KCSE 2024
CHEMISTRY PAPER 2
MARKING SCHEME

a) The grid below represents part of the periodic table. Study it and answer the questions that follow. The letters do not represent actual symbols of the elements

C				F	G		I	
						H		K
D	E							
							J	

i) Identify the most reactive non-metal. Explain (2 Marks)

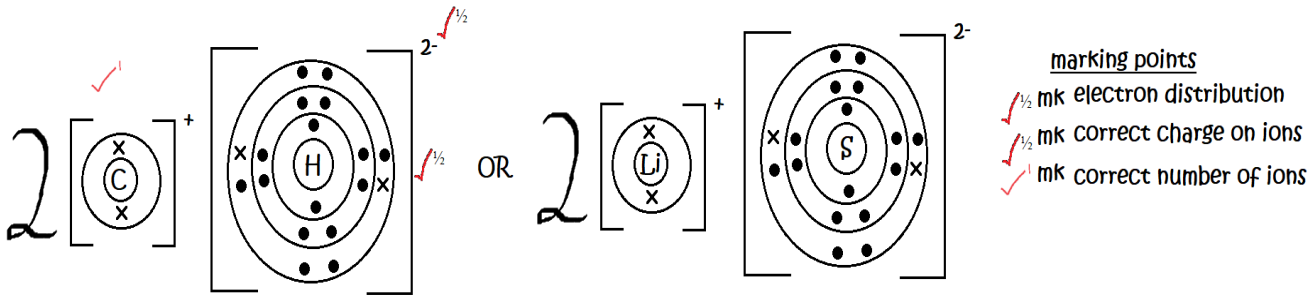
Element I. It has the smallest atom with the highest effective nuclear force of attraction.

[1 mk statement; 1 mk explanation]

ii) What is the name given to the family of elements to which **I** and **J** belong? (1 Mark)

Halogens **Reject: Group VII**

iii) Using dots (•) and crosses (×) to represent electrons, show bonding in the compound formed between **C** and **H**. (2 Marks)



marking points
- ½ mk electron distribution
- ½ mk correct charge on ions
- 1 mk correct number of ions

iv) How does the atomic radius of **F** compare with that of **I**? Explain. (2 Marks)

F is <u>larger</u> than I. F experiences a <u>lower effective nuclear force of attraction</u> on its energy levels hence more loosely held // F has <u>fewer protons for the same number of energy levels</u> as I hence its energy levels are more loosely held.

b) Study the table below and answer the questions that follow.

Substance	**M**	**N**	**O**	**P**	**Q**	**R**
Melting Point (°C)	801	1356	-101	26	-39	113
Boiling Point (°C)	1410	2850	-36	154	457	445
Electrical conductivity in solid state	Poor	Poor	Poor	Poor	Good	Poor
Electrical conductivity in molten state	Good	Poor	Poor	Poor	Good	Poor

i) Explain why **substance M** is a good conductor of electricity in the molten state but not in the solid state. (2 Marks)

It has a giant ionic structure. Its ions are held by strong ionic bonds in the solid state but these are weakened in the molten state to allow their movement.

ii) What is the most likely structure and bond in **substance N**? Explain. (2 Marks)

Structure **Giant covalent//Giant atomic** Bond **Covalent**

It has high melting point and boiling point and does not conduct electricity in the solid and in the molten state

[½mk each for structure and bond; 1mk for explanation]

iii) Identify, with a reason, a substance that exists as a liquid at room temperature. (2 Marks)

Q. Its melting point is below room temperature and its boiling point above room temperature.

1.

a)

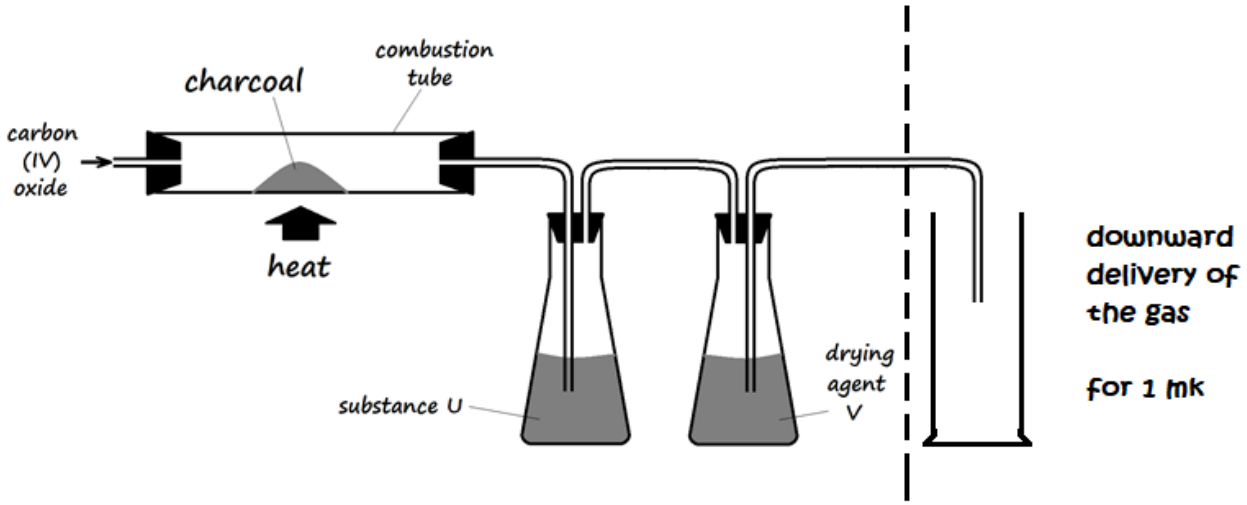
i) What name is given to different forms of an element which exist in the same physical state? (1 Mark)

Allotropes

ii) Name **two** crystalline forms of carbon (1 Mark)

Diamond **Graphite**

b) The figure below is part of a setup used to prepare and collect dry carbon (II) oxide from carbon (IV) oxide.



i) Complete the diagram to show how dry carbon (II) oxide gas is collected. (1 Mark)

ii) Identify:

- Substance **U** and state its use
  Concentrated sodium hydroxide solution // Concentrated potassium hydroxide solution
- Drying agent **Y**
  Concentrated sulphuric (VI) acid

iii) Write a chemical equation for the reaction which takes place in the combustion tube (1 Mark)

$$CO_{2\,(g)} + C_{(s)} \rightarrow 2CO_{(g)}$$

iv) Carbon (II) oxide is a major environmental pollutant.

- Give **one** major source of carbon (II) oxide in the atmosphere (1 Mark)
  Automobile exhaust fumes // Industrial emissions
- Explain how carbon (II) oxide causes poisoning (1 Mark)
  It forms stable carboxyhaemoglobin that prevents oxygen from reaching body cells to result in suffocation

c) State **one** use of carbon (II) oxide (1 Mark)

Used as a reducing agent in the extraction of metals from their ores
Used in the industrial production of methanol
A mixture of carbon (II) oxide and hydrogen is used as a fuel (water gas)
[the candidate's first answer for 1 mk]

d) Write an equation for the formation of water gas. (1 Mark)

$$C_{(s)} + H_2O_{(g)} \rightarrow CO_{(g)} + H_{2\,(g)}$$

[rules for writing chemical equations apply]

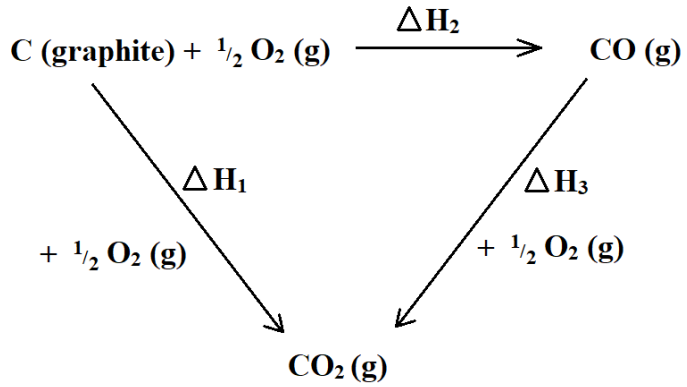
e) Explain why sodium hydroxide solution is not used in testing for carbon (IV) oxide gas, while calcium hydroxide is preferably used. (2 Marks)

Sodium hydroxide reacts with carbon (IV) oxide to form soluble sodium carbonate <u>hence no change in physical appearance</u>; while calcium

hydroxide can be used **reacts with carbon (IV) oxide to <u>form a white precipitate</u> which to detect the reaction.**

2.

a) Study the following energy cycle diagram and then answer the questions that follow.



i) Name the enthalpy change represented by ΔH_2. (1 Mark)

Heat of formation of carbon (II) oxide

ii) Use the following information to calculate the value of ΔH_1 for 144g of graphite. (2 Marks)

ΔH_2 = -110 kJ/mole ΔH_3 = -283kJ/mole

from energy cycle diagram

$\Delta H_2 = \Delta H_1 - \Delta H_3$

$\Delta H_1 = \Delta H_2 + \Delta H_3$ ✓1

$= -110 + (-283)$ ✓½

$= -393$ kJ/mole ✓½

b) The following are thermochemical equations for molar enthalpies of combustion for some substances. Study them and answer the questions that follow.

C_4H_{10} (g) + $\frac{13}{2}O_2$ (g) → 4CO_2 (g) + 5H_2O **ΔH^θ_c = -2877kJ/mole**

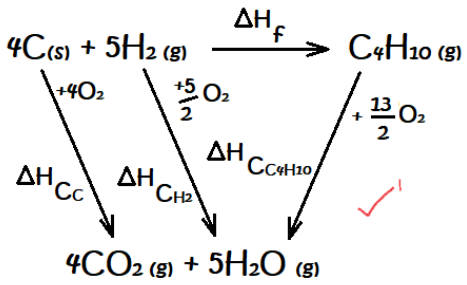
C (s) + O_2 (g) → CO_2 (g) **ΔH^θ_c = -399kJ/mole**

H_2 (g) + ½O_2 (g) → H_2O (l) **ΔH^θ_c = -286kJ/mole**

i) What is molar enthalpy of combustion of a substance? (1 Mark)

This is the enthalpy change that occurs when one mole of a substance is completely burnt in oxygen.

ii) Calculate the molar enthalpy of formation of butane (**C_4H_{10}**) using the information given above. (3 Marks)



from cycle diagram OR

$\Delta H_f = 4\Delta H_{Cc} + 5\Delta H_{CH_2} - \Delta H_{C_4H_{10}}$

$= 4(-399) + 5(-286) - (-2877)$

$= -149kJ/mole$

[1st mark either at correct energy cycle or at correct expression from cycle diagram]

[2nd mark at correct substitution of values; 3rd correct answer with units]

c) The following results were obtained in an experiment, to determine the heat of neutralization of 25cm³ of 2M sodium hydroxide solution, using 25cm³ of hydrochloric acid:

Initial temperature of acid	= 25.0°C
Initial temperature of alkali	= 26.0°C
Final temperature of mixture of acid + alkali	= 38.5°C
Density of solution	=1g/cm³
Specific heat capacity of solution	=4.2 J/g/K

i) Define molar heat of neutralization (1 Mark)

This is the enthalpy change that occurs when an acid and a base react to form <u>one mole of water</u>.

ii) Write an **ionic equation** for the neutralization reaction involving hydrochloric acid and sodium hydroxide solution. (1 Mark)

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

iii) Calculate:

- The enthalpy change during this experiment. (2 Marks)

$\Delta T = 38.5 - (\frac{25+26}{2}) = 13$ ½ **mass = volume = 25 + 25 = 50g** ½

$\Delta H = mc\Delta T = 50g \times 4.2\ J/g/K \times 13K$ ½ **= -2730J** ½

- The molar enthalpy of neutralization for this reaction (2 Marks)

<u>Moles H_2O</u>

Moles H_2O = moles NaOH

If 1000cm³ base contains 2 moles

Then 25cm³ base contains $\frac{25 \times 2}{1000}$ ½ **= 0.05 moles** ½

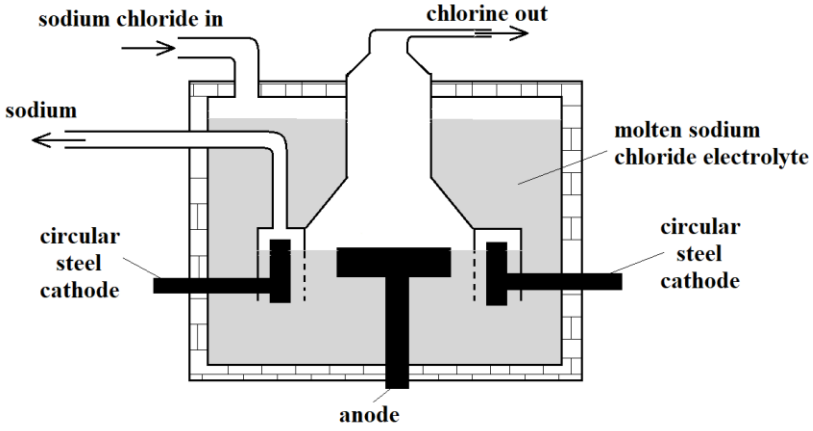
<u>Molar heat of neutral</u>

Since 0.05 moles of base evolves -2730 J

1 mole of base evolves = $\frac{1 \times -2730}{0.05}$ ½ **= - 54600J/mole = 54.6kJ/mole** ½

3.

a) Below is a simplified diagram of the Down's Cell, used for the manufacture of sodium. Study it and answer the questions that follow.



i) What material is the anode made of? Give the reason why that material is used. (2 Marks)

Carbon. It is inert and will therefore not react with the chlorine.

[1mk statement; 1mk explanation]

ii) What precaution is taken to prevent chlorine and sodium from re-combining? (1 Mark)

The anode is <u>surrounded by wire meshing</u> to prevent chlorine from coming in contact with the hot sodium metal.

iii) Write an ionic equation for the reaction in which chlorine gas is formed (1 Mark)

$$2Cl_{(l)} \rightarrow Cl_{2(g)} + 2e^-$$

b) In the Downs process, (used for manufacture of sodium), a certain salt is added to lower the melting point of sodium chloride from about 800°C to about 600°C.

i) Name the salt that is added. (1 Mark)

Magnesium chloride

ii) State why it is necessary to lower the temperature in **b)** above (1 Mark)

To lower the amount of energy required to maintain the electrolyte in the molten state [hence lower production cost].

c) Explain why aqueous sodium chloride is not suitable as an electrolyte for the manufacture of sodium in the Down's Process.
(2 Marks)

H^+ is preferentially discharged, and not Na^+ at the anode since $Na^+_{(aq)}$ requires a high potential.

The Na formed will also react explosively with water.

d) Sodium metal reacts with air to form two oxides. Give the formulae of the two oxides (1 Mark)

Na_2O Na_2O_2 Reject: Na_3N Reject names written in <u>words</u>.

e) State **two** uses of sodium (2 Marks)

The yellow glow of sodium is used in making fog-lights and street lamps

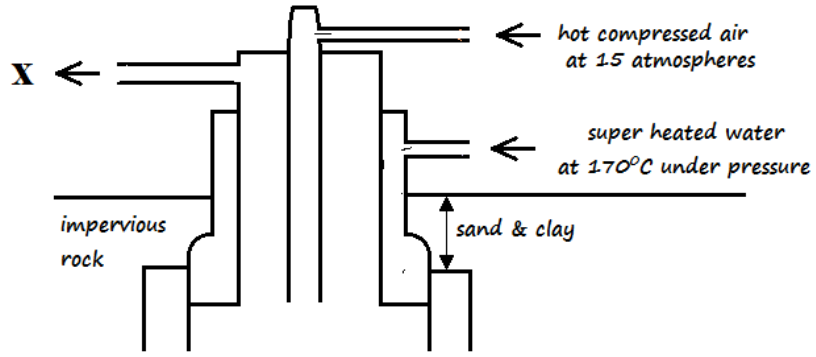
Sodium chloride is used as a food additive

It is used as a reducing agent in the extraction of titanium from its ore

[1st two of the candidate's answers]

4.

a) The diagram below shows part of the Frasch process, used for the extraction of sulphur. Use it to answer the questions that follow.



i) Identify **X** **molten sulphur and water** (1 Mark)

ii) Why is it necessary to use superheated water and hot compressed air in this process? (2 Marks)

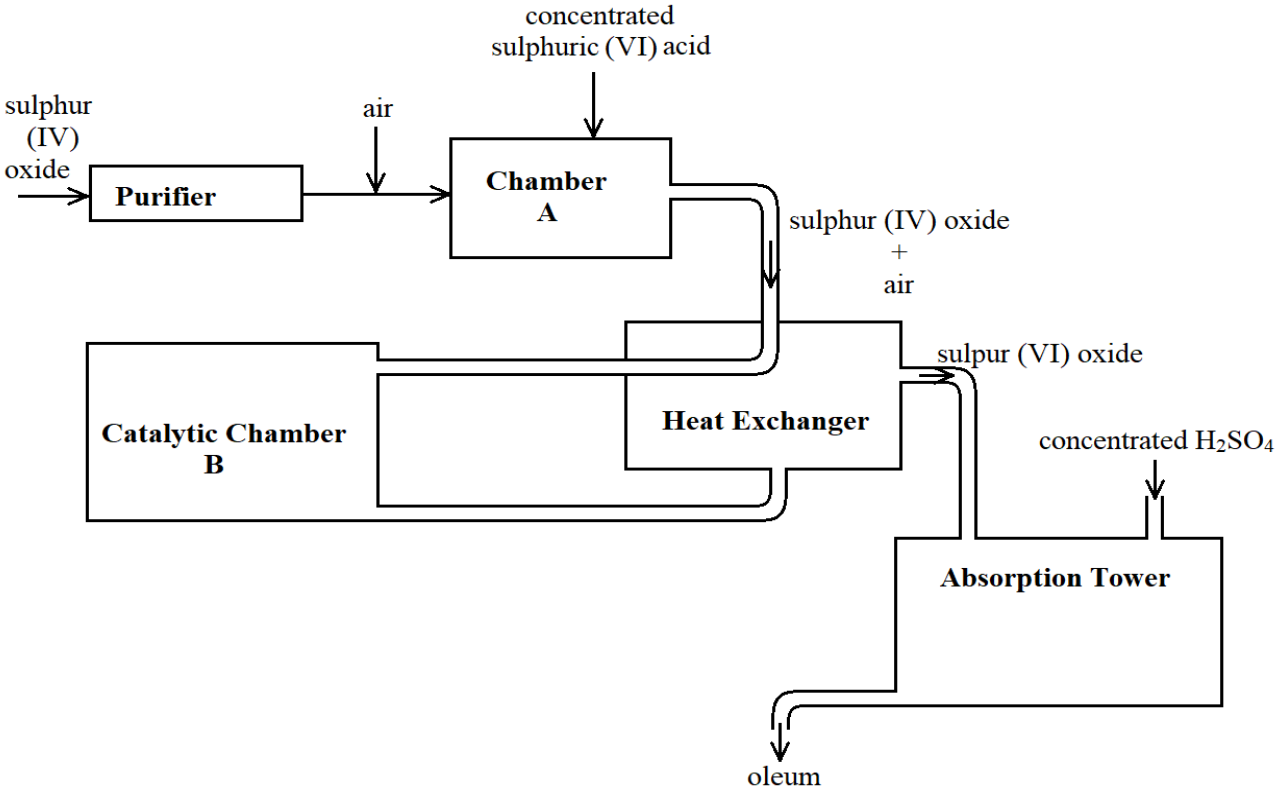
Superheated water melts the sulphur deposits while hot compressed air increases pressure in the sulphur deposit to push the molten sulphur up the middle concentric pipe.

iii) State **two** physical properties of sulphur that makes it possible for it to be extracted by this method. (2 Marks)

It does not does not dissolve in water

It has a low melting point // It melts easily

b) The diagram below shows part of the process in the manufacture of sulphuric (VI) acid. Study it and use it to answer the questions that follow.



i) Give **two** reasons why air is referred to as a mixture (2 Marks)

Its components can be separated by physical means

It does not have a specific melting and boiling point.

ii) What is the role of concentrated sulphuric (VI) acid in **Chamber A**? (1 Mark)

It dries the gas produced // It acts as a drying agent.

iii) Name **two** catalysts that can be used in the Catalytic **Chamber B**. (2 Marks)

Vanadium (V) oxide

Platinum

iv) State **two** roles of the heat exchanger (2 Marks)

It preheats the mixture of sulphur (IV) oxide and air before being taken to the catalytic chamber

It coo ls down the sulphur (VI) oxide prepared in the catalytic chamber

v) Describe the test for sulphite anion, SO_3^{2-} (2 Marks)

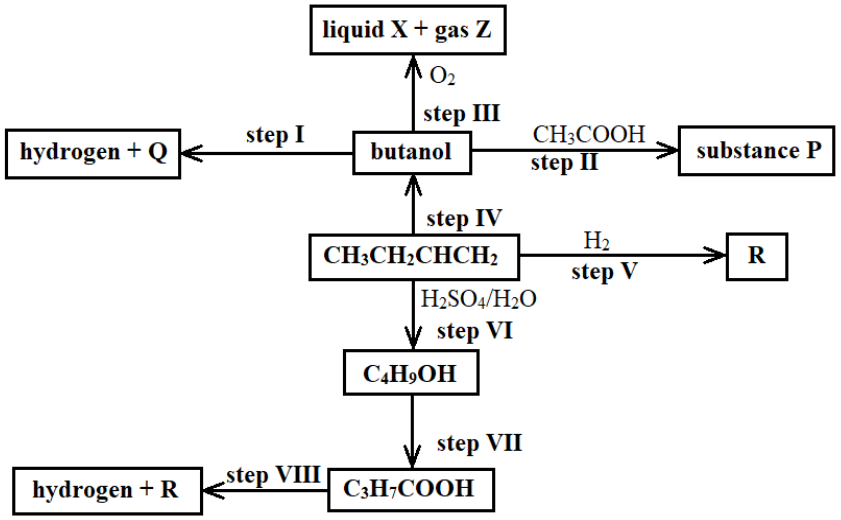
Add a few drops of barium nitrate solution to a small of the test substance. Add 1cm³ of hydrochloric acid to the resultant mixture. If a white precipitate that dissolves on addition of hydrochloric acid is observed, it indicates that sulphite ions are present.

[marking points are underlined, each scores ½ mark]

vi) Explain the observation made when a few drops of concentrated sulphuric (VI) acid are added to crystals of hydrated copper (II) sulphate. Explain your answer. (2 Marks)

The blue crystals turn to white. Blue hydrated copper (II) sulphate loses its water of crystallization and changes to white powder.

5. Study the reaction scheme below and answer the questions the follow:



i) What is the distinguishing physical property of **Substance P**? (1 Mark)

It has a pleasant smell **Reject: It has a sweet smell**

ii) Identify a suitable reagent that can be used in **Step I**. (1 Mark)

Sodium metal // Potassium metal

iii) Describe a chemical test on how **C_3H_7COOH** can be distinguished from **C_4H_9OH**. (2 Marks)

Put samples of the C_3H_7COOH and C_4H_9OH in separate test tubes. Add a spatula of sodium carbonate in both test tubes ✓¹. Effervescence of a colourless gas is observed in the test tube containing C_3H_7COOH ✓½ while no effervescence is observed in the test tube containing C_4H_9OH ✓½.

iv) Write an equation for the reaction that takes place in **Step III** (1 Mark)

$$C_4H_7OH_{(l)} + 6O_{2(g)} \rightarrow 4CO_{2(g)} + 4H_2O_{(l)}$$

[rules for writing chemical equations apply; state symbols may only be ignored if they have not been put completely; if one is stated the all MUST be included]

v) Name the types of reaction that occur in steps **II**, **III**, **V**, and **VII** (2 Marks)

II addition reaction **III combustion reaction**
V addition reaction **VII oxidation**

[hydrogenation, esterification etc are considered as processes and NOT types of reaction hence cannot answer the question of 'type of reaction']

vi) If 7.4g of butanol completely underwent Step III, determine the volume of gas Z produced at s.t.p. (MGV = 22.4 litres, C = 12, H = 1, O = 16) (3 Marks)

moles butanol

R.M.M. = 4(12) + 7(1) + 16 + 1
= 72

if 72g butanol is 1 mole
then 7.4g will be $\frac{7.4 \times 1}{72}$ ✓½
= 0.1028 moles (4sf) ✓½

moles CO_2

butanol : CO_2
1 : 4 ✓½
0.1028 : $\frac{0.1028 \times 4}{1}$ ✓½
= 0.4112 moles

volume CO_2

1 mole = 22.4L ✓½
0.4112 mole = $\frac{0.4112 \times 22.4}{1}$
= 9.211L ✓½

vii) Write an equation for the reaction between **R** and one mole of fluorine gas (1 Mark)

$$C_4H_{10(g)} + F_{2(g)} \rightarrow C_4H_9F_{(g)} + HF_{(g)}$$

viii) Describe a chemical test for **liquid X** (2 Marks)

Add a few drops of liquid X to white anhydrous ✓¹ copper (II) sulphate powder. The white powder turns to blue crystals ✓¹

OR

Add a few drops of liquid X to blue anhydrous cobalt (II) chloride powder. The blue powder turns to pink crystals.