

G.C.E.(A.L.) Support Seminar - 2015
Chemistry I
Answer Guide

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Question number	Answer
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40	4
41	5
42	4
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45	2
46	4
47	4
48	1
49	2
50	1

2 × 50 = 100 marks

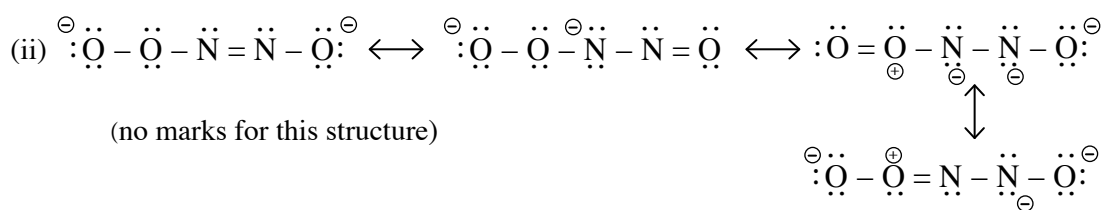
G.C.E.(A.L.) Support Seminar - 2015

Chemistry II

Answer Guide

PART A - STRUCTURED ESSAY

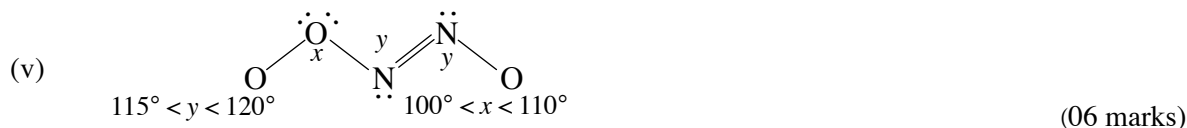
1. (a) (i) $\text{NH}_2^- < \text{N}_2\text{H}_4 < \text{NH}_2\text{OH}$
 (ii) $\text{O}_2 < \text{O}_3 < \text{H}_2\text{O}_2$
 (iii) $\text{SF}_6 < \text{SF}_4 < \text{SF}_2$
 (iv) $\text{Na} < \text{Zn} < \text{V}$
 (v) $\text{Al}(\text{OH})_3 < \text{Mg}(\text{OH})_2 < \text{Ba}(\text{OH})_2$ (06 × 5 = 30 marks)



(04 × 3 = 12 marks)

- (iii) O^2- - tetrahedral N^3- - trigonal planar (03 × 2 = 06 marks)

- (iv) N^4- - sp^2 O^5- - $\text{sp}^3 / 2\text{p}$ (03 × 2 = 06 marks)



- (c) (i) Lyman (05 marks)

- (ii) -36 and -327 kJ mol^{-1} (03 + 03 marks)

- (iii) $-36 - (-327) \text{ kJ mol}^{-1}$ (03 + 01 marks)
 = 291 kJ mol^{-1} (03 + 01 marks)

- (iv) Energy of a photon, $E = \frac{291 \text{ kJ mol}^{-1}}{6.022 \times 10^{23} \text{ mol}^{-1}} = 48.32 \times 10^{-23} \text{ kJ}$ (03 + 01 marks)

$$\nu = \frac{E}{h} \Rightarrow \nu = \frac{48.32 \times 10^{-23} \times 10^3 \text{ J}}{6.626 \times 10^{-34} \text{ J s}} = 7.29 \times 10^{14} \text{ s}^{-1} \quad (03 + 01 \text{ marks})$$

- (v) $E = 0 - (-1311) \text{ kJ mol}^{-1}$ (03 + 01 marks)
 = 1311 kJ mol^{-1} (03 + 01 marks)

2. (a) (i) (I) NH_3
 (II) $\text{NH}_3, \text{H}_2\text{S}, \text{HI}$
 (III) H_2S and HI (03 × 6 = 18 marks)
- (ii) (I) $\text{Na} + \text{H}_2\text{S} \longrightarrow \text{Na}_2\text{S} + \text{H}_2$ or
 $2\text{Na} + 2\text{NH}_3 \longrightarrow 2\text{NaNH}_2 + \text{H}_2$ or
 $2\text{Na} + 2\text{HI} \longrightarrow 2\text{NaI} + \text{H}_2$ or
 (excess) $2\text{H}_2\text{S} + 2\text{Na} \longrightarrow 2\text{NaHS} + \text{H}_2$
 (II) $\text{H}_2\text{S} + \text{Cl}_2 \longrightarrow 2\text{HCl} + \text{S}$ or
 $3\text{Cl}_2 + 2\text{NH}_3 \longrightarrow \text{N}_2 + 6\text{HCl}$ or
 $3\text{Cl}_2 + 8\text{NH}_3 \longrightarrow 2\text{N}_2 + 6\text{NH}_4\text{Cl}$ or
 $3\text{Cl}_2 + \text{NH}_3 \longrightarrow \text{NCl}_3 + 3\text{HCl}$ or
 $\text{Cl}_2 + \text{H}_2\text{S} \longrightarrow 2\text{HCl} + \text{S}$ or
 $\text{Cl}_2 + 2\text{HI} \longrightarrow \text{I}_2 + 2\text{HCl}$
 (III) $\text{SO}_2 + 2\text{H}_2\text{S} \longrightarrow 3\text{S} + 2\text{H}_2\text{O}$ (05 × 3 = 15 marks)
- (iii) $(\text{NH}_4)\text{I}$ (05 marks)
 covalent bonds
 ionic bonds
 dative bonds / dative covalent bonds / coordinate covalent bonds (02 × 3 = 06 marks)
- (iv) (I) NH_3
 (II) $\text{NH}_3, \text{H}_2\text{S}, \text{HI}$ (03 × 4 = 12 marks)
- (v) $(\text{NH}_4)_2\text{S} / \text{NH}_4\text{HS}$
 ammonium sulphide / ammonium hydrogensulphide / ammonium bisulphide (03 × 2 = 06 marks)
- (b) (i) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$
 $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$ (04 × 2 = 08 marks)
- (ii) Electron configuration of Zn is more stable. So, the ability to release electrons to the delocalised sea of electrons is low. Thus the strength of metallic bond is relatively low, and melting point of Zn is lower than that of other elements in 3d series.
 (02 × 3 = 06 marks)
- (iii) (I) Black precipitate is obtained. (02 + 2 = 04 marks)
 (II) Dark blue solution is formed. (02 + 2 = 04 marks)
- (iv) (I) hexaaquazinc(II) ion (04 marks)
 (II) octahedral (02 marks)
- (v) $7\text{Zn} + 16\text{HNO}_3 \longrightarrow 7\text{Zn}(\text{NO}_3)_2 + \text{N}_2\text{H}_4 + 6\text{H}_2\text{O}$ (10 marks)

3. (a) (i) $\text{H}_2\text{A}(\text{aq}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{HA}^-(\text{aq})$ or $\text{H}_2\text{A}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{HA}^-(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$ (05 marks)

$$K_a = \frac{[\text{H}_3\text{O}^+(\text{aq})][\text{HA}^-(\text{aq})]}{[\text{H}_2\text{A}(\text{aq})]} \quad \text{or} \quad K_{a_1} = \frac{[\text{H}^+(\text{aq})][\text{HA}^-(\text{aq})]}{[\text{H}_2\text{A}(\text{aq})]} \quad (05 \text{ marks})$$

(ii) point B (05 marks)

$$\begin{aligned} \text{(iii)} \quad [\text{H}_2\text{A}(\text{aq})] &= [\text{HA}^-(\text{aq})] \\ K_{a_1} &= [\text{H}^+(\text{aq})] \\ \text{pH} &= \text{p}K_{a_1} \\ K_{a_1} &= \text{antilog}(-3.0) \\ K_{a_1} &= 1 \times 10^{-3} \text{ mol dm}^{-3} \end{aligned} \quad (10 \text{ marks})$$

(iv) point C (05 marks)

	$\text{HA}^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{A}^{2-}(\text{aq})$
initial concentration(mol dm ⁻³)	0.05 — —
equilibrium concentration(mol dm ⁻³)	0.05 - x x x

$$K_{a_2} = \frac{[\text{H}_3\text{O}^+(\text{aq})][\text{A}^{2-}(\text{aq})]}{[\text{HA}^-(\text{aq})]}$$

$$5.0 \times 10^{-8} \text{ mol dm}^{-3} = \frac{[\text{H}_3\text{O}^+(\text{aq})]^2}{(0.05 - x) \text{ mol dm}^{-3}}$$

since $x \ll 0.05$;

$$(0.05 - x) \approx 0.05$$

$$[\text{H}_3\text{O}^+(\text{aq})]^2 = 25 \times 10^{-10} \text{ mol}^2 \text{ dm}^{-6}$$

$$[\text{H}_3\text{O}^+(\text{aq})] = 5 \times 10^{-5} \text{ mol dm}^{-3}$$

$$\text{pH} = -\log_{10}[\text{H}_3\text{O}^+(\text{aq})]$$

$$= -\log_{10}(5 \times 10^{-5})$$

$$= 4.301$$

(20 marks)

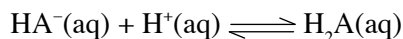
(v) point E (05 marks)

(vi) point B or point D (05 marks)

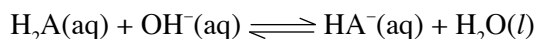
at point B

Solution contains H_2A and HA^- with the same concentration.

* When a small amount of H^+ is added



* When a small amount of OH^- is added



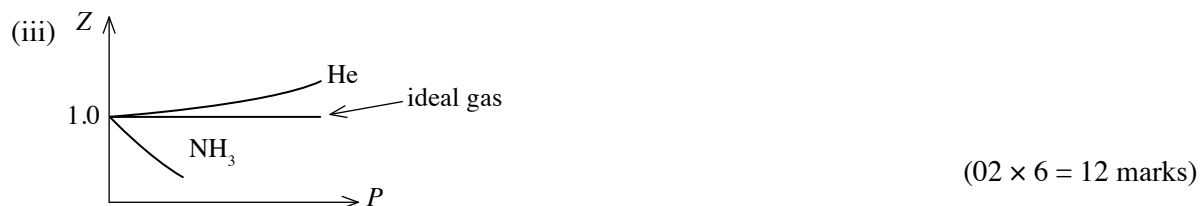
at point D

This can be explained by using HA^- instead of H_2A and A^{2-} instead of HA^- .

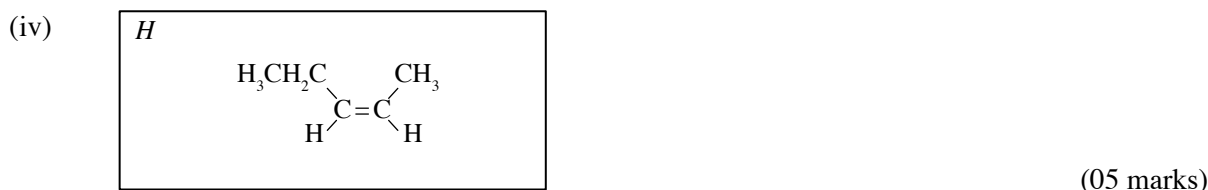
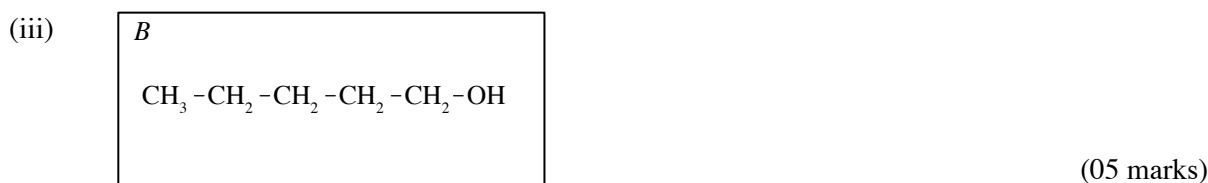
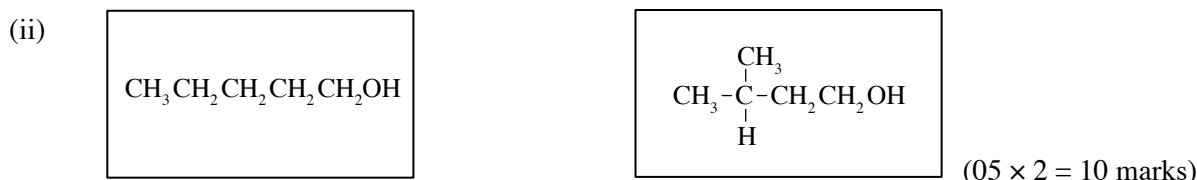
(10 marks)

(b) (i) The maximum temperature at which a gas can be converted to a liquid by compression. (06 marks)

(ii) $\text{He} < \text{CO}_2 < \text{NH}_3$ (05 marks)

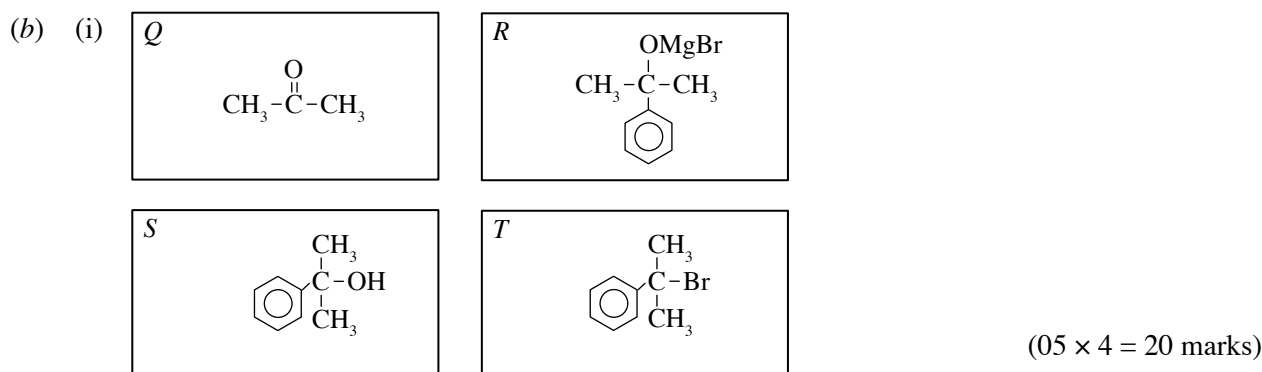


(iv) When the intermolecular attractive forces of a real gas are strong, Z value decreases, so the critical temperature increases. (07 marks)

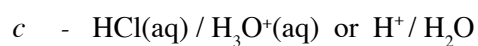
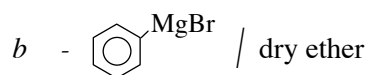


(v) geometrical isomerism / cis - trans isomerism (03 marks)

(vi) pent - 2 - ene or 2 - pentene (03 marks)



(ii) a - $\text{Hg}^{2+} / \text{HgSO}_4$ and dil. H_2SO_4



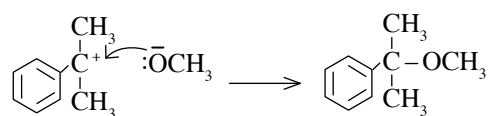
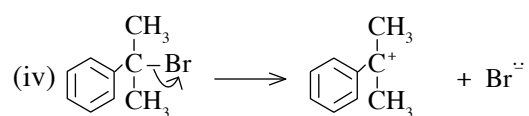
(03 × 4 = 12 marks)



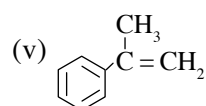
(iii)

Reaction	Type of reaction	Active species
1	A_E	H ⁺
2	A_N	 ⁽⁻⁾
3	O	-
4	S_N	Br ⁻
5	S_N	CH ₃ O ⁻

(01 × 10 = 10 marks)



(03 × 5 = 15 marks)



(05 marks)

(vi) as a base

(02 marks)

**

PART B - ESSAY

5. (a) (i) A solution which obeys Raoult's law for any composition

or

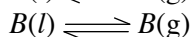
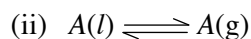
If the intermolecular forces of a binary solution prepared by completely mixing liquids

A and B are equal, i.e.

(06 marks)

$$f(A-B) = f(A-A) = f(B-B),$$

such a solution is an ideal solution.



(03 × 2 = 06 marks)

- (iii) Considering A, when rate of forward reaction is r_1 and rate of backward reaction is r_2 .

$$r_1 = K_1 [A(l)]$$

$$r_2 = K_2 [A(g)]$$

at dynamic equilibrium, $r_1 = r_2$

$$K_1 [A(l)] = K_2 [A(g)]$$

$$[A(l)] \propto X_A \text{ and } [A(g)] \propto P_A$$

$$\therefore K_1 X_A = K_2 P_A$$

$$P_A = \frac{K_1}{K_2} \cdot X_A$$

$$P_A = K \cdot X_A$$

(12 marks)

- (iv) when $x = 1$, $P_A = P_A^\circ$

$$\therefore P_A^\circ = K$$

$$P_A = P_A^\circ \cdot x_A$$

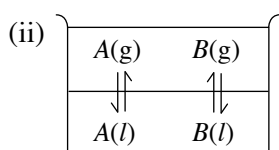
(06 marks)

(b) (i) number of moles of A, $n_A = \frac{0.8314 \text{ dm}^3}{8.314 \times 10^{-2} \text{ dm}^3 \text{ mol}^{-1}} = 10 \text{ mol}$

(04 marks)

number of moles of B, $n_B = \frac{0.8314 \text{ dm}^3}{4.157 \times 10^{-2} \text{ dm}^3 \text{ mol}^{-1}} = 20 \text{ mol}$

(04 marks)



$$X_{A(g)} = 0.2$$

assuming the ideal behaviour of the vapour,

$$P_A = X_{A(g)} \cdot P_T$$

$$= 0.2 (3 \times 10^5 \text{ Pa})$$

$$P_A = 6 \times 10^4 \text{ Pa}$$

(05 marks)

$$X_{A(g)} + X_{B(g)} = 1.0$$

$$\therefore X_{B(g)} = (1.0 - 0.2) = 0.8 \quad \text{or}$$

$$\therefore P_B = 0.8 (3 \times 10^5 \text{ Pa})$$

$$P_B = 2.4 \times 10^5 \text{ Pa}$$

$$P_B = P_T - P_A$$

$$= 3.00 \times 10^5 \text{ Pa} - 6.00 \times 10^4 \text{ Pa}$$

$$= 2.4 \times 10^5 \text{ Pa}$$

(05 marks)

(iii) $PV = nRT$

$$\text{for gas A} \Rightarrow n_A = \frac{6 \times 10^4 \text{ Pa} \times 100 \times 0.8314 \times 10^{-3} \text{ m}^3}{8.314 \text{ J mol}^{-1} \text{ K}^{-1} \times 300 \text{ K}} \quad (02 \text{ marks})$$

$$n_A = 2 \text{ mol} \quad (05 \text{ marks})$$

$$\text{for gas B} \Rightarrow n_B = \frac{2.4 \times 10^5 \text{ Pa} \times 100 \times 0.8314 \times 10^{-3} \text{ m}^3}{8.314 \text{ J mol}^{-1} \text{ K}^{-1} \times 300 \text{ K}}$$

$$n_B = 8 \text{ mol} \quad (05 \text{ marks})$$

(iv) at equilibrium;

$$n_A \text{ in liquid phase} = (10 - 2) \text{ mol} = 8 \text{ mol}$$

$$n_B \text{ in liquid phase} = (20 - 8) \text{ mol} = 12 \text{ mol} \quad (02 \text{ marks})$$

from Raoult's law,

$$P_A = P_A^\circ \cdot X_A \quad (02 \text{ marks})$$

$$6 \times 10^4 \text{ Pa} = P_A^\circ \times \frac{8}{20}$$

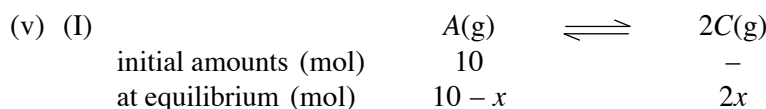
$$P_A^\circ = \frac{6 \times 10^4}{8} \times 20 \text{ Pa} = 1.5 \times 10^5 \text{ Pa}$$

$$P_A^\circ = 1.5 \times 10^5 \text{ Pa} \quad (05 \text{ marks})$$

$$P_B^\circ = \frac{P_B}{X_B}$$

$$= \frac{2.4 \times 10^5 \text{ Pa}}{12} \times 20$$

$$P_B^\circ = 4 \times 10^5 \text{ Pa} \quad (05 \text{ marks})$$



(02 marks)

$$PV = nRT$$

$$\frac{1.4 \times 10^6 \text{ Pa} \times 100.8 \times 0.8314 \times 10^{-3} \text{ m}^3}{8.314 \text{ J K}^{-1} \text{ mol}^{-1} \times 403.2 \text{ K}} = n \quad (03 \text{ marks})$$

$$n = 35 \text{ mol}$$

$$n_A + n_C + n_B = 35 \text{ mol}$$

$$10 - x + 2x + 20 = 35$$

$$x = 5 \text{ mol} \quad (04 \text{ marks})$$

$$P_A = P_T \cdot X_A$$

$$= 1.4 \times 10^6 \text{ Pa} \times \frac{5}{35}$$

$$= 2 \times 10^5 \text{ Pa} \quad (03 \text{ marks})$$

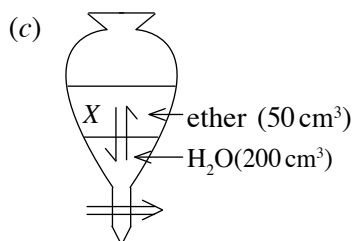
$$P_C = 1.4 \times 10^6 \text{ Pa} \times \frac{10}{35}$$

$$= 4 \times 10^5 \text{ Pa} \quad (03 \text{ marks})$$

$$P_B = 1.4 \times 10^6 \text{ Pa} \times \frac{20}{35}$$

$$= 8 \times 10^5 \text{ Pa} \quad (03 \text{ marks})$$

$$\begin{aligned}
 \text{(II)} \quad K_p &= \frac{P_c^2(\text{g})}{P_A} & (05 \text{ marks}) \\
 &= \frac{(4 \times 10^5 \text{ Pa})^2}{2 \times 10^5 \text{ Pa}} \\
 &= 8 \times 10^5 \text{ Pa} & (03 \text{ marks})
 \end{aligned}$$



(ii) for 1st extraction;

Let's assume that the number of moles of X remaining in H_2O is n_1 and number of moles of X extracted to ether is n_2 ;

$$16 = \frac{\frac{n_2}{50} \times 1000 \text{ mol dm}^{-3}}{\frac{n_1}{200} \times 1000 \text{ mol dm}^{-3}}$$

$$16 = \frac{n_2}{n_1} \times 4$$

$$\frac{n_2}{n_1} = \frac{4}{1} \quad (20 \text{ marks})$$

$\therefore$ Amount of X remaining in water after 1st extraction (as a fraction to the initial amount)

$$\begin{aligned}
 &= \frac{n_1}{n_1 + n_2} \\
 &= \frac{1}{4 + 1} = \frac{1}{5}
 \end{aligned}$$

$$\text{(iii) Amount of } X \text{ remaining in water after 3rd extraction (as a fraction)} = \frac{1}{5} \times \frac{1}{5} \times \frac{1}{5} = \frac{1}{125}$$

(15 marks)

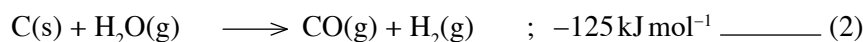
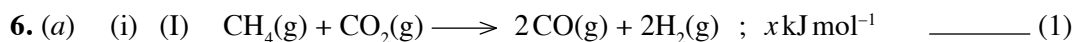
$$\begin{aligned}
 \therefore \text{Amount of } X \text{ extracted into the ether as a percentage} &= \frac{124}{125} \times 100\% \\
 &= 99.2\%
 \end{aligned}$$

(iv) (I) Ether and water are completely immiscible.

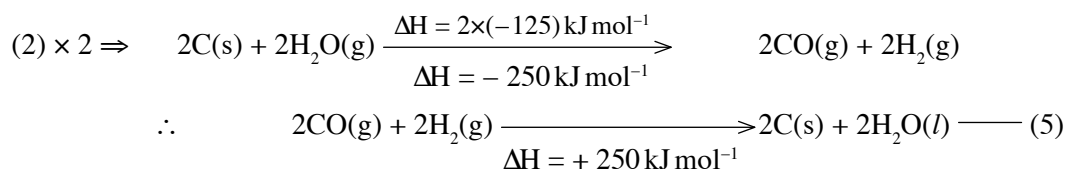
(II) X , exists in the same molecular form in both ether and water. (03 $\times$ 2 = 06 marks)

(III) Temperature remains constant.

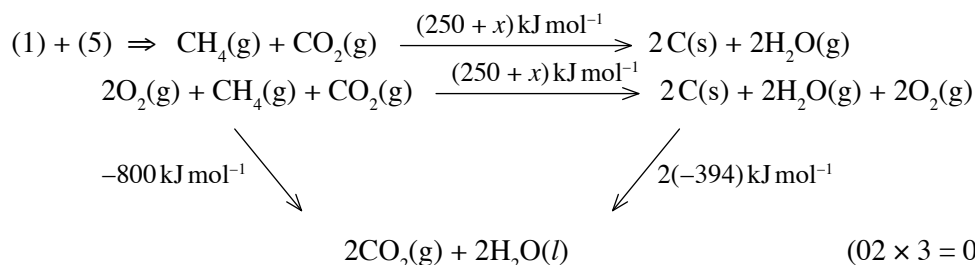
(any two)



(03 $\times$ 4 = 12 marks)



(02 × 3 = 06 marks)



from Hess's law ;

$$250 \text{ kJ mol}^{-1} + x + 2(-394) \text{ kJ mol}^{-1} = -800 \text{ kJ mol}^{-1} \quad (02 + 01 = 03 \text{ marks})$$

$$x = (-800 + 788 - 250) \text{ kJ mol}^{-1}$$

$$\underline{\underline{x = -262 \text{ kJ mol}^{-1}}} \quad (02 + 01 = 03 \text{ marks})$$

(b) (i) Initial number of moles of X = $\frac{2.0}{1000} \times 50 \text{ mol}$

$\therefore$ Number of moles of X reacted = $\frac{2.0}{1000} \times 50 \times \frac{20}{100} \text{ mol}$

$\therefore$ Rate of consumption of X = $\frac{2 \times 50 \times 20}{1000 \times 100} \times \frac{1000}{200} \times \frac{1}{4} \text{ mol dm}^{-3} \text{ s}^{-1} \quad (12 \text{ marks})$

= $0.025 \text{ mol dm}^{-3} \text{ s}^{-1}$

(ii) Rate of consumption of Y = $2(0.025) \text{ mol dm}^{-3} \text{ s}^{-1}$

= $0.05 \text{ mol dm}^{-3} \text{ s}^{-1} \quad (04 \text{ marks})$

(iii) $r = K [X]^x [Y]^y [Z]^z \quad (05 \text{ marks})$

(iv) $x = 1, y = 1, z = 0 \quad (09 \text{ marks})$

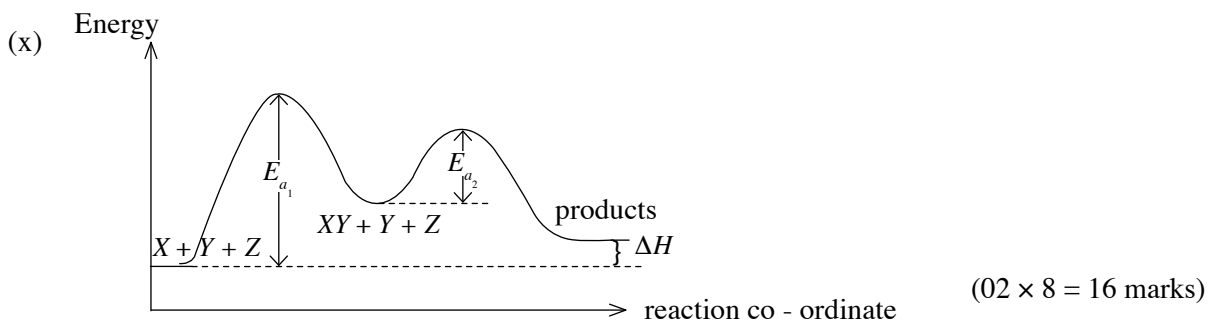
(v) $r = K [X] [Y] \quad (05 \text{ marks})$

(vi) Z is required. The reaction is zeroth order with respect to Z. Therefore Z is required for the reaction but it does not affect the rate of reaction. (Rate of reaction does not depend on Z) (06 marks)



(viii) molecularity is 2 (03 marks)

(ix) XY (06 marks)



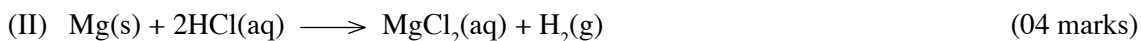
(c) (i) burette (03 marks)

- (ii) * Stopcock of the burette should be closed tightly.
 * Burette should be completely filled with HCl acid without air bubbles before starting the reaction. (03 × 2 = 06 marks)

(iii) (I) Assuming the ideal behaviour of H₂ gas and applying

$$PV = nRT \text{ for its average volume} \quad (02 \text{ marks})$$

$$n_{\text{H}_2} = \frac{1.0 \times 10^5 \text{ Pa} \times 33 \times 10^{-6} \text{ m}^3}{8.314 \text{ J mol}^{-1} \text{ K}^{-1} \times 300 \text{ K}} = 0.0013 \text{ mol} \quad (05 \text{ marks})$$



$$n_{\text{Mg}} = n_{\text{H}_2} = 0.0013 \text{ mol} \quad (04 \text{ marks})$$

(III) $n = \frac{m}{M}$ (for average mass)

$$0.0013 \text{ mol} = \frac{34 \times 10^{-3}}{M} \text{ g}$$

$$M_{\text{Mg}} = 26.15 \text{ g mol}^{-1}$$

(Deduct 05 marks if average values are not taken)

$$\therefore A_r(\text{Mg}) = 26.15 \quad (12 \text{ marks})$$

- (iv) There is a small change.
 Leak in burette.
 Impurities in magnesium ribbon.
 Errors when making measurements. (02 × 2 = 04 marks)

- (v) Difficult
 Errors can arise when measuring the volume of H₂ when the reaction proceeds faster. (04 marks)

- (vi) Do not agree
 When 100.0 mg of Mg is used, percentage error in the mass of Mg can be reduced.
 But other errors remain unchanged. (06 marks)

- (ii) (I) with Na - a, b, c, d
with aqueous NaOH - a, d

(10 marks)

PART C - ESSAY

8. (a) (i) $A = \text{Al}$
 $B = \text{AlCl}_3$
 $C = \text{Al(OH)}_3$
 $D = \text{Al}_2\text{O}_3$
 $E = \text{NaAlO}_2 / \text{Na[Al(OH)}_4\text{]}$
 $F = \text{H}_2$

(03 × 6 = 18 marks)

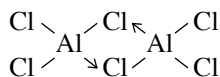
- (ii) $\text{Al}_2\text{O}_3 + 2\text{NaOH} \longrightarrow 2\text{NaAlO}_2 + \text{H}_2\text{O}$
or
 $\text{Al}_2\text{O}_3 + 2\text{NaOH} + 3\text{H}_2\text{O} \longrightarrow 2\text{Na[Al(OH)}_4\text{]}$

(05 marks)

- (iii) AlCl_3 is hydrolysed as follows.
 $\text{AlCl}_3 + 3\text{H}_2\text{O} \rightleftharpoons \text{Al(OH)}_3 + 3\text{HCl}$
or
 $\text{AlCl}_3 + 3\text{H}_2\text{O} \rightleftharpoons \text{Al(OH)}_3 + \text{H}^+ + \text{Cl}^-$
HCl is a strong acid.

∴ It is completely ionized in solution and $\text{H}^+ / \text{H}_3\text{O}^+$ concentration is higher in the medium.
(10 marks)

- (iv) AlCl_3 dimerizes as follows

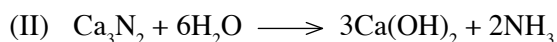


(07 marks)

- (b) (i) $E = \text{O}_2 / \text{oxygen}$
 $Q = \text{N}_2 / \text{nitrogen}$
 $R = \text{Ca} / \text{calcium}$
 $L = \text{CaO} / \text{calcium oxide}$
 $T = \text{Ca(OH)}_2 / \text{calcium hydroxide}$
 $U = \text{Ca}_3\text{N}_2 / \text{calcium nitride}$
 $V = \text{NH}_3 / \text{ammonia}$

(03 × 7 = 21 marks)

- (ii) (I) $3\text{Ca} + \text{N}_2 \longrightarrow \text{Ca}_3\text{N}_2$



(05 × 2 = 10 marks)

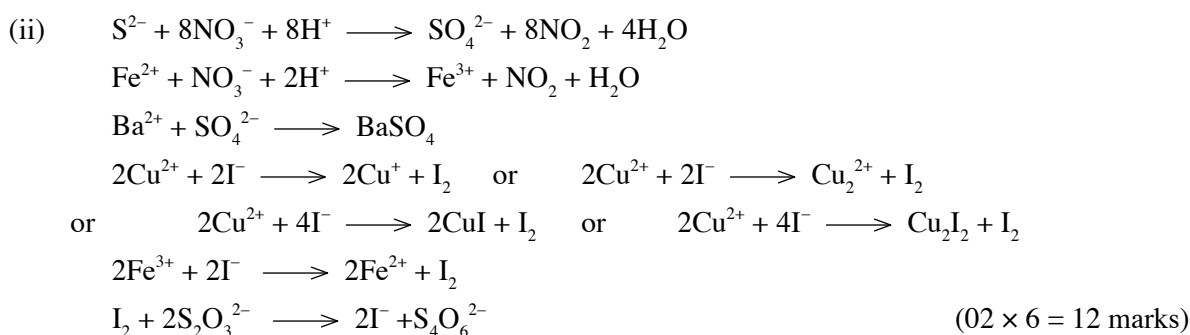
- (iii) to produce slaked lime
to produce calcium carbide
to reduce acidity of soil
to produce bleaching powder
to neutralise acidic gases
to construct buildings / to make mortar
(any one)

(03 marks)

to produce fertilizers containing nitrogen
 to produce HNO_3 acid
 to produce nylon/polymers
 to neutralise acidic substances in petroleum industry
 to control pH of water
 to neutralise SO_2 produced by combustion of fuel in motor vehicles
 as a coolant
 to prevent coagulation of rubber
 to produce sodium carbonate
 (any two)

(06 marks)

- (c) (i) $X = \text{BaSO}_4$ / barium sulphate
 $Y = \text{CuI} / \text{Cu}_2\text{I}_2$ / copper(I) iodide / cuprous iodide (03 × 2 = 06 marks)



(iii) amount of moles of $\text{BaSO}_4 = \frac{0.1864 \text{ g}}{233 \text{ g mol}^{-1}}$
 $= 0.0008 \text{ mol}$
 amount S in the sample $= 0.0008 \times \frac{250}{25} \text{ mol}$
 $= 0.008 \text{ mol}$
 mass of S $= 0.008 \text{ mol} \times 32 \text{ g mol}^{-1}$
 $= 0.256 \text{ g}$
 mass percentage of S $= \frac{0.256 \text{ g}}{1.000 \text{ g}} \times 100$
 $= 25.6\%$ (12 marks)

amount of moles of $\text{CuI} = \frac{0.0381 \text{ g}}{190.5 \text{ g mol}^{-1}}$
 $= 0.0002 \text{ mol}$
 amount Cu in the sample $= 0.0002 \times \frac{250}{25} \text{ mol}$
 $= 0.002 \text{ mol}$
 mass of Cu $= 0.002 \text{ mol} \times 63.5 \text{ g mol}^{-1}$
 $= 0.127 \text{ g}$
 mass percentage of Cu $= \frac{0.127 \text{ g}}{1.000 \text{ g}} \times 100$
 $= 12.7\%$

(18 marks)

$$\text{amount of S}_2\text{O}_3^{2-} = \frac{0.0400 \times 20.00}{1000} \text{ mol}$$

$$\text{amount of I}_2 = \frac{0.0400 \times 20.00}{1000 \times 2} \text{ mol}$$

$$= 0.0004 \text{ mol}$$

$$\text{amount of I}_2 \text{ generated by Cu}^{2+} = \frac{0.002 \text{ mol}}{2}$$

$$= 0.0001 \text{ mol}$$

$$\therefore \text{amount of I}_2 \text{ generated by Fe}^{3+} = (0.0004 - 0.0001) \text{ mol}$$

$$= 0.0003 \text{ mol}$$

$$\therefore \text{amount of Fe}^{3+} \text{ in } 25.00 \text{ cm}^3 = 0.0003 \text{ mol} \times 2$$

$$= 0.0006 \text{ mol}$$

$$\text{amount Fe in the sample} = 0.0006 \times \frac{250}{25} \text{ mol}$$

$$= 0.006 \text{ mol}$$

$$\text{mass of Fe} = 0.006 \text{ mol} \times 56 \text{ g mol}^{-1}$$

$$= 0.336 \text{ g}$$

$$\text{mass percentage of Fe} = \frac{0.336 \text{ g}}{1.000 \text{ g}} \times 100$$

$$= 33.6\%$$

(22 marks)

alternative method :

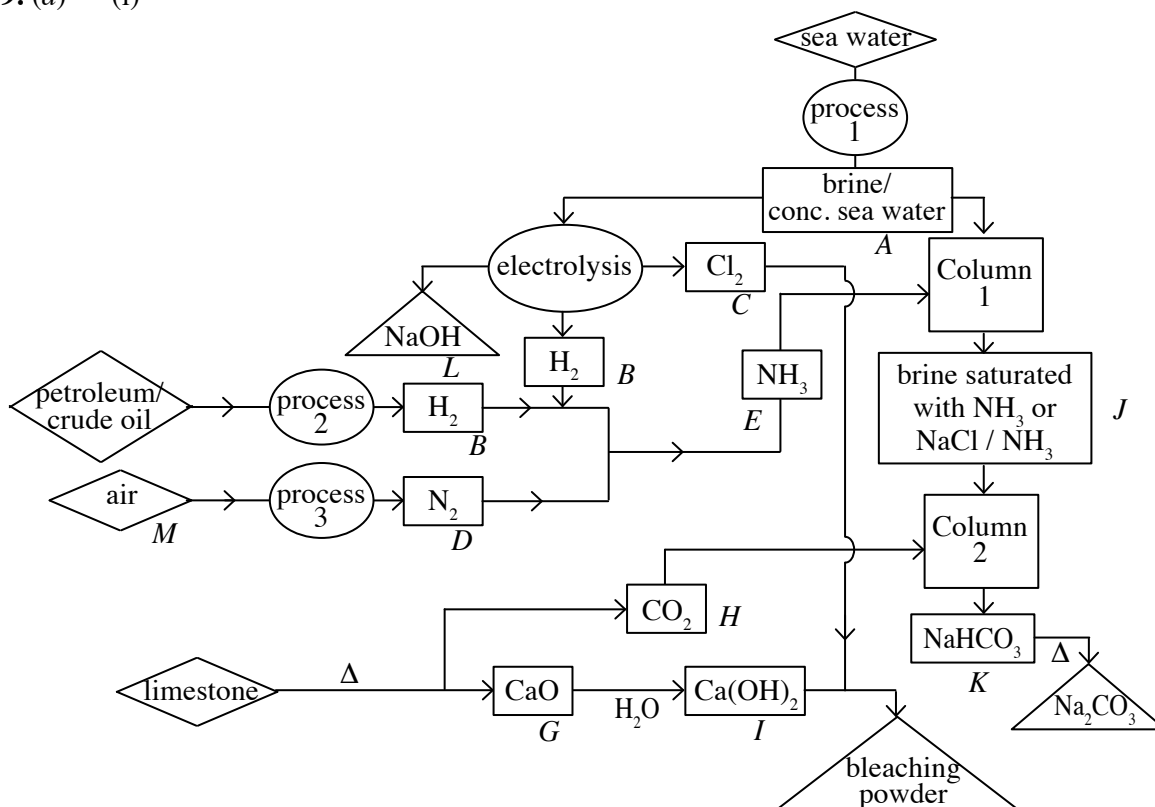
$$n(\text{S}) = n(\text{Fe}) + n(\text{Cu})$$

$$\therefore n(\text{Fe}) = n(\text{S}) - n(\text{Cu})$$

$$= 0.008 \text{ mol} - 0.002 \text{ mol}$$

$$= 0.006 \text{ mol}$$

9. (a) (i)



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(03 × 13 = 39 marks)

- (ii) Process 1 : concentration/evaporation
 Process 2 : reaction with steam/partial combustion with O₂
 Process 3 : fractional distillation (02 × 3 = 06 marks)

- (iii) Column 1 : $\text{NH}_3(\text{aq}) + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$
 or
 $\text{NH}_3(\text{aq}) + \text{NaCl}(\text{aq}) \rightleftharpoons \text{NH}_4^+\text{Cl}^-(\text{aq}) + \text{Na}^+(\text{aq}) + \text{OH}^-(\text{aq})$ (05 marks)
 Column 2 : $\text{OH}^-(\text{aq}) + \text{CO}_2(\text{g}) \rightleftharpoons \text{HCO}_3^-(\text{aq})$ (05 marks)

- (iv) $2\text{NaCl}(\text{aq}) + 2\text{NH}_3(\text{aq}) + 2\text{CO}_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \xrightarrow{\Delta} \text{Na}_2\text{CO}_3(\text{s}) + 2\text{NH}_4\text{Cl}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$
 $2\text{NaCl}(\text{aq}) + 2\text{NH}_3(\text{aq}) + \text{CO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \xrightarrow{\Delta} \text{Na}_2\text{CO}_3(\text{s}) + 2\text{NH}_4\text{Cl}(\text{aq})$
 $2\text{NaCl}(\text{aq}) + \text{CaCO}_3(\text{s}) \longrightarrow \text{Na}_2\text{CO}_3(\text{s}) + \text{CaCl}_2(\text{aq})$ } (08 marks)

- (v) gas dissolution is an exothermic process. Therefore mixing gases with water is accelerated by cooling. (04 marks)

- (vi) $3\text{Ca}(\text{OH})_2(\text{s}) + 2\text{Cl}_2(\text{g}) \longrightarrow \text{Ca}(\text{OCl})_2 \cdot \text{Ca}(\text{OH})_2 \cdot \text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ (08 marks)

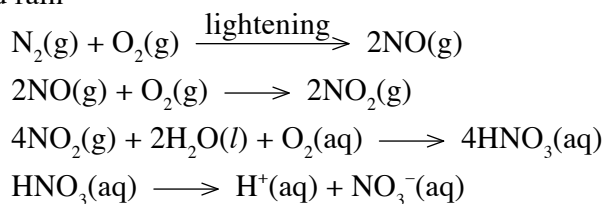
- (b) (i) It is too difficult to break the triple bond between N atoms in N₂./
 It is a very stable molecule. (05 marks)

- (ii) NO, NO₂, ..., N₂O, N₂O₄ (any two) (05 × 2 = 10 marks)

- (iii) lightening, burning fossil fuels, internal combustion in motor vehicle engines,
 combustion related with cooking purposes.
 (any three) (04 × 3 = 12 marks)

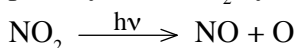
- (iv) acid rain, global warming
 photochemical smog, depletion of the ozone layer (04 × 4 = 16 marks)

- (v) acid rain

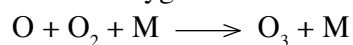


photochemical smog

photolysis of NO₂ by absorbing sunlight

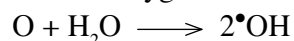


- (a) Atomic oxygen combines with O₂ molecules to form ozone.



(M is a gas or particle in air which can absorb excess energy)

- (b) Atomic oxygen reacts with water vapour to form OH free radicals.

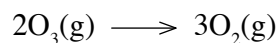


(°OH can initiate reaction to produce different chemical compounds like aldehydes, PAN, PBN ect)

Ozone layer depletion



$$(1) \times 2 + (2) + (3) \times 2$$



(any three) (12 × 2 = 24 marks)

(vi) reduce the temperature of the combustion process

reduce the combustion of fuel containing 'N'

connect catalytic converters to motor vehicles

reduce NO_x by using catalysts in furnaces

reduce acidic gases by absorption

(04 × 2 = 08 marks)

10. (a) (i) $\text{Hg}_2\text{Cl}_2(\text{s}) + 2\text{e} \rightleftharpoons 2\text{Hg}(\text{l}) + 2\text{Cl}^-(\text{aq})$ (08 marks)

(ii) $\text{Hg}(\text{l}), \text{Hg}_2\text{Cl}_2(\text{s}) / \text{Cl}^-(\text{aq}) (1.0 \text{ mol dm}^{-3}) // \text{Cl}^-(\text{aq}) (1.0 \text{ mol dm}^{-3}) / \text{Cl}_2(\text{g}) (1 \text{ atm}), \text{Pt}(\text{s})$ (10 marks)

(iii)
$$\begin{aligned} E_{\text{cell}}^{\theta} &= E_{\text{cathode}}^{\theta} - E_{\text{anode}}^{\theta} \\ &= 1.36 \text{ V} - 0.24 \text{ V} \\ &= 1.12 \text{ V} \end{aligned}$$
 (12 marks)

(b) (i) anodic reaction, $\text{Mg}(\text{s}) \longrightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{e}$

cathodic reaction, $2\text{e} + 2\text{H}_2\text{O}(\text{l}) \longrightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$

overall reaction,

$\text{Mg}(\text{s}) + 2\text{H}_2\text{O}(\text{l}) \longrightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq}) + \text{H}_2(\text{g})$ (05 × 3 = 15 marks)

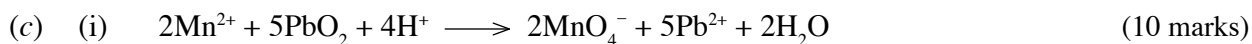
(ii) $\text{Mg}(\text{OH})_2(\text{s}) \rightleftharpoons \text{Mg}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq})$

By the reaction of electrolysis, Mg^{2+} and OH^- are formed with the molar ratio 1 : 2 just after forming turbidity or when the solution becomes saturated with $\text{Mg}(\text{OH})_2$, concentration of $[\text{Mg}^{2+}] = x$

$$\begin{aligned} K_{\text{sp}} &= [\text{Mg}^{2+}(\text{aq})][\text{OH}^-(\text{aq})]^2 \\ 4.0 \times 10^{-12} \text{ mol}^3 \text{ dm}^{-9} &= (x)(2x)^2 \\ x &= 1 \times 10^{-4} \text{ mol dm}^{-3} \\ n_{\text{Mg}^{2+}} &= \frac{1 \times 10^{-4}}{1000} \times 250 = 2.5 \times 10^{-5} \text{ mol} \\ Q &= 2.5 \times 10^{-5} \text{ mol} \times 96500 \text{ C mol}^{-1} \times 2 \\ Q &= It = 50 \times 10^{-3} \text{ A} \times t \\ t &= \frac{2.5 \times 10^{-5} \times 96500 \times 2}{50 \times 10^{-3}} \text{ s} \\ t &= 9650 \text{ s} \end{aligned}$$

(30 marks)

(iii) no other reactions occur during electrolysis. (05 marks)



(ii) Similar test tubes (similar cross sectional area and height) should be used. (04 marks)

(iii) to have equal colour intensities, concentrations should be equal.
Since the final volumes are equal,

$$\begin{aligned} n_{\text{MnO}_4^-} \text{ in } 5 \text{ cm}^3 \text{ of } X &= n_{\text{MnO}_4^-} \text{ in the test tube (4)} \\ &= \frac{0.05}{1000} \times 8 \text{ mol} \end{aligned}$$

$$\begin{aligned} \therefore n_{\text{MnO}_4^-} \text{ in } 250 \text{ cm}^3 \text{ of } X &= \frac{0.05}{1000} \times 8 \times \frac{250}{5} \text{ mol} \\ &= 0.02 \text{ mol} \end{aligned}$$

$$n_{\text{MnO}_4^-} = n_{\text{Mg}^{2+}}$$

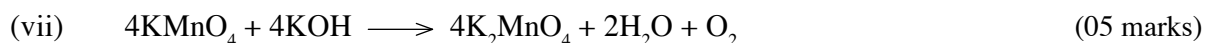
relative atomic mass of Mn = 55.

$$\begin{aligned} \frac{m_{\text{Mn}}}{m} \% &\Rightarrow \frac{0.02 \text{ mol} \times 55 \text{ g mol}^{-1}}{3.0 \text{ g}} \times 100 \\ &= 36.67\% \end{aligned} \quad (28 \text{ marks})$$

(iv) There are no other coloured substances except MnO_4^- are present in the solution X. (04 marks)

(v) • Potassium permanganate does not exist as a pure substance.
• Since it is a strong oxidising agent, it can easily get reduced. (08 marks)

(vi) • Prepare an oxalic acid solution of known concentration.
• Take a known volume of given KMnO_4 solution and acidify with dilute H_2SO_4 .
• Titrate with oxalic acid by maintaining the temperature at about 60°C . (06 marks)



(viii) purple $\longrightarrow$ green (05 marks)
