diagram to show bonding in tetrachloromethane.

(1 mark)



19. (a) Deduce the molecular formula of the alkanol whose molecular mass is 158. (1 mark)

$C_nH_{2n+1}OH$

$12n + 2n + 1 + 16 + 1 = 158$

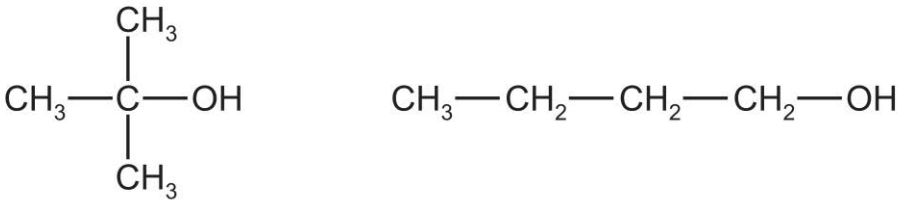
$14n + 18 = 158$

$\frac{14n}{14} = \frac{140}{14}$

$n = 10$

$\therefore C_{10}H_{21}OH$

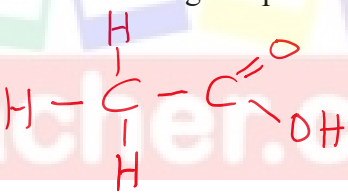
(b) Explain why the following alcohols are isomers. (1 mark)



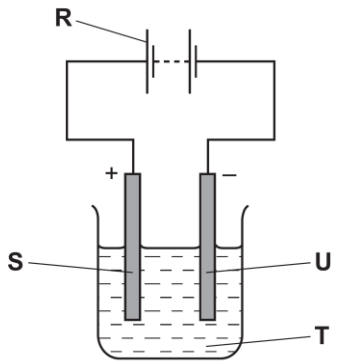
They have the same molecular formula but different structural formulae.

(c) Ethanol is oxidized by acidified potassium manganate (VII). Deduce the name and write the structural formula of the organic product. (1 mark)

Name: **ethanoic acid** Structure:



20. The diagram below shows the electrolysis of concentrated zinc (II) chloride solution.



(a) Which letter in the diagram, R, S, T, or U represents the cathode? (1 mark)

U

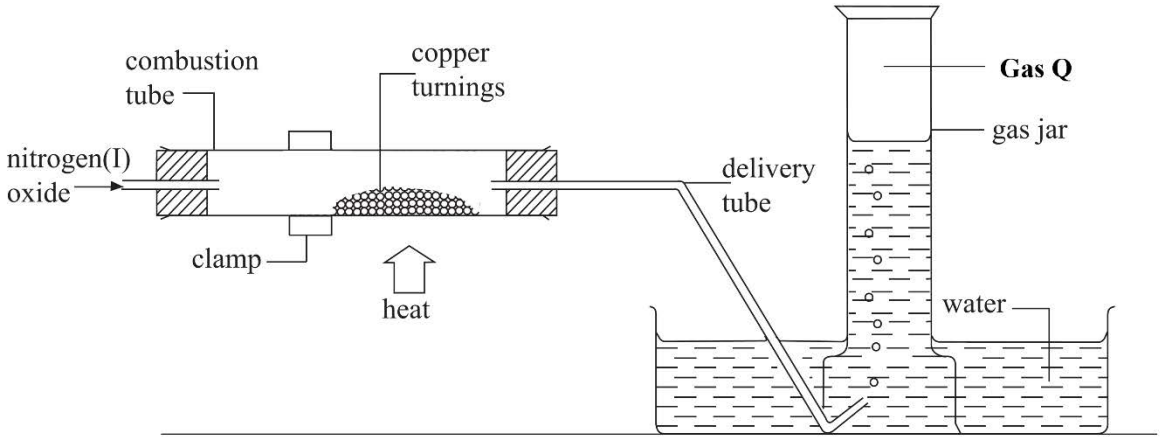
(b) Write the equation for the reaction that takes place at the anode. (1 mark)

$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

(c) What is electrolysis? (1 mark)

It is the process of decomposing an electrolyte by passing an electric current through it.

21. Study the diagram below and answer the following questions.



(a) Identify gas Q. (1 mark)

Nitrogen gas

(b) State and explain the observation made in the combustion tube. (1 mark)

Brown copper metal changes into black copper (II) oxide.

or

Brown solid changes into a black solid.

(c) Write the equation for the reaction that takes place in the combustion tube. (1 mark)

$Cu\ (s) + N_2O\ (g) \rightarrow CuO\ (s) + N_2\ (g)$

22. Water hardness is caused by dissolved minerals that contain calcium ions and magnesium ions.

(a) Give another method of removing permanent water hardness apart from distillation. (1 mark)

Use of ion exchanger

(b) 60 g of a saturated solution of salt W at 20°C was evaporated to dryness over a water bath and yielded 24g of solid. Calculate the solubility of the salt at 20°C. (2 marks)

Mass of Solvent = 60 - 24 = 36 g

24g of W → 36g of water

? → 100g of water

$\frac{100 \times 24}{36}$ = 66.67 g/100g of water

23. Use the enthalpy of the following reactions to answer the questions that follow.

H_2O (s) → H_2O (l) $\Delta H_1 = +6.02$ kJ/mol

MgO (s) → MgO (l) $\Delta H_2 = +77.4$ kJ/mol

(a) What is the name given to ΔH_1? (1 mark)

Molar heat of fusion.

(b) Explain the difference between ΔH_1 and ΔH_2. (2 marks)

The ΔH_1 is lower than ΔH_2 this is because more energy is required to weaken or break the strong ionic bonds in MgO than the weak Van der Waal forces between water molecules.

24. The Solvay process is used to manufacture sodium carbonate.

(a) Give two raw materials used in the Solvay process apart from brine. (1 mark)

- **Ammonia**
- **Limestone**
- **Coke**

(b) Explain why potassium carbonate cannot be manufactured by simply replacing the brine with potassium chloride in the Solvay process. (1 mark)

Potassium hydrogen carbonate that would be formed in the Solvay tower is very soluble in ammonium chloride and hence separation of the mixture is not possible by filtration.

(c) How is carbon (IV) oxide used as a refrigerant? (1 mark)

Dry ice is used in ice cream boxes because it sublimes keeping the ice cream cold.

25. The following table shows the **pH values** of some solutions.

Solution	**pH value**
A	2.1
B	4.5
C	13.5
D	7.0

(a) Name the indicator used to determine the pH values. (1 mark)

The universal indicator.

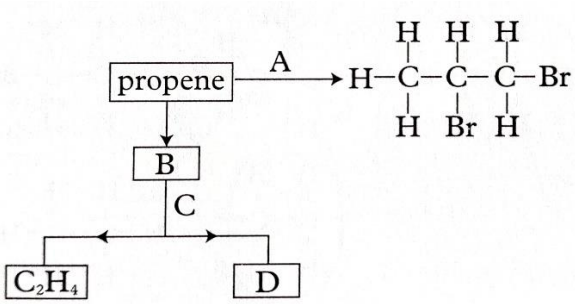
(b) Which solution is likely to react with ethanoic acid? (1 mark)

Solution C.

(c) 1 cm of magnesium ribbon was placed in separate beakers containing 2M solution **A** and 2M solution **B**. State and explain the difference in the observations made. (1 mark)

More effervescence is produced in the flask containing solution A than solution B. Solution A is strongly acidic while solution B is weakly acidic.

26. Study the scheme below and answer the questions that follow.



(a) Give the name of: (1 mark)

(i) Reagent **A**

Bromine

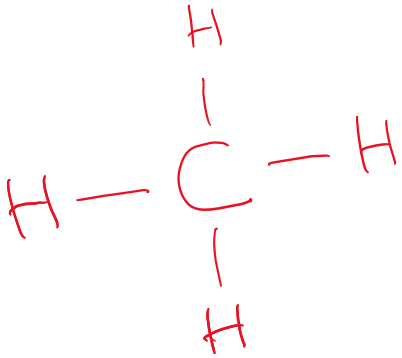
(ii) Process **C**

Cracking

(b) Write the equation for the reaction of 1 mole of **B** and 1 mole of chlorine gas. (1 mark)

$C_3H_8 + Cl_2 \rightarrow C_3H_7Cl + HCl$

(c) Draw the structure of substance **D**. (1 mark)



27. Describe how a mixture of silver chloride, magnesium chloride and iron (III) chloride can be separated in the laboratory. (3 marks)

Heat the mixture. Iron (III) chloride will sublime and it is collected on a cool surface. Add water to the remaining mixture and stir. Filter to obtain silver chloride as the residue. Heat the filtrate to saturation and allow it to cool to form crystals. Pour out the mother liquor and dry the crystals between filter papers.

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