

G.C.E (A.L.) Support Seminar – 2016
Chemistry - Paper I
Answer Guide

Question No.	Answer	Question No.	Answer
(1)	3	(26)	3
(2)	1	(27)	2
(3)	3	(28)	4
(4)	5	(29)	5
(5)	2	(30)	1
(6)	1	(31)	4
(7)	4	(32)	4
(8)	2	(33)	2
(9)	5	(34)	1
(10)	1	(35)	2
(11)	3	(36)	3
(12)	2	(37)	2
(13)	3	(38)	5
(14)	4	(39)	5
(15)	3	(40)	2
(16)	5	(41)	2
(17)	2	(42)	4
(18)	4	(43)	4
(19)	2	(44)	4
(20)	5	(45)	3
(21)	4	(46)	1
(22)	4	(47)	5
(23)	2	(48)	2
(24)	2	(49)	1
(25)	4	(50)	3

(50 marks with one mark for each question)

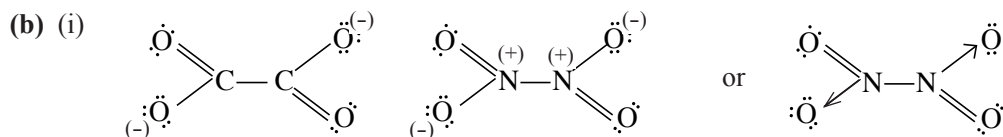
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G.C.E (A.L.) Support Seminar – 2016
Chemistry - Paper II
Answer Guide

Part A

1. (a) (i) V
(ii) Tetrahedral
(iii) $\text{Fe}^{2+} / \text{C}_2\text{O}_4^{2-} / \text{I}^-$
or
ferrous/ iron(II) /oxalate/ iodide
(iv) + 6 / VI
(v) $\text{Ba}^{2+} / \text{Sr}^{2+}$ or barium/ strontium
(vi) Cl_2O_7
(vii) greater/ higher
(viii) acidic

(3 × 8 = 24)



(5 × 2 = 10)

- (ii) In N_2O_4 molecule each N atom carries a positive charge, so there is repulsion between them. There is no such repulsion between the C atoms in the oxalate ion.

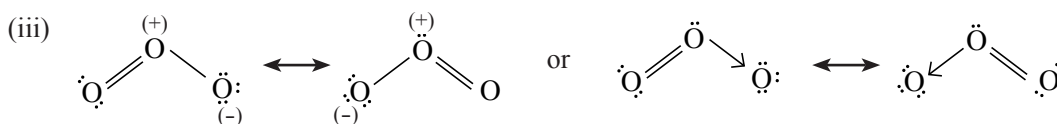
(3 × 3 = 09)

- (c) (i) J - O / oxygen
K - S / sulphur / sulfur

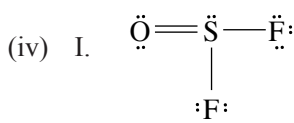
(3 × 2 = 06)

- (ii) angular / “V” shaped

(03)



(6 × 2 = 12)



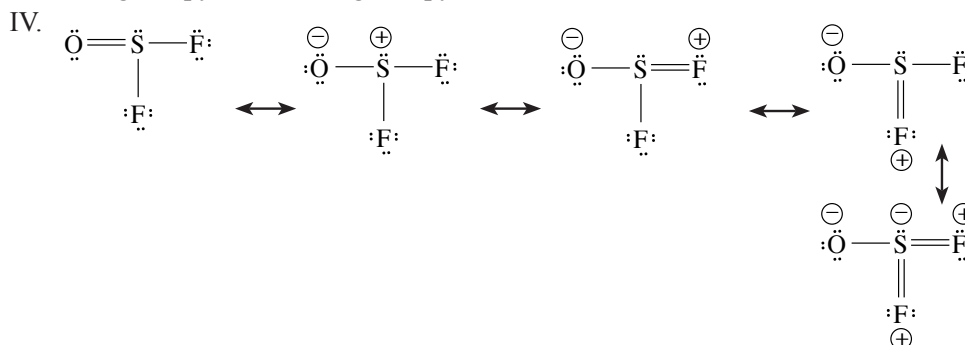
(06)

- II. tetrahedral

(03)

- III. triangular pyramidal / trigonal pyramid

(03)



(for any four 3 × 4 = 12)



(total marks 100)



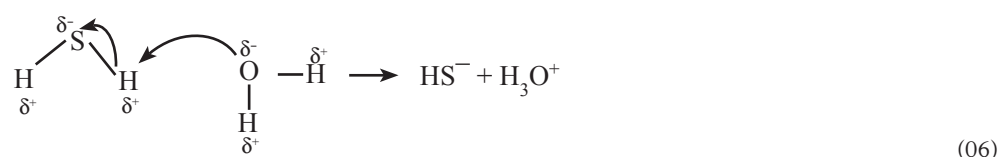
(b) (i) I. The reactivity of alkali metals depends on the ability of forming positive ions by removing electrons whereas the reactivity of halogens depends on the ability of forming negative ions by gaining electrons. Descending a group the atomic radius increases. Therefore, in alkali metals, the tendency to form cations increases down the group. But in the halogens, the ability to form anions decreases down the group. (06)

II. In C the electron configuration of the valence shell is of the type ns^2np^2 whereas in "N" it is of the type ns^2np^3 . Thus carbon has an ability to gain another electron. But in "N" the outer p orbitals are half-filled and stable. So, it has a little tendency to accept another electron for which energy has to be supplied. (06)

III. In aqueous solution LiH is basic because it forms OH^- ions as follows.



In aqueous solution H_2S is acidic because it forms H_3O^+ ions as follows.

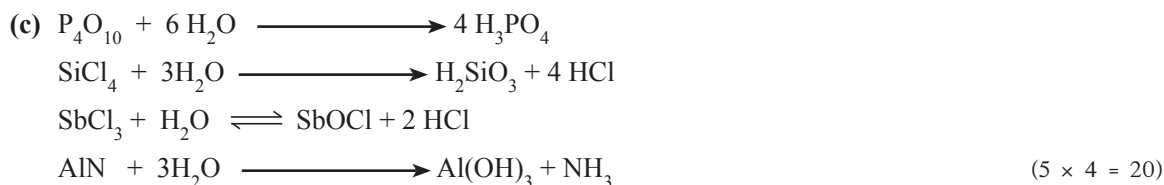


IV. "Na" and V are metals. The atomic/metallic radius of V is smaller than that of "Na". When forming the metallic bond, in "Na" only the "s" electrons are delocalised whereas in V both "s" electrons and "d" electrons get delocalised. Therefore, the strength of the metallic bond in V is much greater than that in "Na". Thus the melting point is relatively higher in V. (06)

(ii) I. (A) yellow (B) green (C) black

II. (D) violet (E) colourless (F) green (12)

- III. A - As_2S_3
 B - Ni^{2+} or $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$
 C - NiS
 D - I_2
 F - Fe^{2+} or $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ (10)



(Total marks 100)

3. (a) (i) $\Delta G^\ominus = \sum G^\ominus(\text{products}) - \sum G^\ominus(\text{reactants})$
 $= (-137 - 229) \text{ kJ mol}^{-1} - (-394 - 0) \text{ kJ mol}^{-1}$
 $= 28 \text{ kJ mol}^{-1}$ (4 × 3 = 12)

(ii) $\Delta S^\ominus = \sum S^\ominus(\text{products}) - \sum S^\ominus(\text{reactants})$
 $= (197.5 + 188.7) \text{ J mol}^{-1}\text{K}^{-1} - (213.7 + 130.6) \text{ J mol}^{-1}\text{K}^{-1}$
 $= 41.9 \text{ J K}^{-1} \text{ mol}^{-1}$ (4 × 3 = 12)

(iii) $\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$
 $\Delta H^\ominus = 28 \text{ kJ mol}^{-1} + T\Delta S^\ominus$
 $\Delta H^\ominus = 28 \text{ kJ mol}^{-1} + 298 \text{ K} \times \frac{41.9}{10^3} \text{ kJ K}^{-1} \text{ mol}^{-1}$
 $= 40.48 \text{ kJ mol}^{-1}$
 $= 40.5 \text{ kJ mol}^{-1}$ (4 × 3 = 12)

(iv) Since $\Delta G^\ominus > 0$, the reaction doesn't take place in the given directions spontaneously. For it to be spontaneous it is required that $\Delta G^\ominus < 0$.

$$\Delta H^\ominus - T\Delta S^\ominus < 0$$

$$T > \frac{\Delta H^\ominus}{\Delta S^\ominus} = \frac{40.5 \text{ kJ mol}^{-1}}{41.9 \times 10^{-3} \text{ kJ mol}^{-1}\text{K}^{-1}}$$

$$= 967 \text{ K}$$

$$= 693 \text{ }^\circ\text{C}$$

(4 × 3 = 12)

(v) $G_1^\ominus = -394 \text{ kJ mol}^{-1}$
 $G_2^\ominus = -137 - 229$
 $= -366 \text{ kJ mol}^{-1}$ (04)

(vi) When the system is in dynamic equilibrium, $\Delta G_r = 0$.

$$0 = \Delta G^\ominus + 2.303 RT \log K$$

$$\Delta G^\ominus = -2.303 RT \log K$$
 (08)

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(vii) $28 \text{ kJ mol}^{-1} = -2.303 \times 8.314 \text{ J K}^{-1} \text{ mol}^{-1} \times 298 \text{ K} \times \log K$
 $\log K = -4.9$
 $K = 1.25 \times 10^{-5}$ (10)

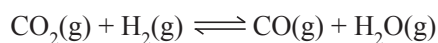
(viii) Yes.

According to $\Delta G^\theta = -2.303 RT \log K$

$\log K > 0$ for $\Delta G^\theta < 0$.

$\therefore K > 1$. (10)

(ix) At the composition x the system is in dynamic equilibrium.



$$K = \frac{[\text{CO}(\text{g})][\text{H}_2\text{O}(\text{g})]}{[\text{CO}_2(\text{g})][\text{H}_2(\text{g})]}$$

$[\text{CO}(\text{g})] = [\text{H}_2\text{O}(\text{g})]$. As equal amounts of CO_2 and H_2 are mixed and the stoichiometry of the reaction is 1 : 1,

$$[\text{CO}_2(\text{g})] = [\text{H}_2(\text{g})].$$

$$\therefore K = \frac{[\text{CO}(\text{g})]^2}{[\text{CO}_2(\text{g})]^2}$$

$$\frac{[\text{CO}(\text{g})]}{[\text{CO}_2(\text{g})]} = \sqrt{K}$$

$$= (1.25 \times 10^{-5})^{1/2}$$

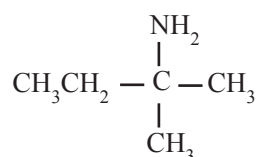
$$= 3.5 \times 10^{-3}$$

(20)

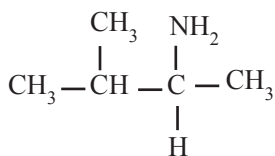
(Total marks 100)

4.

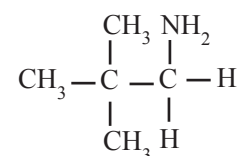
(a)



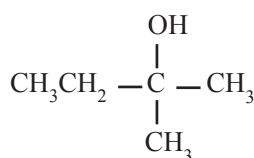
A



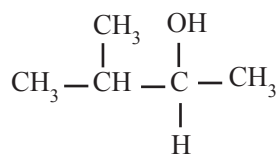
B



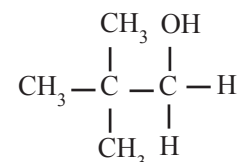
C



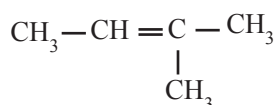
D



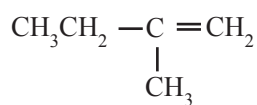
E



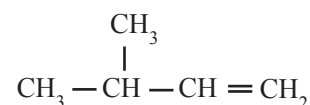
F



G



H



I

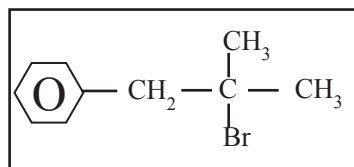
(4 × 9 = 36)

(b) (i) H - Zn(Hg) / conc. HCl

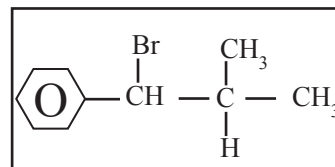
I - LiAlH₄ or NaBH₄J - LiAlH₄K - CH₃CH₂MgBrL - Cl₂ / diffuse light or Cl₂ / diffuse sunlight or Cl₂ / uvM - Cl₂ / AlCl₃ or Cl₂ / ZnCl₂ or Cl₂ / FeCl₃ or Cl₂ / Fe

(4 × 6 = 24)

(c) (i)

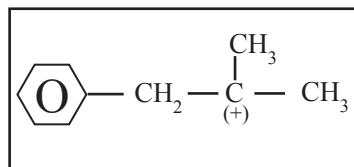


(A)

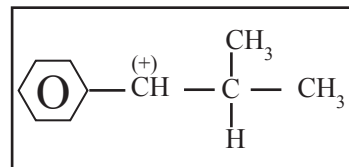


(B)

(ii)



(X)



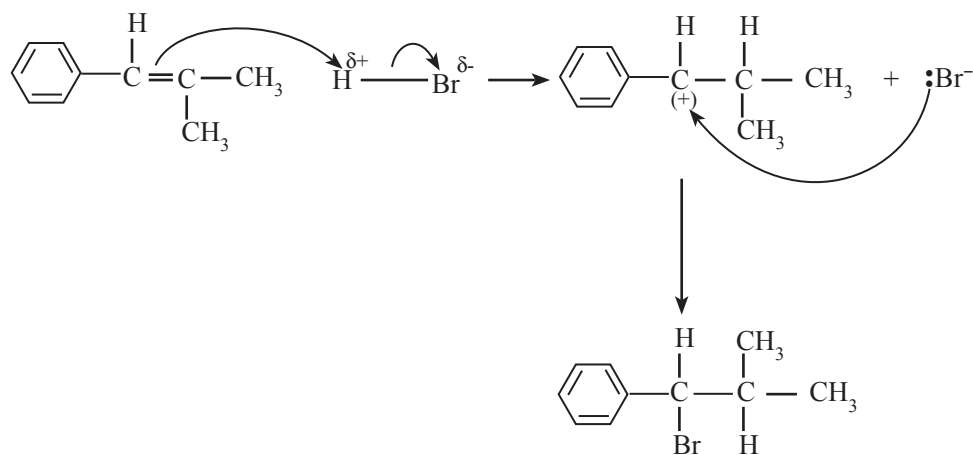
(Y)

(iii) Y or its structure

(iv) B

(5 × 6 = 30)

(iv)



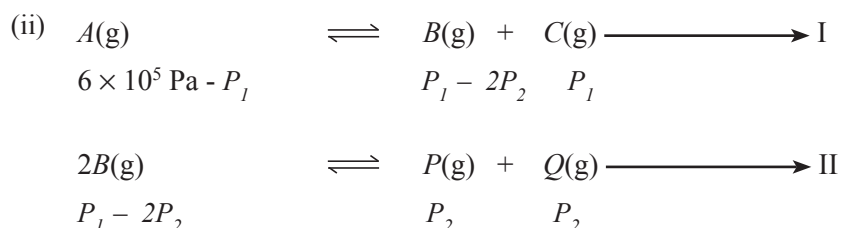
(10)

(Total marks 100)

Part B - Essay

05. (a) (i) Applying

$$\begin{aligned} \frac{P_1}{T_1} &= \frac{P_2}{T_2} \text{ for gas A} \\ P &= 3.6 \times 10^5 \text{ Pa} \times \frac{500 \text{ K}}{300 \text{ K}} \\ &= 6 \times 10^5 \text{ Pa} \end{aligned} \quad (06)$$



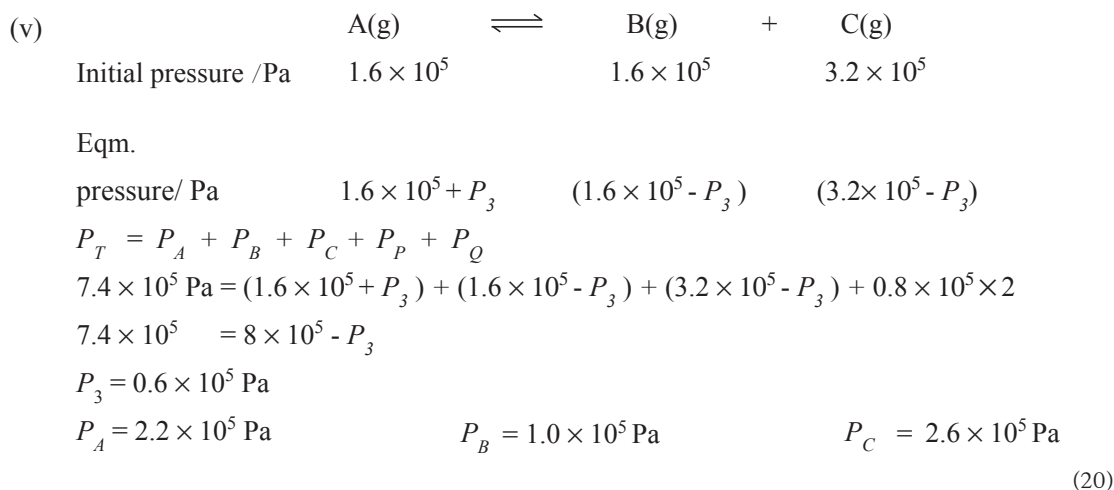
Considering reaction II,

$$\begin{aligned} K_p &= \frac{P_p \times P_Q}{P_B^2} \\ 0.25 &= \frac{P_2^2}{(P_1 - 2P_2)^2} \\ 0.5 &= \frac{P_2}{P_1 - 2P_2} \\ 0.5 P_1 - P_2 &= P_2 \\ P_1 &= 4P_2 \\ \\ P_T &= P_A + P_B + P_C + P_P + P_Q \\ 1 \times 10^6 \text{ Pa} &= (6 \times 10^5 \text{ Pa} - P_1) + (P_1 - 2P_2) + P_1 + 2P_2 \\ 4 \times 10^5 \text{ Pa} &= P_1 \\ P_2 &= \frac{1}{4} \times 4 \times 10^5 \text{ Pa} = 1 \times 10^5 \text{ Pa} \\ P_A &= 2 \times 10^5 \text{ Pa} \quad P_B = 2 \times 10^5 \text{ Pa} \\ P_C &= 4 \times 10^5 \text{ Pa} \quad P_P = P_Q = 1 \times 10^5 \text{ Pa} \end{aligned} \quad (20)$$

(iii) Applying $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ for P

$$\begin{aligned} P_P &= 1 \times 10^5 \text{ Pa} \times \frac{400 \text{ K}}{500 \text{ K}} \\ &= 8 \times 10^4 \text{ Pa} \end{aligned} \quad (06)$$

$$\begin{aligned} \text{(iv) } P_A &= 2 \times 10^5 \times \frac{4}{5} \text{ Pa} = 1.6 \times 10^5 \text{ Pa} \\ P_B &= 1.6 \times 10^5 \text{ Pa} \\ P_C &= 4 \times 10^5 \text{ Pa} \times \frac{4}{5} = 3.2 \times 10^5 \text{ Pa} \end{aligned} \quad (12)$$



(vi)

$$K_p = \frac{P_B \times P_C}{P_A}$$

$$= \frac{1.0 \times 10^5 \text{ Pa} \times 2.6 \times 10^5 \text{ Pa}}{2.2 \times 10^5 \text{ Pa}}$$

$$= 1.2 \times 10^5 \text{ Pa}$$

(06)

(vii) $K_p(127^\circ\text{C}) < K_p(227^\circ\text{C})$

Decrease in temperature favours the backward reaction. That means a backward reaction is exothermic and the forward reaction is endothermic. So, ΔH is positive ($\Delta H > 0$). (05)

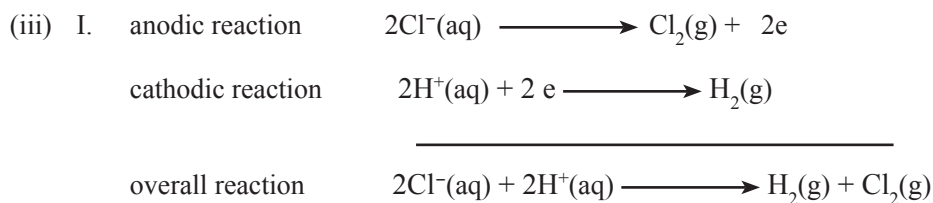
- (b) (i) During electrolysis, the amount/ mass of a substance discharged at an electrode is directly proportional to the amount of electricity passed through the circuit.

The mass of an element discharged by a given amount of electricity is proportional to its equivalent mass. (equivalent mass = atomic mass of the element/ charge of the ion discharged) (10)

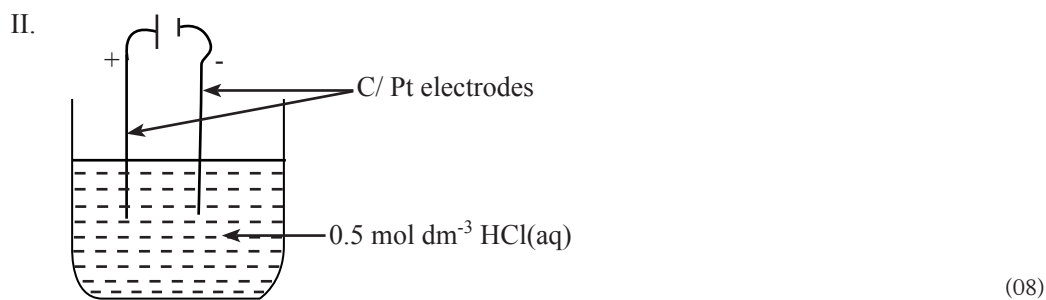
(ii)

Electrochemical cell	Electrolytic cell
1. converts chemical energy into electrical energy	converts electrical energy into chemical energy
2. electricity is produced by the changes in matter	electricity brings about changes in matter
3. a spontaneous process	not a spontaneous process

(06)



(15)



III. At the (+) terminal a light green gas/ a gas with a suffocating odour (Cl_2) is evolved.
 At the (-) terminal colourless gas bubbles (H_2) are liberated. (04)

(iv) $Q = 10 \text{ A} \times 3600 \text{ s}$
 $= 36\,000 \text{ C}$

\therefore Amount of electrons $= 36\,000 \text{ C} / 96\,500 \text{ C mol}^{-1} = 0.35 \text{ mol}$

Initial pH $= -\log[\text{H}^+(\text{aq})] = -\log [0.50]$
 $= \underline{0.35}$

Moles of H^+ lost : moles of electrons $= 1 : 1$

Amount of H^+ remaining $= (0.50 - 0.35) \text{ mol} = 0.15 \text{ mol}$

\therefore Final pH of the solution $= -\log [0.15]$
 $= 0.82$

\therefore Difference in pH $= 0.82 - 0.35$
 $= \underline{0.47}$

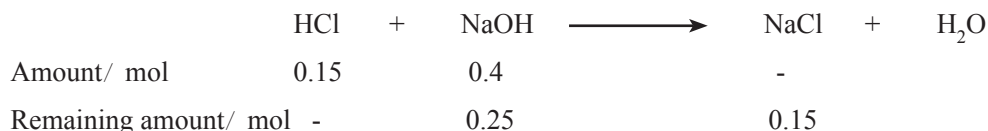
Assumptions : (1) The volume remains unchanged.

(2) The temperature doesn't change. (18)

(v) The entropy increases due to the conversion
 liquid \longrightarrow gas (H_2, Cl_2) (02)

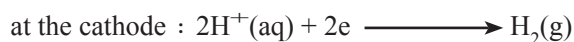
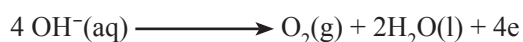
(vi) The amount of HCl remaining $= 0.15 \text{ mol}$

After the reaction with NaOH



$\therefore \text{OH}^-, \text{Cl}^-, \text{H}^+$ can discharge in the solution.

\therefore plausible reactions at the anode :



(12)

(Total marks 150)

06. (a) (i) As the stoichiometry of the reaction between FeCl_3 and KI_3 is 2 : 1, (04)

$$R' = 2 R \quad (04) \quad (08)$$

(ii) to find R' in (i) above

$$R' = 2 R = 2 \times 0.08 \text{ mol dm}^{-3} \text{ s}^{-1} = 0.16 \text{ mol dm}^{-3} \text{ s}^{-1} \quad (04) \quad (04)$$

(iii) Rate equation of the reaction

$$R = k [\text{FeCl}_3(\text{aq})]^x [\text{KI}_3(\text{aq})]^y \quad (04)$$

★ Determining order with respect to FeCl_3

$$\text{from experiment (1) : } 0.08 \text{ mol dm}^{-3} \text{ s}^{-1} = k [0.01 \text{ mol dm}^{-3}]^x [0.02 \text{ mol dm}^{-3}]^y \quad \text{----- (1) (04)}$$

$$\text{from experiment (2) : } 0.16 \text{ mol dm}^{-3} \text{ s}^{-1} = k [0.01 \text{ mol dm}^{-3}]^x [0.04 \text{ mol dm}^{-3}]^y \quad \text{----- (2) (04)}$$

$$(1) / (2) \quad 2 = 2^y \quad y = 1 \quad (04)$$

★ Determining order with respect to KI

$$\text{from experiment (1) : } 0.08 \text{ mol dm}^{-3} \text{ s}^{-1} = k [0.01 \text{ mol dm}^{-3}]^x [0.02 \text{ mol dm}^{-3}]^y \quad \text{----- (1)}$$

$$\text{from experiment (3) : } 0.16 \text{ mol dm}^{-3} \text{ s}^{-1} = k [0.2 \text{ mol dm}^{-3}]^x [0.02 \text{ mol dm}^{-3}]^y \quad \text{----- (3) (04)}$$

$$(3) / (1) \quad 2 = 2^x \quad x = 1 \quad (04)$$

$$\therefore \text{ overall order of the reaction} = x + y = 1 + 1 = 2 \quad (04) \quad (28)$$

(iv) substituting in (1)

$$0.08 \text{ mol dm}^{-3} \text{ s}^{-1} = k [0.01 \text{ mol dm}^{-3}] [0.02 \text{ mol dm}^{-3}] \quad (04)$$

$$k = \frac{0.08 \text{ mol dm}^{-3} \text{ s}^{-1}}{2 \times 10^{-4} \text{ mol}^2 \text{ dm}^{-6}} = 4 \times 10^2 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1} \quad (04) \quad (08)$$

- (v)
- Adding a constant amount of $\text{Na}_2\text{S}_2\text{O}_3$ and the starch solution to the reaction mixture to measure a constant amount of KI_3 . (02)
 - Preparing two reaction mixtures by separately mixing KI solution with $\text{Na}_2\text{S}_2\text{O}_3$ solution (01) and FeCl_3 solution with starch solution (01)
 - Mixing the two mixtures and measuring the time for the appearance of blue colour (02)
- (06)

(b) (i) $R = k [S_2]^x [B]^y$ (04)

(ii) second step (04)

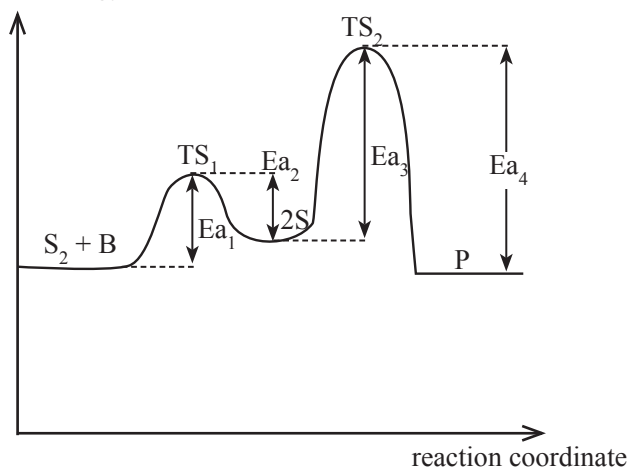
(iii) $R \propto [S]^2[B]$

$$K_c = \frac{[S]^2}{[S_2]} \Rightarrow [S]^2 = K_c \times [S_2]$$

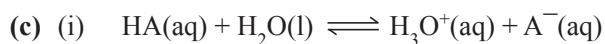
$$\therefore R \propto [S_2][B]$$

\therefore order with respect to $S_2 = 1$ (04)

(iv) potential energy



(09)



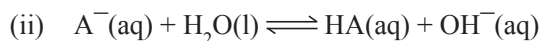
$$K_c = \frac{[H_3O^+(aq)] [A^-(aq)]}{[HA(aq)][H_2O(l)]}$$

$$K_c \times [H_2O(l)] = \frac{[H_3O^+(aq)] [A^-(aq)]}{[HA(aq)]}$$

As $[H_2O(l)]$ is a constant at constant temperature,

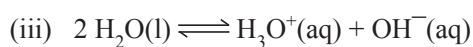
$$K_a = \frac{[H_3O^+(aq)] [A^-(aq)]}{[HA(aq)]} \quad \text{_____ (1)}$$

(10)



$$K_b = \frac{[HA(aq)] [OH^-(aq)]}{[A^-(aq)]} \quad \text{_____ (2)}$$

(05)

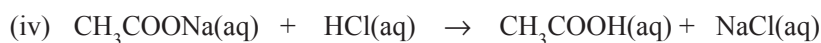


$$K_w = [H_3O^+(aq)][OH^-(aq)]$$

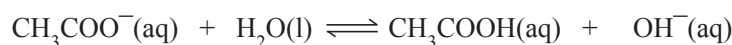
$$(1) \times (2) = K_a \times K_b = [H_3O^+(aq)][OH^-(aq)]$$

$$K_a \times K_b = K_w$$

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A. When $V_{\text{HCl}} = 0$



$$[\text{CH}_3\text{COOH(aq)}] = [\text{OH}^-(\text{aq})]$$

As the degrees off hydrolysis of CH_3COO^- is very small,

$$K_b = \frac{K_w}{K_a} = \frac{[\text{OH}^-(\text{aq})]^2}{[\text{CH}_3\text{COO}^-(\text{aq})]} \Rightarrow \therefore [\text{OH}^-(\text{aq})]^2 = \frac{10^{-14} \times 0.18}{1.8 \times 10^{-5}} \text{ mol dm}^{-3}$$

$$[\text{OH}^-(\text{aq})]^2 = 10^{-10} \text{ mol}^2 \text{ dm}^{-6}$$

$$[\text{OH}^-(\text{aq})] = 10^{-5} \text{ mol dm}^{-3}$$

$$\text{pOH} = -\log_{10} [\text{OH}^-(\text{aq})]$$

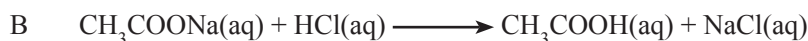
$$\text{pOH} = 5$$

$$\text{pH} + \text{pOH} = 14$$

$$\text{pH} = 14 - 5$$

$$\text{pH} = 9$$

(10)



When $V_{\text{HCl}} = 12.50 \text{ cm}^3$ half equivalence point is obtained. Then,

$$[\text{CH}_3\text{COONa(aq)}] = [\text{CH}_3\text{COOH(aq)}]$$

Neglecting the ionisation of CH_3COOH which is small,

$$\begin{aligned} [\text{H}_3\text{O}^+(\text{aq})] &= K_a \\ &= 1.8 \times 10^{-5} \text{ mol dm}^{-3} \end{aligned}$$

$$\text{pH} = -\log_{10} [1.8 \times 10^{-5}]$$

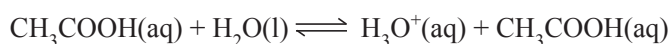
$$\text{pH} = 4.74$$

(10)

C When $V_{\text{HCl}} = 25.00 \text{ cm}^3$

$$[\text{CH}_3\text{COOH(aq)}] \text{ in the medium} = \frac{0.18}{1000} \times \frac{25}{50} \times 1000 \text{ mol dm}^{-3}$$

$$= 0.09 \text{ mol dm}^{-3}$$



As CH_3COOH is a weak acid its degree of dissociation is negligibly small.

$$\begin{aligned} K_a &= \frac{[\text{H}_3\text{O}^+(\text{aq})]^2}{[\text{CH}_3\text{COOH(aq)}]} \longrightarrow [\text{H}_3\text{O}^+(\text{aq})] = \sqrt{K_a \times 0.09} \text{ mol dm}^{-3} \\ &= \sqrt{1.8 \times 10^{-5} \times 9 \times 10^{-2}} \text{ mol dm}^{-3} \\ &= 1.27 \times 10^{-3} \text{ mol dm}^{-3} \end{aligned}$$

$$\text{pH} = -\log_{10} (1.27 \times 10^{-3})$$

$$\text{pH} = 2.89 \text{ or } \text{pH} = 2.9$$

(10)

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D When $V_{\text{HCl}} = 50.00 \text{ cm}^3$

$$[\text{HCl}(\text{aq})] \text{ in the medium} = \frac{0.18}{1000} \times \frac{50}{75} \times 1000 \text{ mol dm}^{-3}$$

$$= 0.12 \text{ mol dm}^{-3}$$

As the $[\text{H}^+]$ given by the dissociation of CH_3COOH is negligible compared to that provided by HCl,

$$\text{pH} = -\log_{10}(1.2 \times 10^{-1})$$

$$\text{pH} = 0.92 \quad (10)$$

(v) $Q < P < R < S$

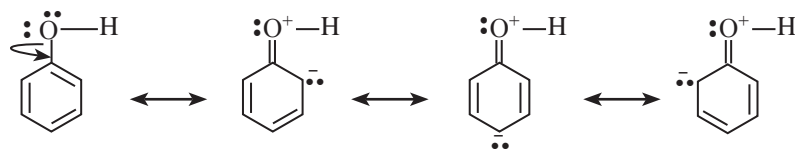
Solution Q corresponds to point B in the graph. Since this is a buffer solution the change in pH is minimum on addition of a little amount of HCl acid.

Solution R corresponds to point C in the graph. It is an equimolar mixture of CH_3COOH and HCl. As indicated by the graph, at point C, a large change in pH occurs for a small change in V_{HCl} (10)

(Total marks 150)

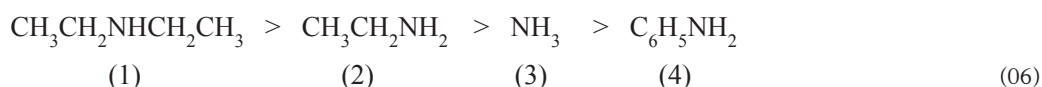
07. (a) (i) I. Nucleophilic substitution reaction (S_{N}) (04)

II. In phenol, the lone pair of electrons on oxygen gets delocalised in the ring. Hence the C-O bond assumes a double bond character becoming shorter and stronger. This makes it difficult to break. Therefore, phenol does not undergo nucleophilic substitution reactions.

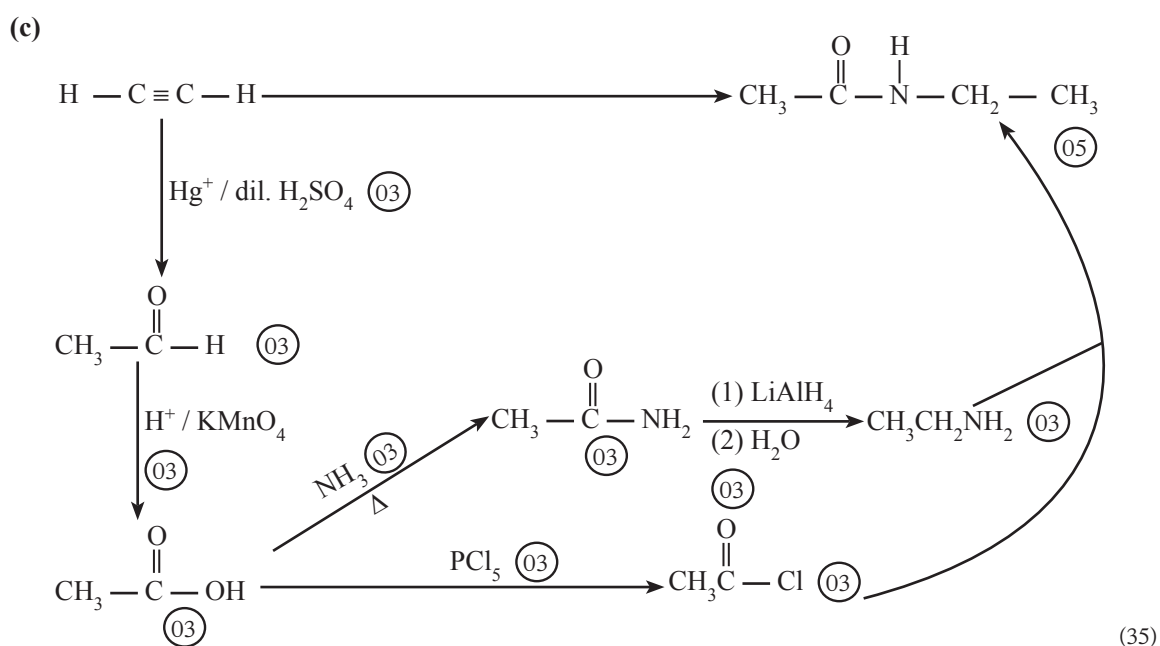
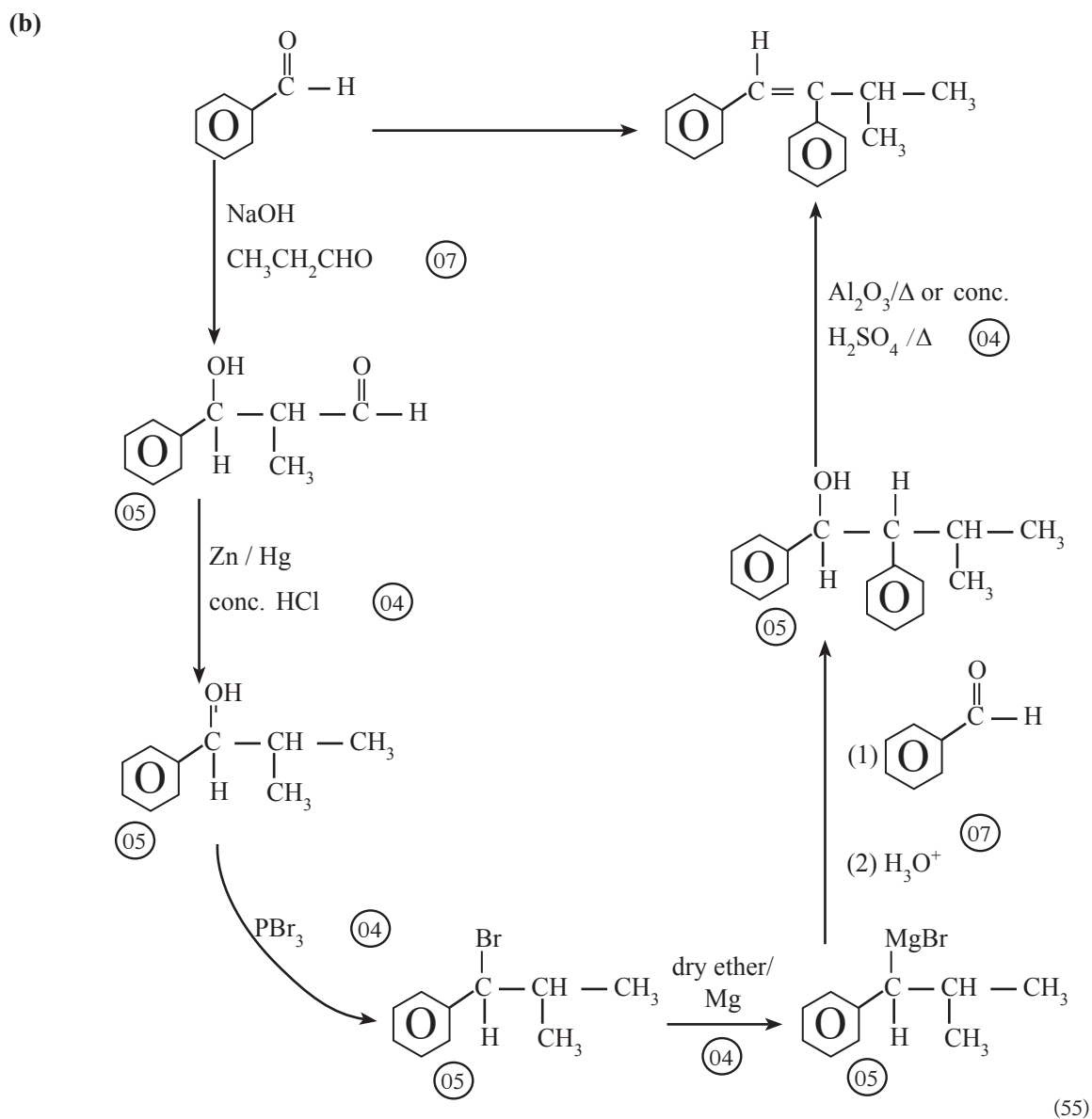


(15)

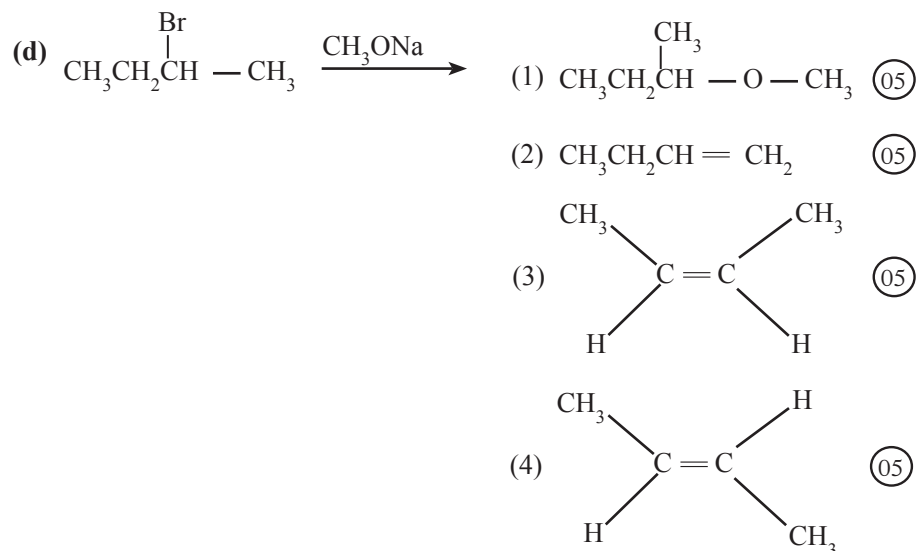
(ii) Basicity



In $\text{CH}_3\text{CH}_2\text{NHCH}_2\text{CH}_3$ both CH_3CH_2 - groups repel electrons whereas in $\text{CH}_3\text{CH}_2\text{NH}_2$ only one CH_3CH_2 - group repels electrons. This enables $\text{CH}_3\text{CH}_2\text{NHCH}_2\text{CH}_3$ to donate its lone pair on the "N" atom more than that in $\text{CH}_3\text{CH}_2\text{NH}_2$. Thus (1) is the most basic. As NH_3 lacks alkyl groups the basicity of (3) is less than the basicity of (2). In (4), the lone pair on the "N" atom gets delocalised in the ring making it less available for proton coordination. Therefore, (4) is the least basic. (15)



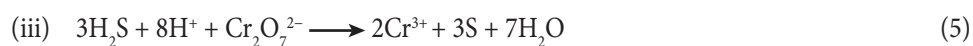
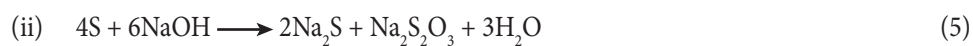
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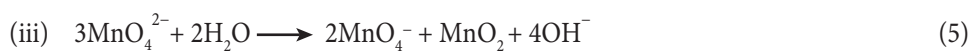
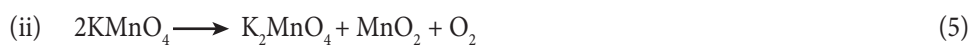
(20)
(Total marks 150)

Part C - Essay

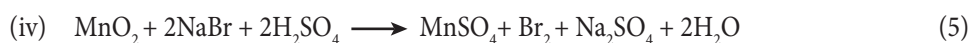
8. (a) (i) A - CuS
 B - $\text{CuCl}_2 / [\text{CuCl}_4]^{2-}$
 C - H_2S
 D - S
 E - $\text{CrCl}_3 / \text{Cr}^{3+}$
 F - $\text{Na}_2\text{S} / \text{Na}_2\text{S}_2\text{O}_3$
 G - $\text{Na}_2\text{S}_2\text{O}_3 / \text{Na}_2\text{S}$
 H - $\text{SO}_2 / \text{H}_2\text{S}$
 I - $\text{Cu}(\text{OH})_2$
 J - $[\text{Cu}(\text{NH}_3)_4]^{2+}$ (4 × 10 = 40)



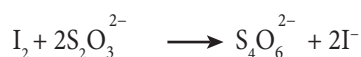
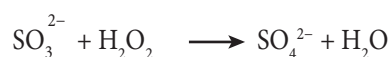
(50)



The green solution turns purple. }
A brown precipitate is formed. } (4)



A brown coloured solution is formed/ or a gas is evolved. (2)



(ii) $\text{BaSO}_4 = \frac{0.5825 \text{ g}}{233 \text{ g mol}^{-1}} = 0.0025 \text{ mol} = 2.5 \times 10^{-3} \text{ mol}$ (4)

$x + y = 2.5 \times 10^{-3} \times 2 \text{ mol}$ (2)

$x + y = 5.0 \times 10^{-3} \text{ mol}$ ----- (1) (2)

(iii) Initial amount of $\text{H}_2\text{O}_2 = \frac{0.2}{1000} \times 50 \text{ mol} = 0.01 \text{ mol}$ (3)

Amount of H_2O_2 reacted with $\text{Fe}^{2+} = \frac{x+y}{2}$ (2)

Amount of H_2O_2 reacted with $\text{SO}_3^{2-} = x$ (2)

Amount of H_2O_2 left in T = $0.01 - \left(\frac{x+y}{2} + x \right) \text{ mol}$
(in 100 cm³)

= $0.01 - \left(\frac{3x+y}{2} \right) \text{ mol}$ (4)

(iv) for 50 cm³ of the solution

$$\text{Amount of } \text{S}_2\text{O}_3^{2-} \text{ reacted} = 2 \times \text{amount of } \text{I}_2 \quad (2)$$

$$= 2(\text{amount of } \text{I}_2 \text{ liberated by } \text{Fe}^{3+} + \text{amount of } \text{I}_2 \text{ liberated by } \text{H}_2\text{O}_2 \text{ left}) \quad (5)$$

$$\frac{0.4}{1000} \times 20 = 2 \left\{ \frac{(x+y)}{2} \times \frac{1}{2} + \left(\frac{0.01}{2} \right) - \left(\frac{3x+y}{2} \right) \frac{1}{2} \right\}$$

$$8 \times 10^{-3} = 0.01 - x$$

$$x = 2 \times 10^{-3} \text{ mol}$$

$$\text{from (1) } y = 3 \times 10^{-3} \text{ mol} \quad (10)$$

$$\text{(v) Concentration of } \text{FeSO}_3 = \frac{2 \times 10^{-3}}{50} \times 1000 \text{ mol dm}^{-3} = 0.04 \text{ mol dm}^{-3} \quad (5)$$

$$\text{Concentration of } \text{FeSO}_4 = \frac{3 \times 10^{-3}}{50} \times 1000 \text{ mol dm}^{-3} = 0.06 \text{ mol dm}^{-3} \quad (5)$$

(Total marks 150)

9. (a) (i) A = HCl / H₂SO₄ / HNO₃ or their names or any other suitable acid.
(e.g. : acetic acid)

B = name or formula of any carbonate or a bicarbonate (2 × 2 = 04)

(ii) common salt / sodium chloride / NaCl
ammonia (solution) / ammonium hydroxide / NH₃ / NH₄OH (2 × 2 = 04)

(iii) In Solvay process limestone is thermally decomposed / heated.
Acids are not used. (2 × 2 = 04)

(iv) sodium bicarbonate / sodium hydrogencarbonate / NaHCO₃ (03)



(vi) I. The solution is divided into small droplets.

Therefore, the surface area of the solution increases.

This makes the absorption of carbon dioxide gas more efficient. (2 \times 3 = 06)

II. The solution almost about to be saturated with the gas meets the new gas front.

This makes the dissolving of the gas/ CO₂ efficient. (2 \times 2 = 04)

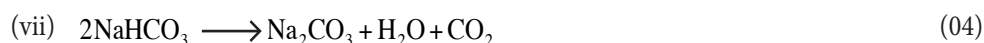
III. The reactions (1) and (2) in (v) are exothermic.

Under low temperature their equilibrium points shift to the right.

Therefore, the yield of those reactions increases.

As the solubility of NaHCO₃ is low at low temperatures it crystallises/ separates easily.

(2 \times 4 = 08)



(viii) Used as washing soda/ softening hard water/production of soap/ glass/ detergents/ paper

Removal of Ca²⁺ / Mg²⁺ ions in sea water during the production of NaOH (any 2 \times 2 = 04)

$$\text{(ix)} \quad \frac{M(\text{Na}_2\text{CO}_3)}{M(\text{CaCO}_3) + 2M(\text{NaCl})} \times 100$$

$$\frac{106}{100 + (2 \times 58.5)} \times 100$$

$$= 48.85\%
 \tag{2 \times 3 = 06}$$

(x) It is an indicator of the fraction converted to the desired product from the raw materials.

It indirectly indicates the amount of unwanted products added to the environment.

It inspires to seek alternative methods with higher cost effectiveness in an industry. (any 2 \times 2 = 04)

(xi)

Species	Pollutant	Unfavourable effect
(b) Solid	CaCl ₂	making water hard
	Na ₂ CO ₃	making soil/ water/ alkaline/ retarding plant growth/ destroying soil/ aquatic organisms
Gaseous	CO ₂	increasing global warming
	NH ₃	making soil/ water/ alkaline/ destroying soil/ aquatic organisms/ respiratory diseases
Non material	heat	climatic changes

(2 × 6 = 12)

(b) (i) N₂ O₂ Ar CO₂ (2 × 4 = 8)

78.09 20.99 0.94 0.03

78 21 0.9 0.03 (2 × 4 = 8)

(ii) CO₂ respiration
combustion
photosynthesis

CO incomplete combustion
anaerobic degradation of organic substances
oxidation of CH₄

SO₂ combustion of fossil fuels
eruption of volcanoes
biological decay of organic substances containing sulphur
reduction of sulphates
isolation of metals from metallic sulphides

SO₃ oxidation of SO₂

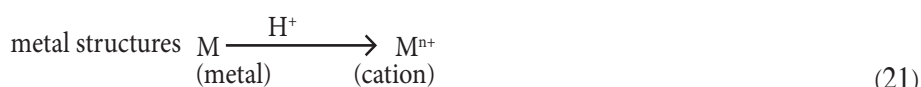
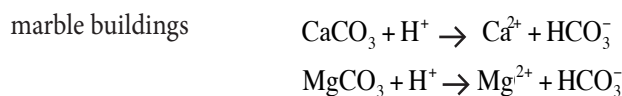
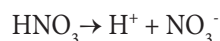
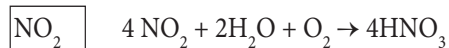
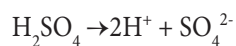
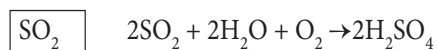
NO_x lightning and thunderbolts
from internal combustion engines

H₂S microbial digestion of organic substances containing sulphur
reduction of sulphate ions

(1 × 5 + 1 × 5 = 10)

(iii) global warming, acid rains, photochemical smog, depletion of ozone layer (2 x 4 = 08)

(iv) acid rains (04)



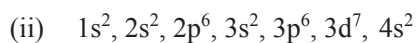
(v) Increasing hardness of water
Addition of heavy metal cations to soil (08)

(vi) I. SO_2
Scrubbing acidic gases using limestone and a slurry containing lime
Using the products formed here again to produce H_2SO_4

II. NO / NO_2
Converting the above gas/gases to N_2 and O_2 using catalytic converters
Using the products formed here again to produce HNO_3 (08)

(Total marks 150)

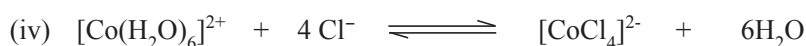
10. (a) (i) Cobalt / Co (04)



or



(iii) +2, +3 / II, III (06)



or



(v) I. A - diamminetetraaquacobalt(II) chloride
B - diamminediaquadichloridocobalt(III) chloride

or

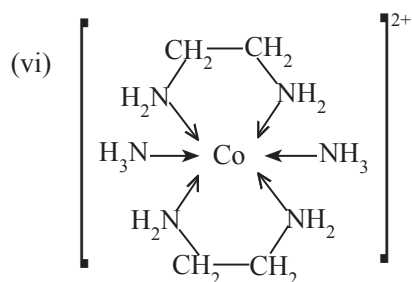
diamminediaquadichlorocobalt(III) chloride

(5 x 2 = 10)

II. Octahedral

(05)

- III.
- Taking equal volumes of solutions A and B (to identical test tubes)
 - Adding equal volumes of the silver nitrate solution in excess to the above test tubes separately
 - Comparing the height/ mass of the (silver chloride) precipitate formed
 - The compound giving more precipitate is A / The compound giving less precipitate is B/ The amount of precipitate given by A is twice the amount of precipitate given by B.
- (4 × 4 = 16)

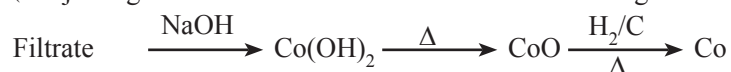


(award full marks even if the central atom is M)

(10)

- (vii)
- Dissolve a sample of the alloy in (a minimum quantity of) nitric acid.
 - Acidify the solution with dil. HCl and pass H_2S gas
 - Filter the precipitate and boil the filtrate.
 - Add a metal like Mg / Zn to the filtrate (or electrolyse).
 - Filter, wash and dry the precipitate formed.

(Subjecting the above filtrate to reactions such as those given below is also acceptable.)



The following alternative answers are also acceptable.

- Dissolve a sample of the alloy in (a minimum quantity of) dil. HCl/ H_2SO_4 and filter.
 - Add Mg / Zn / a named metal above cobalt in the electrochemical series to the filtrate.
 - Filter, wash and dry the precipitate formed.
- or
- Dissolve a sample of the alloy in dil. HCl/ H_2SO_4 and filter.
 - Electrolyse the filtrate using inert electrodes.
- (15)

(b) (i) Finding $[Na^+]$

$$\text{mass of } Na_2SO_4 = 1.42 \text{ g}$$

$$\text{molar mass of } Na_2SO_4 = 142 \text{ g mol}^{-1}$$

$$\begin{aligned} \text{amount of } Na_2SO_4 &= \frac{1.42}{142} \text{ mol} \\ &= 0.01 \text{ mol} \end{aligned}$$

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$$\begin{aligned} \text{mass of NaI} &= 1.50 \text{ g} \\ \text{molar mass of NaI} &= 15.0 \text{ g mol}^{-1} \\ \text{amount of NaI} &= \frac{1.50}{15.0} \text{ mol} \\ &= 0.01 \text{ mol} \\ \text{total amount of Na}^+ &= 0.01 \text{ mol} + 2 \times 0.01 \text{ mol} \\ &= 0.03 \text{ mol} \end{aligned}$$

$$\begin{aligned} [\text{Na}^+(\text{aq})] &= \frac{0.03}{2.5} \times 1 \text{ mol dm}^{-3} \\ &= 0.012 \text{ mol dm}^{-3} \end{aligned}$$

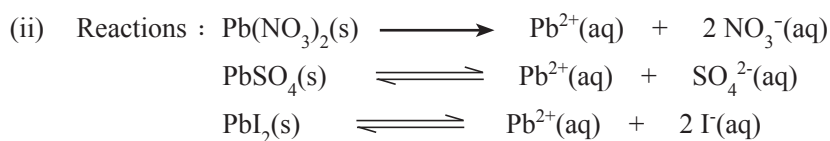
- Finding $[\text{I}^-(\text{aq})]$

$$\begin{aligned} [\text{I}^-(\text{aq})] &= \frac{0.01}{2.5} \times 1 \text{ mol dm}^{-3} \\ &= 0.004 \text{ mol dm}^{-3} \end{aligned}$$

- Finding $[\text{SO}_4^{2-}(\text{aq})]$

$$\begin{aligned} [\text{SO}_4^{2-}(\text{aq})] &= \frac{0.01}{2.5} \times 1 \text{ mol dm}^{-3} \\ &= 0.004 \text{ mol dm}^{-3} \end{aligned}$$

(4 × 3 = 12)



Since $K_{sp}(\text{PbSO}_4) = 1.6 \times 10^{-8} \text{ mol}^2 \text{ dm}^{-6}$

Calculating the minimum $[\text{Pb}^{2+}]$ to precipitate PbSO_4 :

$$\begin{aligned} K_{sp}(\text{PbSO}_4) &= [\text{Pb}^{2+}(\text{aq})][\text{SO}_4^{2-}(\text{aq})] \\ [\text{Pb}^{2+}(\text{aq})] &= \frac{K_{sp}(\text{PbSO}_4)}{[\text{SO}_4^{2-}(\text{aq})]} = \frac{1.6 \times 10^{-8} \text{ mol}^2 \text{ dm}^{-6}}{4 \times 10^{-3} \text{ mol dm}^{-3}} \\ &= 4 \times 10^{-6} \text{ mol dm}^{-3} \end{aligned}$$

- Calculating the minimum $[\text{Pb}^{2+}]$ to precipitate PbI_2 :

$$\begin{aligned} K_{sp}[\text{PbI}_2(\text{s})] &= [\text{Pb}^{2+}(\text{aq})][\text{I}^-(\text{aq})]^2 \\ [\text{Pb}^{2+}(\text{aq})] &= \frac{K_{sp}[\text{PbI}_2(\text{s})]}{[\text{I}^-(\text{aq})]^2} = \frac{1.6 \times 10^{-9} \text{ mol}^3 \text{ dm}^{-9}}{(4 \times 10^{-3})^2 \text{ mol}^2 \text{ dm}^{-6}} \\ &= 1.0 \times 10^{-4} \text{ mol dm}^{-3} \end{aligned}$$

∴ PbSO_4 which needs minimum $[\text{Pb}^{2+}(\text{aq})]$ precipitates first.

(15)

- (iii) To find the mass of $\text{Pb}(\text{NO}_3)_2$ for the precipitation of PbSO_4 :
As the total volume of the solution is 2.5 dm^3 ,

$$\begin{aligned} \text{Amount of } \text{Pb}^{2+} \text{ it should contain} &= 4 \times 10^{-6} \times 2.5 \text{ mol} \\ &= 1 \times 10^{-5} \text{ mol} \\ \therefore \text{Amount of } \text{Pb}(\text{NO}_3)_2 \text{ to be added} &= 1 \times 10^{-5} \text{ mol} \\ \text{Molar mass of } \text{Pb}(\text{NO}_3)_2 &= 331 \text{ g mol}^{-1} \\ \text{Minimum mass of } \text{Pb}(\text{NO}_3)_2 \text{ to be added} &= 1 \times 10^{-5} \times 331 \text{ g} \\ &= 3.31 \times 10^{-3} \text{ g} = 3.31 \text{ mg} \end{aligned} \quad (15)$$

$$\begin{aligned} \text{(iv) } \therefore \text{ new } [\text{Pb}^{2+}(\text{aq})] &= \frac{2 \times 10^{-5}}{2.5} \times 1 \\ &= 8 \times 10^{-6} \text{ mol dm}^{-3} \end{aligned}$$

As the $[\text{Pb}^{2+}(\text{aq})]$ required to precipitate PbI_2 ($1.0 \times 10^{-4} \text{ mol dm}^{-3}$) is not available here too, PbI_2 doesn't precipitate.

To find the mass of PbSO_4 precipitating :

$$\begin{aligned} [\text{SO}_4^{2-}(\text{aq})] \text{ in the solution} &= \frac{0.004}{2} \text{ mol dm}^{-3} \\ &= 0.002 \text{ mol dm}^{-3} \\ \therefore [\text{SO}_4^{2-}(\text{aq})] \text{ remaining} &= 0.002 \text{ mol dm}^{-3} \\ \text{Amount of } \text{PbSO}_4 \text{ formed} &= 0.002 \times 2.5 \text{ mol} \\ \text{Mass of } \text{PbSO}_4 \text{ formed} &= 0.002 \times 2.5 \times 303 \text{ g} \\ &= 1.52 \text{ g} \end{aligned} \quad (15)$$

- (v) To find the mass of $\text{Pb}(\text{NO}_3)_2$ to precipitate all the ions :

$$\begin{aligned} \text{Amount of } \text{Pb}(\text{NO}_3)_2 \text{ required to precipitate } \text{PbI}_2 &= 1.0 \times 10^{-4} \text{ mol} = 2.5 \times 10^{-4} \text{ mol} \\ \text{Mass of } \text{Pb}(\text{NO}_3)_2 &= 2.5 \times 10^{-4} \times 331 \text{ g} \\ &= 8.2754 \times 10^{-2} \text{ g} \\ &= 82.75 \text{ mg} \end{aligned}$$

$$\begin{aligned} \text{Minimum mass of } \text{Pb}(\text{NO}_3)_2 \text{ required to precipitate both } \text{PbSO}_4 \text{ and } \text{PbI}_2 &= (82.75 + 3.31) \text{ mg} \\ &= 86.06 \text{ mg} / 8.6 \times 10^{-2} \text{ g} \end{aligned} \quad (14)$$

- (vi) The temperature and volume of the solution remain unchanged. (04)

(Total marks 150)