CATHOLIC SCHOOLS NORTHERN ZONE
FORM FOUR JOINT EXAMINATION

032/1 **CHEMISTRY 1**

MARKING SCHEME **Year: 2025**

SECTION A (16 Marks)

1.

(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)
B	C	D	B	C	D	B	C	D	D

(10 marks)

2.

List A	(i)	(ii)	(iii)	(iv)	(v)	(vi)
List B	D	F	E	A	G	C

(06 marks)

SECTION B (54 Marks)

3. (a) (i) • Careful handling to avoid damage. Avoid dropping or applying excessive force.

• Proper storage. Away from liquid spills and heat **(01 mark)**

(ii) Because luminous flame is yellow in colour caused by incomplete combustion of fuel While non-luminous flame is blue in colour. **(01 mark)**

(iii) • Controlled variables are kept constant to isolate the effect of the independent variables

• Independent variables are manipulated to obtain different values for comparison.

• Dependent variables are measured to show outcome. **(03 marks)**

(b) (i) • Pure substances are homogeneous because their composition is uniform. **($00\frac{1}{2}$ marks)**

• Homogeneous substances are not pure because contains different substances which may interfere their purity. Example a homogeneous mixture of salt and water. **($00\frac{1}{2}$ marks)**

(ii)

Evaporation	Boiling
• Occurs at any temperature	Occurs at a definite temperature which is boiling point.
• Has cooling effect. Maintain body temperature and cool it when it gets too hot.	Has no cooling effect
• Takes place slowly	Takes place rapidly
• Occurs at the surface of the liquid	Occurs within a liquid with formation of bubbles.

(03 marks)

4. (a) (i) In Mendeleev's periodic table, elements were arranged in the order of increasing atomic weight, while in Modern periodic table, elements are arranged in the order of increasing atomic number. **($01\frac{1}{2}$ marks)**

(ii) Because fluorine is more electronegative than any other halogen. Hence it cannot be displaced by any halogen. **($01\frac{1}{2}$ marks)**

(iii) • Distilled water can dissolve the minerals in the body and cause health problems.

• Distilled water lacks essential minerals that are beneficial for health. **(02 marks)**

(b) (i) Oxygen is prepared from air through fractional distillation. **(01 mark)**
Air is first liquefied (cooled and compressed) to obtain liquid air. The liquid air is then warmed and passed through the fractionating column. In fractionating column, the component with low boiling point (like nitrogen) will be collected first, oxygen is collected later. **(01 mark)**

(ii) • Solar energy is intermittent. It is only obtained during daylight hours and is affected by weather conditions like cloud cover and rain.

• The initial costs for setting up solar energy systems can be high. **(02 marks)**

5. (a) (i) Because the sulphates or chlorides of calcium or magnesium in hard water become more soluble as the temperature increases. So, the precipitates are not formed during boiling.

(ii) Dissolved ions (like Ca^{2+} and Mg^{2+}) in hard water raises the boiling point of water.

(iii) This is because the ions responsible for electrical conductivity precipitate out as solid.

(iv) Soap doesn't initially form lather in hard water because the magnesium and calcium ions react with the soap anions to form insoluble precipitates (scum), consuming the soap. Lather forms later after adding enough soap to precipitate all Mg^{2+} and Ca^{2+} ions.

(v) Hard water contains essential minerals such as calcium and magnesium that are beneficial for plant growth and development. These minerals help to strengthen cell walls, promote photosynthesis, and improve nutrient uptake. **(05 marks)**

(b) (i) • Distillation is expensive in terms of energy maintaining and maintenance. **(01 mark)**
• If too much calcium hydroxide (lime water) is added, the pH of water increases leading to bitter taste (lowering quality of water), mineral buildup in pipes and reduced effectiveness of chlorine disinfection. **(01 mark)**

(ii) • Formation of temporary hard water (Dissolution of carbonate)

$H_2O(l) + CO_2(g) + CaCO_3(s) \longrightarrow Ca(HCO_3)_2(aq)$ **(01 mark)**

• Removal of temporary hardness in water by boiling (Precipitation of carbonate)

$Ca(HCO_3)_2(aq) \xrightarrow{\text{Heat}} \underset{\text{(Insoluble)}}{CaCO_3\ (s)} + H_2O\ (l) + CO_2(g)$ **(01 mark)**

6. (a) (i) Because H^+ and OH^- from water are the only ions that are discharged at electrodes.

(ii) Because the concentration of copper(II) ions (Cu^{2+}) in the solution decreases.

(iii) Because oxygen is more soluble in water than hydrogen. Some oxygen dissolves in water leading to lower volume of oxygen **(03 marks)**

(b) (i) **Data**: • Current, I = 2A • Time, t = 3 min = 180 seconds • Mass of B = 0.1184 g

From: Faraday First Law of Electrolysis, $m = \frac{Ar \times I \times t}{V \times F}$ **(01 mark)**

$$Ar = \frac{m \times V \times F}{I \times t} = \frac{0.1184\ g \times 2 \times 96500\ C/mol}{2A \times 180\ sec} = 63.48$$

Therefore, metal B is copper **(01 mark)**

(ii) **Data:** • Time (t) = 3 hours = 10800 seconds

• Current = 6.0 A

Required: Volume of oxygen gas produced and current for producing 12.36 dm^3 of the gas.

From: Faraday First Law of Electrolysis, $m = \frac{Ar \times I \times t}{V \times F}$ **(01 mark)**

$\frac{m}{Ar} = \frac{I \times t}{V \times F}$ $n = \frac{I \times t}{V \times F}$ (But, at STP; $n = \frac{Volume}{GMV}$)

$\frac{Volume}{GMV} = \frac{I \times t}{V \times F}$

$$Volume = \frac{GMV \times I \times t}{V \times F} = \frac{22.4\ dm^3/mol \times 6.0\ A \times 10800\ sec}{4 \times 9600\ C/mol} = 3.76\ dm^3$$

The volume of oxygen gas = 3.76 dm^3 **(01 mark)**

From: $\frac{Volume}{GMV} = \frac{I \times t}{V \times F}$ (Volume α Current, I) **(01 mark)**

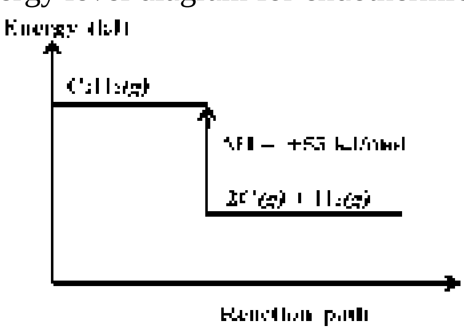
$3.76\ dm^3$ ✕ $6.0\ A$
$12.36\ dm^3$ ✕ X

$$X = \frac{12.36\ dm^3 \times 6.0\ A}{3.76\ dm^3} = 19.72\ A$$

The current for producing 12.36 dm^3 of oxygen gas = 19.72 A **(01 mark)**

7. (a) (i) The reaction was exothermic because the energy released during bond formation exceeded the energy required for bond breaking. **(02 marks)**

(ii) Energy level diagram for endothermic reaction



(02 marks)

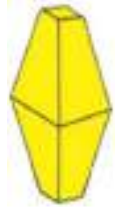
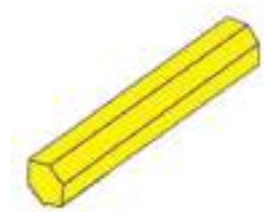
(b) (i) No, the reaction does not cease. This is because the equilibrium is dynamic. **(02 marks)**

(ii) Cooling will shift the equilibrium towards reactant side and cause the colour change from blue to pink. **(01 mark)**

(iii) • Heating the mixture

• Adding concentrated hydrochloric acid, HCl. **(02 marks)**

8. (a)

S/N	Property	Rhombic sulphur	Monoclinic sulphur
(i)	Shape	Octahedral 	Needle shaped 
(ii)	Melting point (^oC)	112	119
(iii)	Density (g/cm^3)	2.06	1.96

(03 marks)

(b) (i) $MnO_2(s) + 4HCl(l) \longrightarrow \underset{\text{Gas } \mathbf{Q}}{Cl_2(g)} + MnCl_2(aq) + 2H_2O(l)$ **(01 mark)**

(ii) Gas **Q** (chlorine gas) can be collected by the downward delivery method because is denser than air. **(01 mark)**

(iii) • Distilled water: Removes any acid spray and hydrogen chloride gas.
• Concentrated sulphuric acid: For drying the gas. **(01 mark)**

(iv) Gas **Q** cannot be collected over water because it is fairly soluble in water forming pale-yellow solution known as chlorine water.

$H_2O(l) + Cl_2(g) \longrightarrow HCl(aq) + HOCl(aq)$ **(01 mark)**

(v) **Data**: Mass of MnO_2 = 8.7 g

From the reaction: $MnO_2(s) + 4HCl(l) \longrightarrow Cl_2(g) + MnCl_2(aq) + 2H_2O(l)$

Number of moles of $MnO_2 = \frac{8.7\text{ g}}{87\text{ g/mol}} = 0.1\text{ mol}$ **(01 mark)**

MnO_2 : Cl_2
1 mol — 1 mol
0.1 mol — X mol   X = 0.1 mol of Cl_2

From: Number of moles = $\frac{V}{GMV}$

Volume = 0.1 mol x 22.4 dm^3 = 2.24 dm^3 of Cl_2

Therefore, the volume of gas Q, chlorine gas = 2.24 dm^3 **(01 mark)**

SECTION C (30 Marks)

9. (a) **Data:** $M_1 = 0.30$ M, $V_1 = 100$ cm^3, $M_2 = 0.50$ M, $V_2 = V$ and $M_d = 0.45$ M

From: $M_1V_1 + M_2V_2 = M_dV_d$ But, $V_d = V_1 + V_2 = 100$ cm^3 + V

Then, (0.30 M x 100 cm^3) + (0.50 M x V cm^3) = 0.45 M x (100 cm^3 + V)

30 + 0.50V = 45 + 0.45V V = 300

Therefore, the value of V = 300 cm^3 **(03 marks)**

(b) **To find the mass of carbon**

44 g of CO_2 : 12 g of carbon

0.451 g : X

$X = \frac{0.451 \text{ g x } 12 \text{ g}}{44 \text{ g}} = 0.123$ **(01 mark)**

To find the mass of hydrogen

18 g of H_2O : 2 g of H_2

0.0617 g : Y

$Y = \frac{0.0617 \text{ g x } 2 \text{ g}}{18 \text{ g}} = 0.0069$ g **(01 mark)**

Mass of chlorine = 0·250 g – (0.123 g + 0.0069 g) = 0.120 **(01 mark)**

To determine the empirical formula of the compound

Element	**C**	**H**	**Cl**
Mass	0.123	0.0069	0.120
Relative Atomic Mass (R.A.M)	12	1	35.5
Dividing mass by R.A.M	$\frac{0.123}{12} = 0.0103$	$\frac{0.0069}{1} = 0.0069$	$\frac{0.120}{35.5} = 0.0034$
Dividing by the smallest ratio	$\frac{0.0103}{0.0034} = 3$	$\frac{0.0069}{0.0034} = 2$	$\frac{0.0034}{0.0034} = 1$

The empirical formula of the solvent is C_3H_2Cl **(02 marks)**

$(C_3H_2Cl)n = 147$ $(36 + 2 + 35.5)n = 147$

$73.5n = 147$ $n = 2$

Molecular formula = (C_3H_2Cl) x 2 = $C_6H_4Cl_2$

Therefore, the molecular formula of the solvent is $C_6H_4Cl_2$ **(01 mark)**

(c) **Data**: • Mass of aluminium = 10.8 g • Mass of chlorine = 35.5 g

• Number of moles of aluminium = $\frac{10.8 \text{ g}}{27 \text{ g/mol}} = 0.4$ mol **($00\frac{1}{2}$ mark)**

• Number of moles of chlorine = $\frac{35.5 \text{ g}}{35.5 \text{ g/mol}} = 1$ mol **($00\frac{1}{2}$ mark)**

• Balanced equation: $2Al(s) + 3Cl_2(g) \longrightarrow 2AlCl_3(s)$ **(01 mark)**

(i) **For Al:**

$2Al$ $3Cl_2$

2 mol 3 mol

X mol 1 mol X = 0.667 mol

Present moles of Al = 0.4 mol

Needed moles of Al = 0.667 mol

For Cl_2:

$2Al$ $3Cl_2$

2 mol 3 mol

0.4 mol Y mol X = 0.6 mol

Present moles = 1 mol

Needed moles = 0.6 mol

Aluminium is the limiting reactant and chlorine is present in excess **(02 marks)**

(ii) The mass of product produced depends on the limiting reagent, aluminium

From the reaction: 2 mol of Al ≡ 2 mol of $AlCl_3$

0.4 mol ≡ X mol X = 0.4 mol of $AlCl_3$

∴ The grams of the product, $AlCl_3$ = 0.4 mol x 133.5 g/mol = 53.4 g **(02 marks)**

10. (a) **Data:** • Mass of impure iron = 0.2 g • Volume of HCl = 27 cm^3 = 0.027 dm^3

• Molarity of HCl = 0.3 M • Required: Percentage purity of iron

• Number of moles of HCl = 0.3 mol/dm^3 x 0.027 dm^3 = 0.0081 mol **(01 mark)**

• Balanced equation for the reaction between iron and hydrochloric acid

$2Fe(s) + 6HCl(aq) \longrightarrow 2FeCl_3(s) + 3H_2(g)$ **(01 mark)**

2 mol ≡ 6 mol

X mol ≡ 0.0081 mol $X = \frac{2 \text{ mol x } 0.0081 \text{ mol}}{6 \text{ mol}} = 0.0027$ mol **(01 mark)**

• Mass of pure iron = 0.027 mol x 56 g/mol = 0.1512 g **(01 mark)**

• Percentage purity of iron = $\frac{\text{Mass of pure iron}}{\text{Mass of impure iron}}$ x 100% = $\frac{0.1512 \text{ g}}{0.2 \text{ g}}$ x 100 % = 75.6 %

Therefore, the percentage purity of iron = 75.6 % **(01 mark)**

(b) **Data:** Va = 15.80 cm^3, Ma = 0.3 M, Vb = 25 cm^3, Mb = ?

• $Na_2CO_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$ (nb = 1 and na = 2) **($00\frac{1}{2}$ mark)**

• Concentration of hydrated salt, $Na_2CO_3 \cdot XH_2O = \frac{6.78 \text{ g}}{0.25 \text{ dm}^3} = 27.12$ g/dm^3 **($00\frac{1}{2}$ mark)**

• From: $\frac{MaVa}{MbVb} = \frac{na}{nb}$ $Mb = \frac{MaVanb}{Vbna} = \frac{0.3 \text{ M} \times 15.80 \text{ cm}^3 \times 1}{25 \text{ cm}^3 \times 2} = 0.0948$ M **(01 mark)**

• Concentration of Na_2CO_3 = 0.0948 mol/dm^3 x 106 g/mol = 10.0488 gdm^3 **(01 mark)**

• From: $\frac{\text{Molar mass of hydrated substance}}{\text{Molar mass of anhydrous substance}} = \frac{\text{Concentration of hydrated substance}}{\text{Concentration of anhydrous substance}}$ **(01 mark)**

$$\frac{\text{Molar mass of } Na_2CO_3 \cdot XH_2O}{\text{Molar mass of } Na_2CO_3} = \frac{\text{Concentration of } Na_2CO_3 . XH_2O}{\text{Concentration of } Na_2CO_3}$$

$\frac{(106+18X) \text{ g/mol}}{106 \text{ g/mol}} = \frac{27.12 \text{ g/dm}^3}{10.0488 \text{ g/dm}^3}$ 286.0759 = 106+ 18X, X = 10

The value of X in the hydrated salt, $Na_2CO_3 \cdot XH_2O$ = 10 **(01 mark)**

(c) **Data:** • Volume of base, Vb = 25 cm^3 • Volume of acid, Va = 30 cm^3

• Molarity of acid, Ma = 0.04 M • Concentration of base = $\frac{3.552 \text{ g}}{1 \text{ dm}^3}$ = 3.552 gdm^{-3}

• Balanced equation: $H_2SO_4(aq) + A(OH)_2(aq) \longrightarrow ASO_4(aq) + 2H_2O(l)$ **(01 mark)**

• From: $\frac{MaVa}{MbVb} = \frac{na}{nb}$ $Mb = \frac{MaVanb}{Vbna} = \frac{0.04 \text{ M} \times 30 \text{ cm}^3 \times 1}{25 \text{ cm}^3 \times 1} = 0.048$ M **(02 marks)**

• **To determine atomic mass of A and its IUPAC name**

From: Molarity = $\frac{\text{Concentraation in g/dm}^3}{\text{Molar mass (g/mol)}}$

Molar mass of base, $A(OH)_2 = \frac{\text{Concentration}}{\text{Molarity}} = \frac{3.552 \text{ g/dm}^3}{0.048 \text{ mol/dm}^3} = 74$ g/mol **(01 mark)**

Molar mass of $A(OH)_2$ = 74 g/mol

A + (16 + 1) x 2 = 74

A + 34 = 74

A = 74 – 34 = 40

Therefore, the atomic mass of A = 40 and its IUPAC name is Calcium **(01 mark)**

11. (a) (i) Due to ability of ethanoic acid to dimerize causing doubling in molar mass. The dimerization form stronger intermolecular forces of attraction.

(ii) The increase in size of alkyl group lead to increase in the number of covalent bonds.

(iii) When burning, ethane produces carbon dioxide gas which turns lime water milky.

(iv) Because of the limited number of carbon atoms which restrict branching. **(04 marks)**

(b) **Given**: The ratio of CO_2 and H_2O produced by combustion of hydrocarbon **T** ($\mathbf{C_xH_y}$) is 5:4.

The given information is represented by the equation below:

$C_xH_y + O_2(g) \longrightarrow 5CO_2(g) + 4H_2O(l)$

- In 5 moles of CO_2 there is 5 moles of carbon.
- In 4 moles of H_2O there is (2 x 4) moles of hydrogen.

So, the hydrocarbon **T** has 5 carbon atoms and 8 hydrogen atoms, **T** ($\mathbf{C_5H_8}$) **(01 mark)**

(i) • $H–C{\equiv}C–CH_2CH_2CH_3$ Pent-1-yne
• $CH_3C{\equiv}C–CH_2CH_3$ Pent-2-yne **(02 marks)**

(ii) The hydrocarbon **T** will show a positive test for unsaturation because it is unsaturated. The hydrocarbon **T** will decolourise the brown colour of bromine water

$$\underset{}{H–C{\equiv}C–CH_2CH_2CH_3} + \underset{\text{Brown}}{2Br_2} \longrightarrow \underset{\text{Colourless}}{H–\overset{Br}{\underset{Br}{C}}–\overset{Br}{\underset{Br}{C}}–CH_2CH_2CH_3}$$

(01 mark)

(c) **Given**: Molecular weight of brominated compound, $ZBr_2 = 188$

Reaction of **Z** with bromine: $Z + Br_2 \longrightarrow ZBr_2$

From: $ZBr_2 = 188$

$Z + Br_2 = 188$

$Z + 160 = 188$

$Z = 188 – 160 = 28$

Molecular weight of Z = 28 which is C_2H_4

(i)

Compound	**P**: Calcium carbide	**Y**: Ethyne	**Z**: Ethene
Structure	CaC_2	CHCH	CH_2CH_2

(03 marks)

(ii) $CaC_2(s) + 2H_2O(l) \longrightarrow CHCH(g) + Ca(OH)_2(aq)$ **(01 mark)**

(d) **Data**: • Mass of nitrogen, N = 160 kg • Mass of one bag of urea = 25 kg
• Number of urea bags = required

$CO(NH_2)_2$: N_2
60 g : 28 g
0.06 kg : 0.028 kg
X : 160 kg **(01 mark)**

$X = \frac{0.06 \text{ kg x } 160 \text{ kg}}{0.028 \text{ kg}} = 342.8571$ kg of urea **(01 mark)**

Number of bags $= \frac{\text{Mass of urea}}{\text{Mass of 1 bag}} = \frac{342.8571 \text{ kg}}{25 \text{ kg}} = 13.71 \approx 14$ bags

Therefore, the farmer has to buy 14 bags of urea fertilizer. **(01 mark)**