Answers for MCQ

Chemistry I GCE A/L 2014

1 - 3
2 - 5
3 - 2
4 - 5
5 - 4
6 - 2
7 - 2
8 - 3
9 - 1
10 - 2

11 - 4
12 - 3
13 - 2
14 - 3
15 - 4
16 - 3
17 - 2
18 - 3
19 - 2
20 - 3

21 - 5
22 - 3
23 - 2
24 - 2
25 - 3
26 - 5
27 - 2
28 - 2
29 - 1
30 - 4

31 - 5
32 - 4
33 - 3
34 - 1
35 - 4/5
36 - 5
37 - 4
38 - 1
39 - 1
40 - 5

41 - 4
42 - 1
43 - 4
44 - 1
45 - 4
46 - 4
47 - 5
48 - 3/5
49 - 3
50 - 5

Answers

Chemistry II GCE A/L 2014

Part A - Structured Essay

$> Mg > Al > Li > Na$ *(5)*

ason Lowest I. E. with Li and Na as there is only one electron the outermost energy level, Na has more screening effect with electron filled shells, as against only one sheild in Li $3s^2$ state of Mg is more stable than $3s^2\ 3p^1$ state of Al. Al gets additional elding from $3s^2$

(ii) $Cl > F > O > C$ *(5)*

(iii) $BaCl_2 > CaCl_2 > BeCl_2$ *(5)*

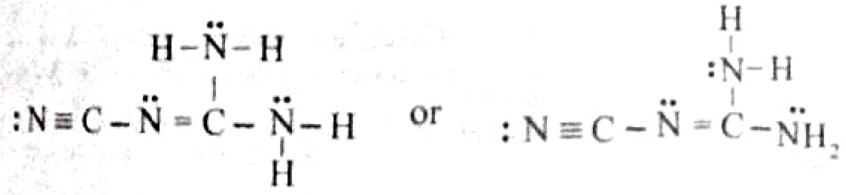
(Reason : $BaCl_2$ most ionic ; $BeCl_2$ most co-valent)

(iv) $SiCl_3 > NCl_3 > ICl_4$ *(5)*

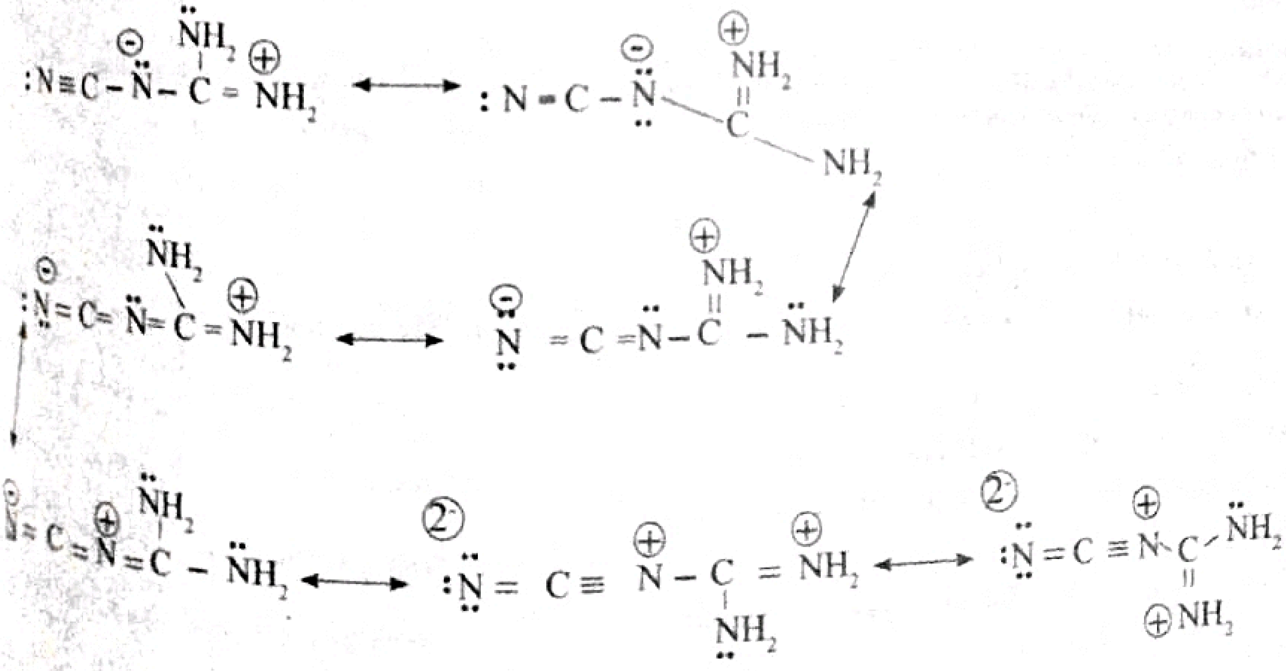
(v) $H_3O^+ > H_2O > OH^{(-)}$ *(5)*

(vi) $NH_2OH > FNO_2 > ClNO > NO^+$ *(5)*

(i)



(ii)



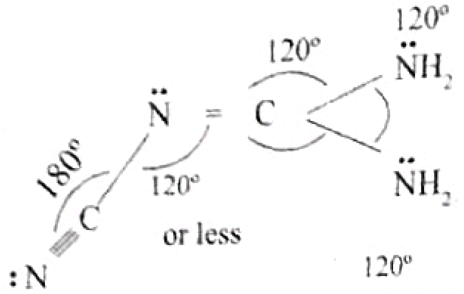
(Any 4 Structures × 4)

(iii)

	C^2	N^3	C^4	N^5 or N^6
electron pair geometry	linear	trigonal planar	trigonal planar	tetrahedral
shape	linear	angular	trigoual planar	pyramidal
hybridization	sp	sp^2	sp^2	sp^3

(1×12)

(iv)



(3 + 1×12) = (8)

(No marks are awarded for b (iv) if b(i) is incorrect)

Accepted angles :- 115° — 120° for 120° or less
116° — 182° for 180°
118° — 1220° for 120°

(v) I N^1... 2p atomic orbital or sp hybrid ordbital; C^2... sp hybrid orbital

II C^2... sp hybrid orbital ; N^3... sp^2 hybrid orbital

III N^3... sp^2 hybrid orbital; C^4... sp^2 hybrid orbital *(01 ×6)*

C (i) CH_3Cl [Because of the higher polarity of C-Cl bond]

(ii) CH_3I [I has a larger electron cloud than Cl]

(iii) CH_3I

(iv) London dispersion forces

or London forces

or instant dipole - induced dipole attractions

(04 ×5 marks)

(a) (i) Aluminium /Al. *(5 marks)*

[The difference in energies between the 3rd and 4th ionisations, is very **high, when compared** with the differences between other pairs; Hence **there must be only three** electrons in the outermost shell.]

(ii) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ *(5)*

(iii) +3 *(5)*

(iv) (I) $2A\lambda + 6HC\lambda \longrightarrow 2A\lambda C\lambda_3 + 3H_2$ *(5)*

or $2A\lambda + 6HC\lambda \longrightarrow 2A\lambda^{3+} + 6C\lambda^- + 3H_2$ *(5)*

(II) $2A\lambda + 2H_2O + 2NaOH \longrightarrow 2NaA\lambda O_2 + 3H_2$

or $2A\lambda + 6H_2O + 2NaOH \longrightarrow 2NaA\lambda(OH)_4 + 3H_2$

$2A\lambda + 6H_2O + 2NaOH \longrightarrow 2NaA\lambda O_2.2H_2O + 3H_2O$ *(5)*

(v) $A_2\lambda O_3$ *(5)*

(vi) $3NaNO_{3(aq)} + 2H_2O_{(\lambda)} + 8A\lambda_{(s)} + 5NaOH_{(aq)} \longrightarrow 3NH_3 + 8NaA\lambda O_{2(aq)}$

or $3NO_{3(aq)}^- + 2H_2O_{(\lambda)} + 8A\lambda_{(s)} + 5OH^- \longrightarrow 3NH_{3(g)} + 8A\lambda O_{2(aq)}^-$

(5)

The half ionic equations for the above are,

$NO_{3(aq)}^- + 6H_2O_{(\lambda)} + 8e \longrightarrow NH_{3(g)} + 9OH_{(aq)}^-$ ..... (a)

$A\lambda_{(s)} + 4OH_{(aq)}^- \longrightarrow A\lambda O_{2(aq)}^- + 2H_2O_{(\lambda)} + 3e$ ..... (b)

((a) x 3)+((b) x 8), $3NO_3^- + 18H_2O + 8A\lambda + 32OH^- \longrightarrow 3NH_3$
$27OH^- + 8A\lambda O_2^- + 16H_2O$

or

$3NO_{3(aq)}^- + 2H_2O_{(\lambda)} + 8A\lambda_{(s)} + 5OH_{(aq)}^- \longrightarrow 3NH_{3(g)} + 8A\lambda O_{2(aq)}^-$

(vii) $A\lambda^{3+}_{(aq)}$ or $[A\lambda(H_2O)_6]^{3+}$ or $[A\lambda(H_2O)_5(OH)]^{2+}$
Evolution of gas bubbles *(5)*

(viii) To make aluminium based paints, alloys, electrical power cables, ca for drinks, cooking utensils, aircraft bodies. *(5)*

2 (b)(i) A = $Pb(NO_3)_2$ (white $PbC\lambda_2$ ppt is soluble when hot. $Pb(OH)_2$ is a white ppt)

B = $ZnSO_4$ (white $BaSO_4$ ppt is insoluble in dilute acids White $Zn(OH)_2$ ppt is soluble in excess alkali.)

C = Na_2CO_3 (white $BaCO_3$ ppt is soluble in dilute acids. NaOH, formed is not a ppt)

D = $KC\lambda$ (All potassium salts are water soluble)

E = $Mg(NO_3)_2$ - ($MgC\lambda_2$ is water soluble $Mg(OH)_2$ is a white ppt.)

(4 marks each ×5=2

2 b (ii) I $Pb(NO_3)_2 + BaC\lambda_2 \longrightarrow PbC\lambda_2\downarrow + Ba(NO_3)_2$

$Pb(NO_3)_2 + 2NH_4OH \longrightarrow Pb(OH)_2\downarrow + 2NH_4NO_3$

$ZnSO_4 + BaC\lambda_2 \longrightarrow BaSO_4\downarrow + ZnC\lambda_2$

$ZnSO_4 + 2NH_4OH \longrightarrow Zn(OH)_2\downarrow + (NH_4)_2SO_4$

$Na_2CO_3 + BaC\lambda_2 \longrightarrow BaCO_3\downarrow + 2NaC\lambda$

$Mg(NO_3)_2 + 2NH_4OH \longrightarrow Mg(OH)_2\downarrow + 2NH_4NO_3$

(4 marks each ×6=2

$C\lambda_{(s)} \xrightarrow{\Delta} PbC\lambda_{2(s)}$ or $Pb^{2+}_{(aq)} + 2C\lambda^-_{(aq)}$ (1)

$Zn(OH)_2 + 4NH_4OH \longrightarrow [Zn(NH_3)_4](OH)_2 + 4H_2O$ or

$Zn(OH)_2 + 4NH_3 \longrightarrow [Zn(NH_3)_4](OH)_2$ or

$Zn(OH)_2 + 6NH_4OH \longrightarrow [Zn(NH_3)_6](OH)_2 + 6H_2O$ or

$Zn(OH)_2 + 6NH_3 \longrightarrow [Zn(NH_3)_6](OH)_2$ (3)

$BaCO_3 + 2HC\lambda \longrightarrow BaC\lambda_2 + CO_2\uparrow + H_2O$ (2)

concentration of HA in solution =

$$[HA_{aq}] = \frac{0.5\ mol\ dm^{-3} \times 40.00 \times 10^{-3}\ dm^3}{25.00 \times 10^{-3}\ dm^3} = 0.80\ mol\ dm^{-3}$$

Using Ka $= C(\alpha^1)^2$

$$\alpha^1 = \sqrt{\frac{1.0 \times 10^{-6}}{0.8}}$$

$= 1.118 \times 10^{-3}$ or $\underline{\underline{1.12 \times 10^{-3}}}$

The degree of dissociation increases when the concentration of the acid is decreased

(10) marks

$$\text{Partition coefficient} = \frac{[HA]_{aq}}{[HA]_{org}}$$

$$= \frac{0.8\ mol\ dm^{-3}}{(1.0 - 0.8)\ mol\ dm^{-3}} = \underline{\underline{4}}$$ (5)

$$\text{Or Partition coefficient} = \frac{[HA]_{org}}{[HA]_{aq}}$$

$$= \frac{(1.0 - 0.8)\ mol\ dm^{-3}}{0.8\ mol\ dm^{-3}} = \underline{0.25}$$ (5)

(10 mark)

3 (i) $HA_{(aq)} \rightleftharpoons H^+_{(aq)} + A^-_{(aq)}$ or

$H_2O_{(l)} + HA_{(aq)} \rightleftharpoons H_3O^+_{(aq)} + A^-_{(aq)}$

$C(1-\alpha) \rightleftharpoons C\alpha \quad C\alpha$

Equilibrium concentration ($mol\ dm^{-3}$)

where C is initial concentration of $HA_{(aq)}$ and α is the degree of dissociation

$pH = 3.0 = -\log_{10}[H^+_{aq}]$

$\therefore [H^+_{aq}] = 1.0 \times 10^{-3}\ mol\ dm^{-3} = C\alpha$ (5)

$\therefore \alpha = [H^+_{aq}] \div C = (1.0 \times 10^{-3}\ mol\ dm^{-3}) \div (1.0\ mol\ dm^{-3})$ (5)

$= \underline{\underline{1.0 \times 10^{-3}}}$ (5)

(ii) $Ka = \frac{[H^+_{aq}][A^-_{(aq)}]}{[HA_{aq}]}$ (5)

$Ka = \frac{C\alpha . C\alpha}{C(1-\alpha)}$ (5)

Assuming $1 - \alpha\ \underline{\Omega}\ 1$

$Ka = C\alpha^2 = 1.0\ mol\ dm^{-3} \times (1.0 \times 10^{-3})^2$

$= \underline{\underline{1.0 \times 10^{-6}}}\ mol\ dm^{-3}$ (5)

15 marks

When NaOH, is added

$$[HA]\text{ in mixture} = \frac{(1.0\ mol\ dm^{-3} \times 25.00 \times 10^{-3}\ dm^3) - (0.5\ mol\ dm^{-3} \times 25.00 \times 10^{-3}\ dm^3)}{50.00 \times 10^{-3}\ dm^3}$$ (5+5)

$= 2.5 \times 10^{-1}\ mol\ dm^{-3}$

When NaA is completely ionised,

(5+5)

$$[A^-_{aq}] = \frac{0.50\ mol\ dm^{-3} \times 25.00 \times 10^{-3}\ dm^3}{50.00 \times 10^{-3}\ dm^3} = 2.5 \times 10^{-1}\ mol\ dm^{-3}$$

$$[H^+_{aq}] = \frac{Ka[HA_{aq}]}{[A^-_{(aq)}]} = \frac{1.0 \times 10^{-6}\ mol\ dm^{-3} \times 2.5 \times 10^{-1}\ mol\ dm^{-3}}{2.5 \times 10^{-1} \times mol\ dm^{-3}} = 1.00 \times 10^{-6}\ mol\ dm^{-3}$$ (5)

$pH = -\log_{10}[H^+_{(aq)}] = -\log_{10}(1.00 \times 10^{-6}) = \underline{\underline{6.0}}$

Answers accepted: $[HA] = [A^-]$ Use of Henderson

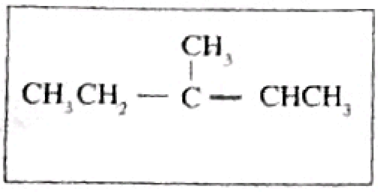
(Total 30 marks)

Equation of Show $[HA] = [A^-]$

4) a) A shows geometric isomerism. Hence it must have two different groups on each of the carbon atoms of the C = C

B can show optical isomerism only if the 3rd carbon atom is chiral. C does not have a chiral carbon atom.

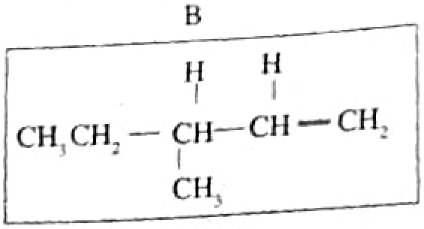
A



$CH_3CH_2-\overset{CH_3}{C}-CHCH_3$

(05)

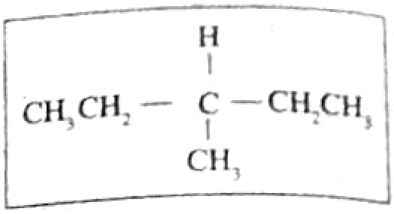
B



$CH_3CH_2-\underset{CH_3}{\overset{H}{CH}}-\overset{H}{CH}-CH_2$

(05)

C

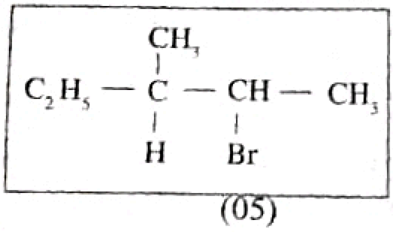


$CH_3CH_2-\underset{CH_3}{\overset{H}{C}}-CH_2CH_3$

(05)

b) (i)

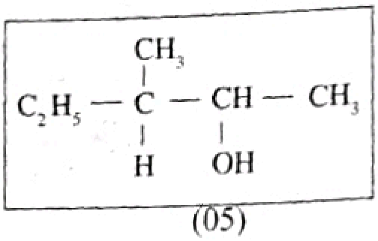
D



$C_2H_5-\underset{H}{\overset{CH_3}{C}}-\underset{Br}{CH}-CH_3$

(05)

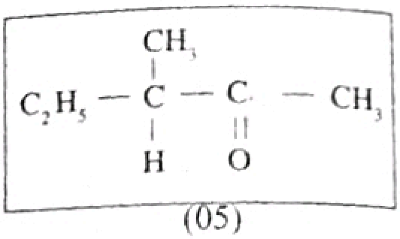
E



$C_2H_5-\underset{H}{\overset{CH_3}{C}}-\underset{OH}{CH}-CH_3$

(05)

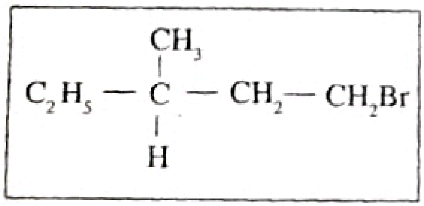
F



$C_2H_5-\underset{H}{\overset{CH_3}{C}}-\underset{O}{\overset{}{C}}-CH_3$

(05)

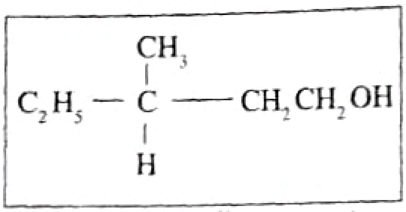
G



$C_2H_5-\underset{H}{\overset{CH_3}{C}}-CH_2-CH_2Br$

(05)

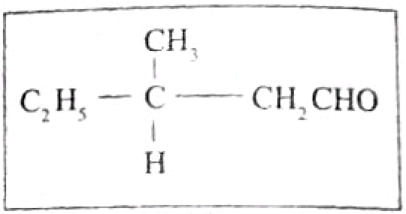
H



$C_2H_5-\underset{H}{\overset{CH_3}{C}}-CH_2CH_2OH$

(05)

I



$C_2H_5-\underset{H}{\overset{CH_3}{C}}-CH_2CHO$

(05)

ii) Mix with ammoniacal silver nitrate solution and heat in a water bath.

'I' gives a silver mirror (Because if is an aldehyde) but 'F' will not form a silver mirror (as if is a ketone) ......

(01+

or Heat with feling's mixture or Bennedict's solution. Brick red precipitate is given by only 'I'

or Warm with dilute H_2SO_4 and $KMnO_4$ 'I' will turn the purple $KMnO_4$ colourless, but F will not

or Warm with dilute H_2SO_4 and $K_2Cr_2O_7$ solution only 'I' will make orange $K_2Cr_2O_7$ turn green

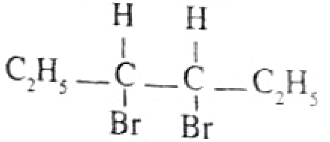
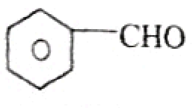
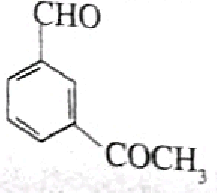
or Warm with I_2, KI and KOH (Iodoform test) Only 'F' will give a yellow precipitate with a characteristic smell 'I' will not answer.

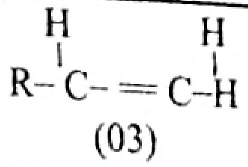
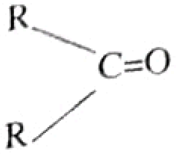
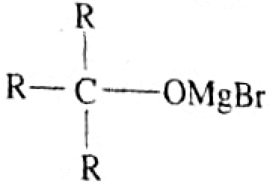
(Compounds that either contain, or will form $CH_3COC\lessgtr$ group or CH_3-C(H) OH goup will answer the iodoform test, 'F' contains $CH_3COC\lessgtr$ gr

(2 marks for test. 2 marks for observation and 1 mark for citing neg

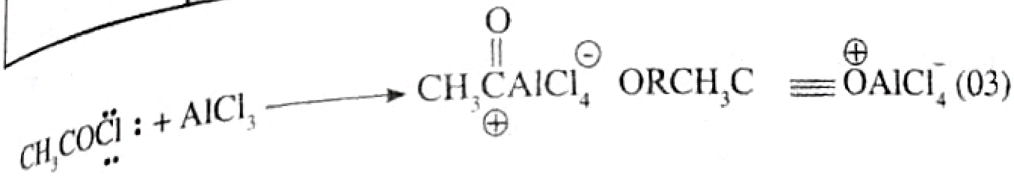
iii) Position isomerism

4 C)

	Reactant	Reagent	Major product	Reaction type
1	$C_2H_5CH=CHC_2H_5$	Br_2/CCl_4	 $C_2H_5-\underset{Br}{\overset{H}{C}}-\underset{Br}{\overset{H}{C}}-C_2H_5$ (03)	A E (02)
2		CH_3COCl with anhydrous $AlCl_3$	 (03)	S_E (02)

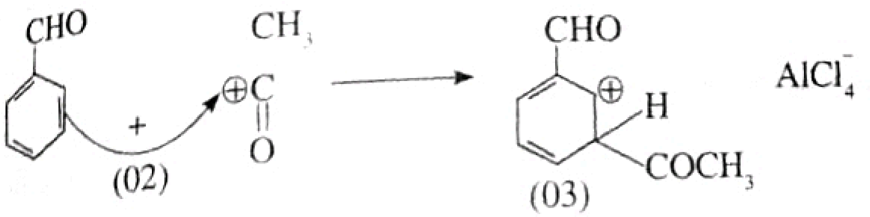
3	ROH	PCl_3	RCl (03)	S_N (02)
4	RCH_2CH_2OH	Anhydrous Al_2O_3 (hot)	 $R-CH=CH_2$ (03)	E (02)
5	 $R_2C=O$	RMgBr	 $R_3C-OMgBr$	A_N (02)

(i)

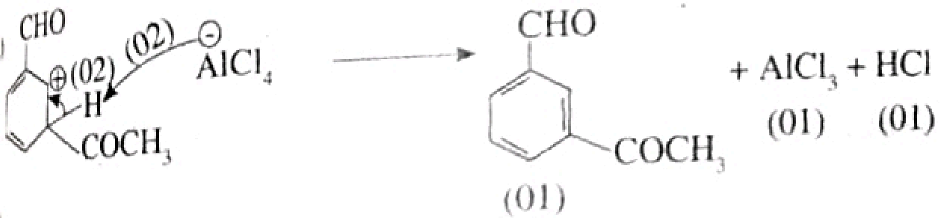


$CH_3CO\ddot{C}l: + AlCl_3 \longrightarrow CH_3\overset{\oplus}{C}(=O)\overset{\ominus}{AlCl_4}$ OR $CH_3C \equiv \overset{\oplus}{O}AlCl_4^-$ (03)

(ii)

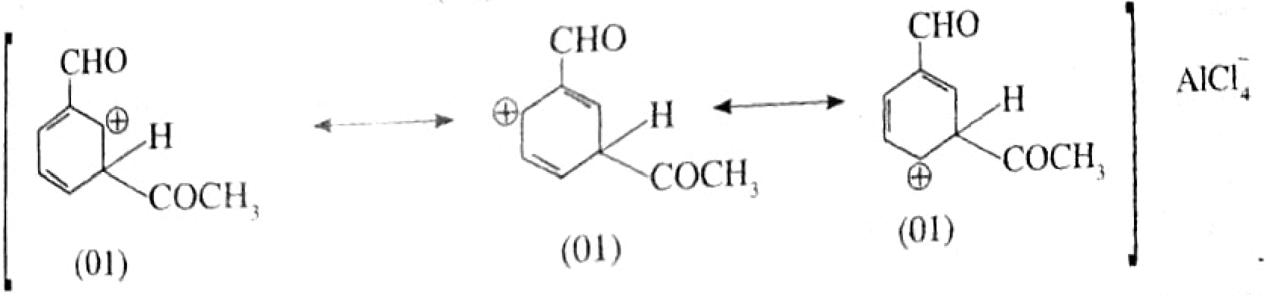


(iii)



(iv)

Resonance structures of carbocation



(02

Intermediate carbo cation formed, is stabilised by delocalization of the positive charge, as shown by the three resonance structures.

Answers
Chemistry II GCE A/L 2014
Part B - Essay

05.a) (i)In Raoults law, it is assumed that the gas/vapour behaves ideally.

Raoults law :- Vapour pressure of a component in an ideal solution which is in equilibrium with its vapour, is proportional to its mole fraction in the solution.

Or In an ideal binary solution at equilibrium with its vapour, the relative depression of the vapour pressure of one component is equal to the mole fraction of the other component in the solution.

Or In an ideal solution at equilibrium with its vapour, the vapour pressure of a component is equal to its saturated vapour pressure multiplied by its mole fraction in solution. Or $P_A = P^0_A X A$

Or $\dfrac{P^0_A - P_A}{P^0_A} = X_B = X_B$ Where

P^0_A = Vapour pressure of pure solvent A at the given temperature
P_A = Partial pressure of A
X_B = mole fraction of solute B
X_A = mole fraction of solvent A

a) (ii) I

$P_A = P^0_A X_A$

mole frac

$X_A = \dfrac{0.1\ (\text{mol})}{(0.1 + 0.2)\ (\text{mol})}$ (04 +

Partial pressure, $P_A = \dfrac{1.00 \times 10^4\ \text{Pa} \times 0.1\ (\text{mol})}{(0.1 + 0.2)\ (\text{mol})}$ (04 +

$P_A = 3.33 \times 10^3\ \text{Pa}$ (04 +

II

$X_B = \dfrac{0.2\ (\text{mol})}{(0.1 + 0.2)\ (\text{mol})}$ (04 +

$P_B = \dfrac{3.50 \times 10^4 \text{Pa} \times 0.2\ (\text{mol})}{(0.1 + 0.2)\ (\text{mol})} = 2.33 \times 10^4\ \text{Pa}$ (04 +

$P_{total} = P_A + P_B = 0.33 \times 10^4 + 2.33 \times 10^4\ \text{Pa}$

$P_{total} = 2.66 \times 10^4\ \text{Pa}$ (04 +

5(a) 50 mark

b) i)

I $C_{(g)} \rightleftharpoons 2D_{(g)} + E_{(g)}$

$1 - \alpha \quad 2\alpha \quad \alpha$ mols at equilibrium

Or $(1.0 - 0.2)$ mol $\quad 2 \times 0.2$ mol $\quad 0.2$ mol *(05)*

Unit is essential

$K_p = \dfrac{P^2_D \times P_E}{P_C}$ *(10)*

Partial pressures,

$P_C = P_{total} \times X_C \quad P_D = P_{total} \times X_D \quad P_E = P_{total} \times X_E$ *(05 × 3)*

Or $P_C = \dfrac{P_{total} \times 0.8\ \text{mol}}{1.4\ \text{mol}} \quad P_D = \dfrac{P_{tot} \times 0.4\ \text{mol}}{1.4\ \text{mol}} \quad P_E = \dfrac{P_{total} \times 0.2\ \text{mol}}{1.4\ \text{mol}}$

$$K_P \; \frac{\left(1.00 \times 10^5\ \text{Pa} \times \frac{0.4}{1.4}\right)^2 \left(1.00 \times 10^5\ \text{Pa} \times \frac{0.2}{1.4}\right)}{(1.00 \times 10^5\ \text{Pa} \times \frac{0.8}{1.4}}$$

$= \underline{2.04 \times 10^8\ \text{Pa}^2 \quad \text{Or} \quad 2.0 \times 10^8\ \text{Pa}^2}$

Note : Steps can be combined

ii)

$K_p = K_C(RT)^{\Delta n}$; $\Delta n = 2+1 - 1 = 2$
$\qquad \underbrace{pr - rea}$

$K_p = K_C(RT)^2$ other recognition of $\Delta n = 2$

$K_C = \dfrac{K_p}{(RT)^2} = \dfrac{2.04 \times 10^8\ \text{Pa}^2}{(8.314\ \text{Jmol}^{-1}\text{K}^{-1} \times 500\text{K})^2}$ (04 +

$K_C = 1.18 \times 10^1\ \text{mol}^2\ \text{m}^{-6}$

$\underline{\underline{\Omega\ 1.2 \times 10^1\ \text{mol}^2\text{m}^{-6}}}$ (04 +

iii) $C_{(g)} \rightleftharpoons 2D_{(g/l)} + E_{(g)}$

$(1 - \alpha \quad 2\alpha \quad \alpha)$ mol at equilibrium

$(1.0\text{-}0.1)$ mol $\quad 2 \times 0.1$ mol $\quad 0.1$ mol
(liq. & vap.)

Total number of moles in gas phase = n

new partial pressures,

$P_C = P_{total} \times X_C$, $P_E = P_{total} \times X_E$ (05

Or

$$= \frac{P_{total} \times 0.9\ mol}{n} \qquad P_E = \frac{P_{total} \times 0.1\ mol}{n}$$

(P_D is equal to saturated vapour pressure of D) *(15)*

The volume of the liquid phase is negligible *(10)*

If the partial pressures have been calculated, 04 +01 for each Pc = 3.86 x 10⁵ Pa and Ps - 4.28 x 10⁴ Pa.

If the ratio P_E/Pc = 1/.9 = 0.111 is directly calculated, 08 +2 marks can be earned

If saturated vapour pressure of D is not used for P_D no marks beyond this Step

$$K_p = \frac{P_D^2 . P_E}{P_C}$$

$$K_p = \frac{(5.00 \times 10^2\ Pa)^2\ (P_{total} \times \frac{0.1}{n})}{(P_{total} \times \frac{0.9}{n})} \qquad (04 + 01)$$

$$K_p = \frac{(5.0 \times 10^{-2}\ P_s)^2}{9}$$

$$K_p = \underline{\underline{2.78 \times 10^4\ Pa^2}} \qquad (04 + 01)$$

5(b) 100 marks

06. a) (i) Rate = K [A]
(10)

a) (ii) I $A \rightleftharpoons B + C$

At t = 0s n - - mol *(02)*

At t = 10s n (1-∝) - n∝ n∝ mol *(02)*

Note : Amounts can be given as concentrations, mol dm⁻³

Ideal gas behaviour in gas phase is assumed.

At 300 K

Total amount of gases after 10s = n (1 + ∝) mol

Initially $P = \frac{n}{v} RT^1$

$$30 \times 10^3\ Pa = \frac{n}{V} RT^1 \quad (1)$$

After 10s $32 \times 10^3\ Pa = \frac{n(1 + \propto)}{V} RT \quad (2) \qquad (03)$

From (2) /(1); $\frac{32}{30} = 1 + \propto$

∝ = 1/15 Or n∝ = 1/15 mol
(04 + 01)

II AT 400 K

Total amount of gases after 10s = n (1 + ∝¹) mol

Initially $45 \times 10^3\ P\propto = \frac{n}{v} RT^1 \quad - (3) \qquad (02)$

After 10s $45 \times 10^3\ Pa = \frac{n(1 + \propto)}{v} RT^1 - (4) \qquad (03)$

From (4)/(3): $\frac{45}{40} = 1 + \propto^1$

$\propto^1 = 1/8$

$n\propto^1 = 1/8$ mol *(04 + 1)*

iii) Rate at 300 K, using initial concentration of A (rate constant at 300 K is K_1)

$$\text{Rate}_{300k} = \frac{\Delta[A]}{\Delta t} = k_1[A]$$

$$\frac{\frac{n}{15v}}{t} = k_1\left(\frac{n}{v}\right) \quad - (5) \qquad (04 + 01)$$

Rate at 400 K, Using initial concentration of A (Rate constant at 400 K is k_2 *(04 +01)*

$$\text{Rate}_{400K} = \frac{\Delta[A]}{\Delta t} = k_2\ [A]$$

$$\frac{\frac{n}{8v}}{t} = k_2\left(\frac{n}{v}\right) \quad - (6) \qquad (6)$$

From (6)/(5): $k_2/k_1 = 15/8$; $k_2 > k_1$ *(5)*

(Full marks can be earned for III if correct arguments to show that $k_2 > k_1$, are given. Eg :

For the same initial concentration, the change in concentration of A for a constant time interval, (eg. 10s) is high at 400K, which is a high temperature, than at a lower temperature like 300K

Hence, k_2 must be greater than k_1

06. b) (i) $HA_{(g)} \longrightarrow H^+_{(g)} + A^-_{(g)}$

or $HA_{(g)} \rightleftharpoons H^+_{(g)} + A^-_{(g)}$ *(5)*

6 (b)ii) I ΔH_5 = Enthalpy change

$$\begin{tikzcd} HA_{(g)} \arrow[r, "\Delta H_5"] \arrow[d, "\Delta H_4"] & H^+_{(g)} \arrow[d, "\Delta H_3"] & + & A^-_{(g)} \arrow[d, "\Delta H_2"] \\ HA_{(aq)} \arrow[r, "\Delta H_1"] & H^+_{(aq)} & + & A^-_{(aq)} \end{tikzcd}$$

(04)

$\Delta H_5 = \Delta H_4 + \Delta H_1 - \Delta H_2 - \Delta H_3$

= - 150.0 +1.0 - (-200.0) - (-1100.0)

= (-150.0 + 1.0 + 200.0 + 1100.0) kJ mol⁻¹ *(03 + 01) ×4*

= <u>(+) 1151.0 kJ mol⁻¹</u> *(04 + 01)*

- Marks will be given for the correct steps of an enthalpy diagram, instead of the above cycle. = ΔS_4

$$\begin{tikzcd} HA_{(g)} \arrow[r, "\Delta S_5"] \arrow[d, "\Delta S_4"] & H^+_{(g)} \arrow[d, "\Delta S_3"] & + & A^-_{(g)} \arrow[d, phantom, "\Delta S_2"] \\ HA_{(aq)} \arrow[r, "\Delta H_1"] & H^+_{(aq)} & + & A^-_{(aq)} \end{tikzcd}$$

(04)

$\Delta S_5 = \Delta S_4 + \Delta S_1 - \Delta S_2 - \Delta H_3$ = - 100.0 +95.0 -(-2000.0) - (-1200.0)

= (-100.0 + 95 + 2000.0 + 1200.0) J K⁻¹ mol⁻¹ *(03+ 01) ×4*

(04 + 01)

= 3195.0JK-1 or 3.195 k mol⁻¹

- Marks will be given for the correct entropy diagram instead of the above.

III Gibbs energy changes at 300 K

For closed system at constant pressure,

$\Delta G = \Delta H - T\Delta S$ *(05)*

$= 1151.0\ \mathrm{kJ\ mol^{-1}} - 300\mathrm{K}\ 3.195\ \mathrm{kJ\ K^{-1}\ mol^{-1}}$ *(04 + 01)*

$= 192.5\ \mathrm{kJ\ mol^{-1}}$ *(04 + 01)*

- Marks are not awarded for $\Delta G^0 = \Delta G^0 - T\Delta S^0$

6 (b) iii) Gibbs energy change for the dissociation of HA in gas phase at 300 K is positive Therefore,

dissociation of HA in gas phase at 300 K is not spontaneous *(10)*

No marks are given if calculations for

ii) III is not done. But marks can earned based on the answer to b) (ii) III

iv) For the dissociation of HA in aqueous phase at 300 K,

$\Delta H_1 = 1.0\ \mathrm{kJ\ mol^{-1}}$ or $\Delta S_1 = 95.0\ \mathrm{JK^{-1}mol^{-1}}$

$\Delta G_1 = 1.0\ \mathrm{KJ\ mol^{-1}} - (300\mathrm{K} \times 95 \times 10^{-3}\ \mathrm{kJ\ mol^{-1}})$ *(04 + 01)*

$= \underline{\underline{-27.5\ \mathrm{kJ\ mol^{-1}}}}$ *(04 + 01)*

6 b v) Let T be the temperature at which the free energy of disso HA (g) become equal to the free energy change of disso HA(aq)

$\Delta G_{(g)} = \Delta H_s - T\Delta S_s$

$\Delta G_{(aqueous)} = \Delta H_1 - T\Delta S_1$

Since at temperature T, $\Delta G_{(gas)} = \Delta G_{(gas)} = \Delta G$

$\Delta H_s - T\Delta S_s = \Delta H_1 - T\Delta S_1$

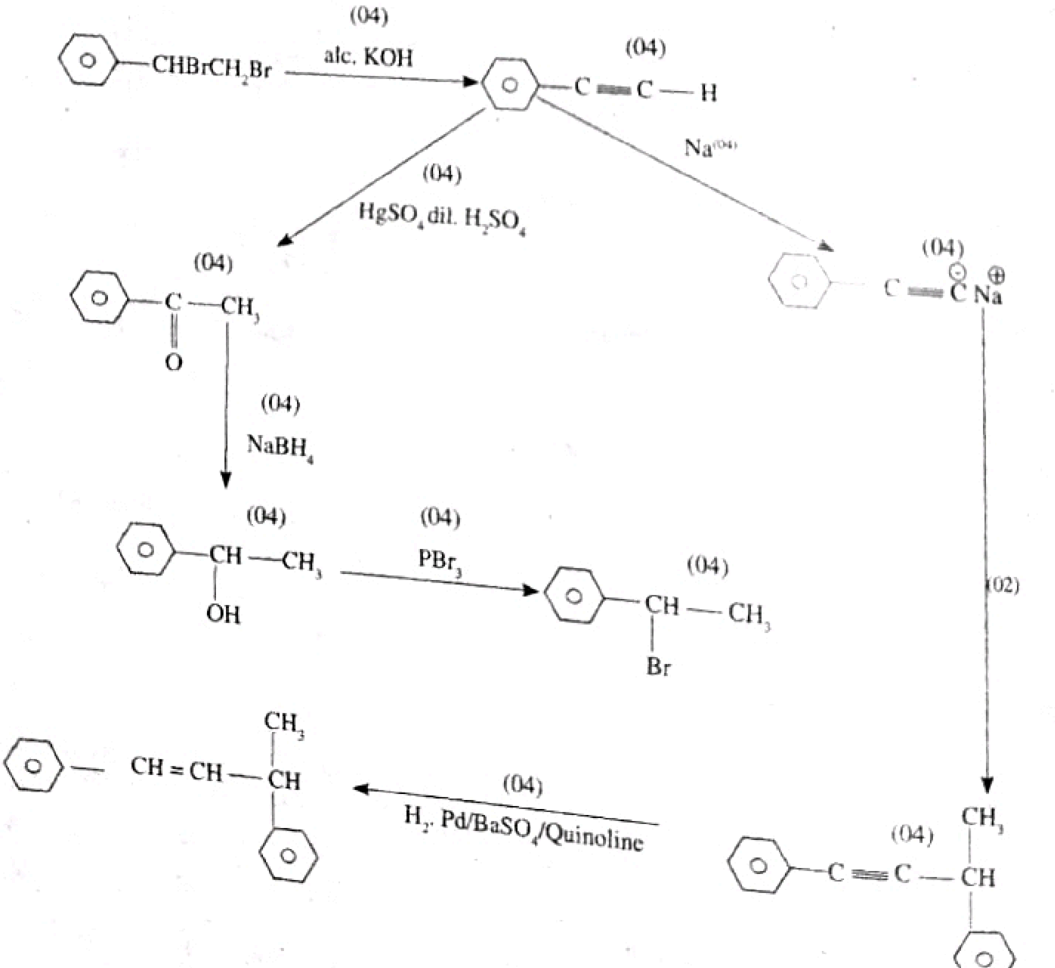
or $\Delta H_s - \Delta H_1 = T\Delta S_s - T\Delta S_1 = T(\Delta S_s - \Delta S_1)$

$\therefore T = \dfrac{\Delta H_s - \Delta H_1}{\Delta S_s - \Delta S_1}$

$T = \dfrac{(1151.0 - 1.0)\ \mathrm{kJ\ mol^{-1}}}{(3.195 - 0.095)\ \mathrm{kJ\ mol^{-1}}}$

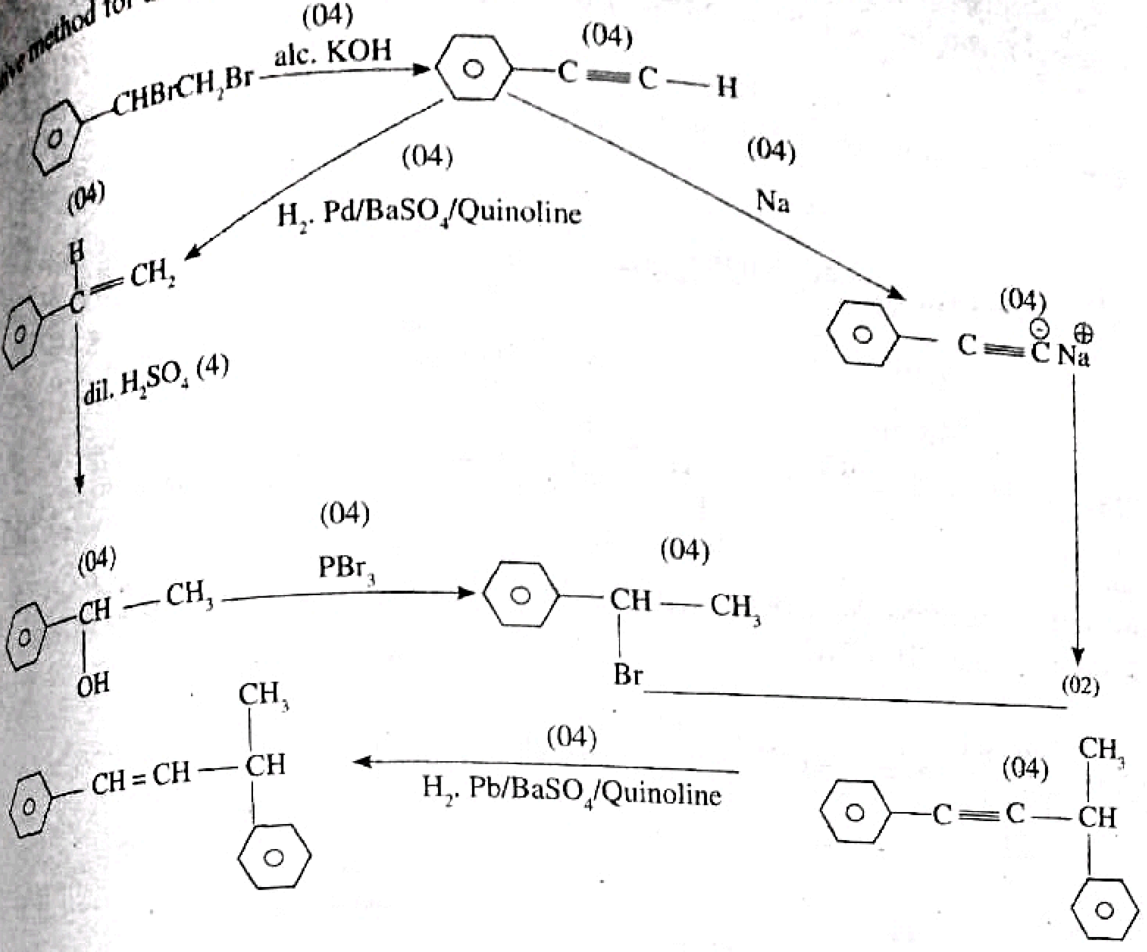
$\therefore T = \underline{\underline{370.9\ \mathrm{K}\ \text{or}\ 97.96°\mathrm{C}}}$

7. a)

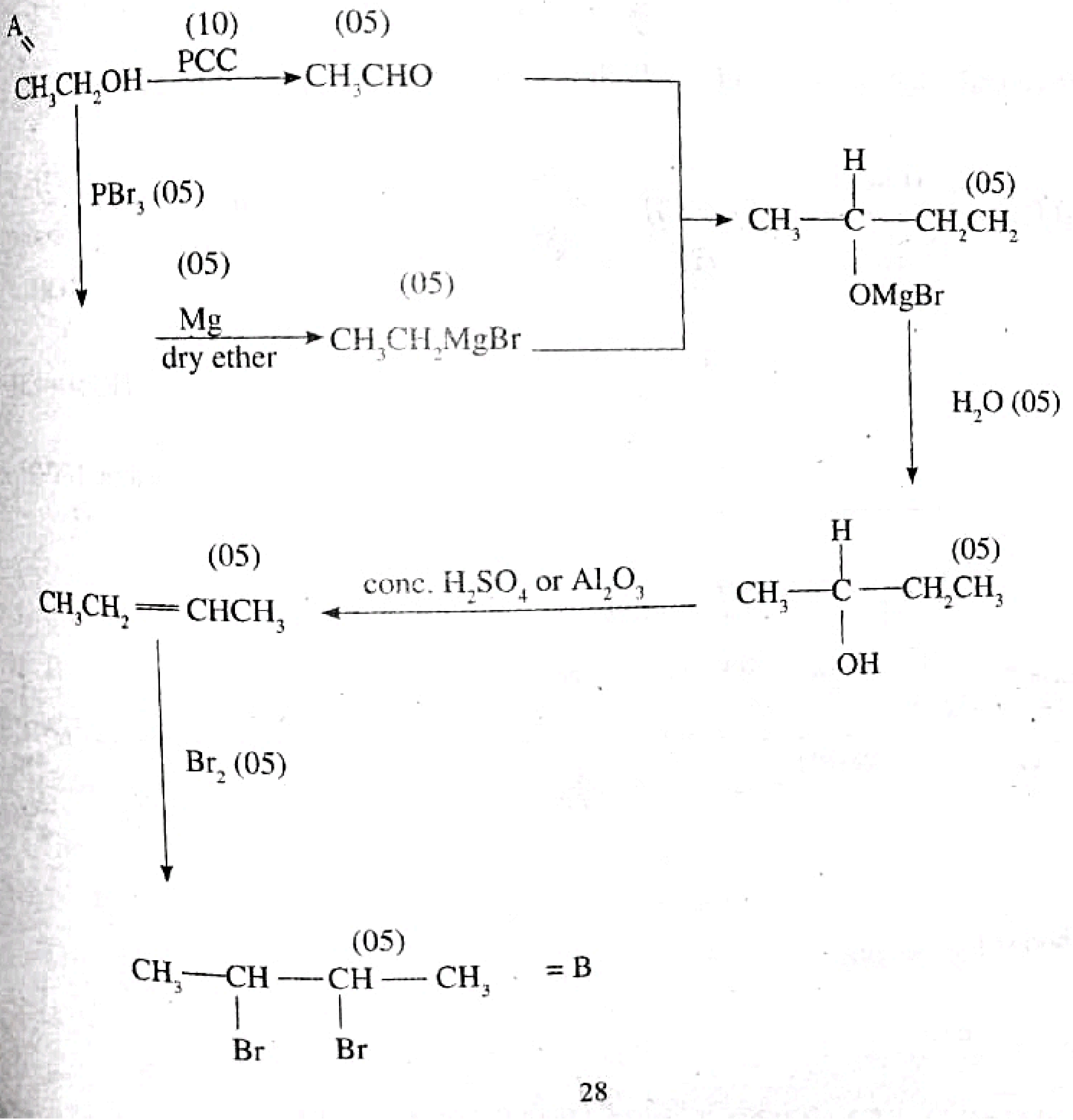


7(a) 50 marks

ative method for the synthesis:-

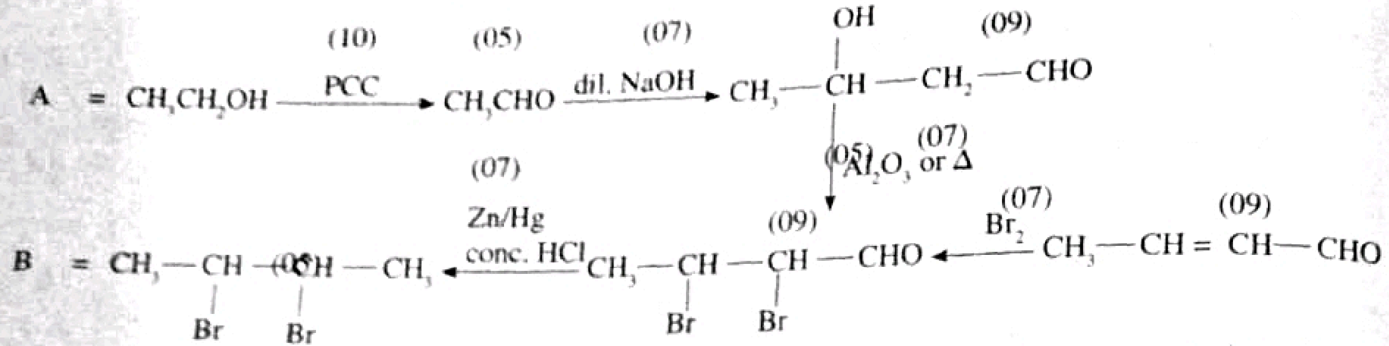


b)

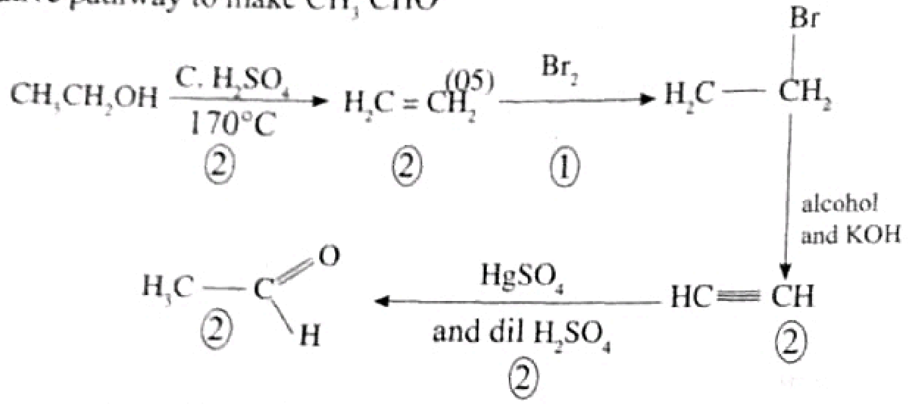


- In the 1st step, instead of PCC (pyridinium chloro chromate) either Cu at 300°C or distilling with acidif KMnO$_4$, or chromic acid, can be used. But, acidified KMnO$_4$ or chromic acid "under controlled conditions" not accepted.

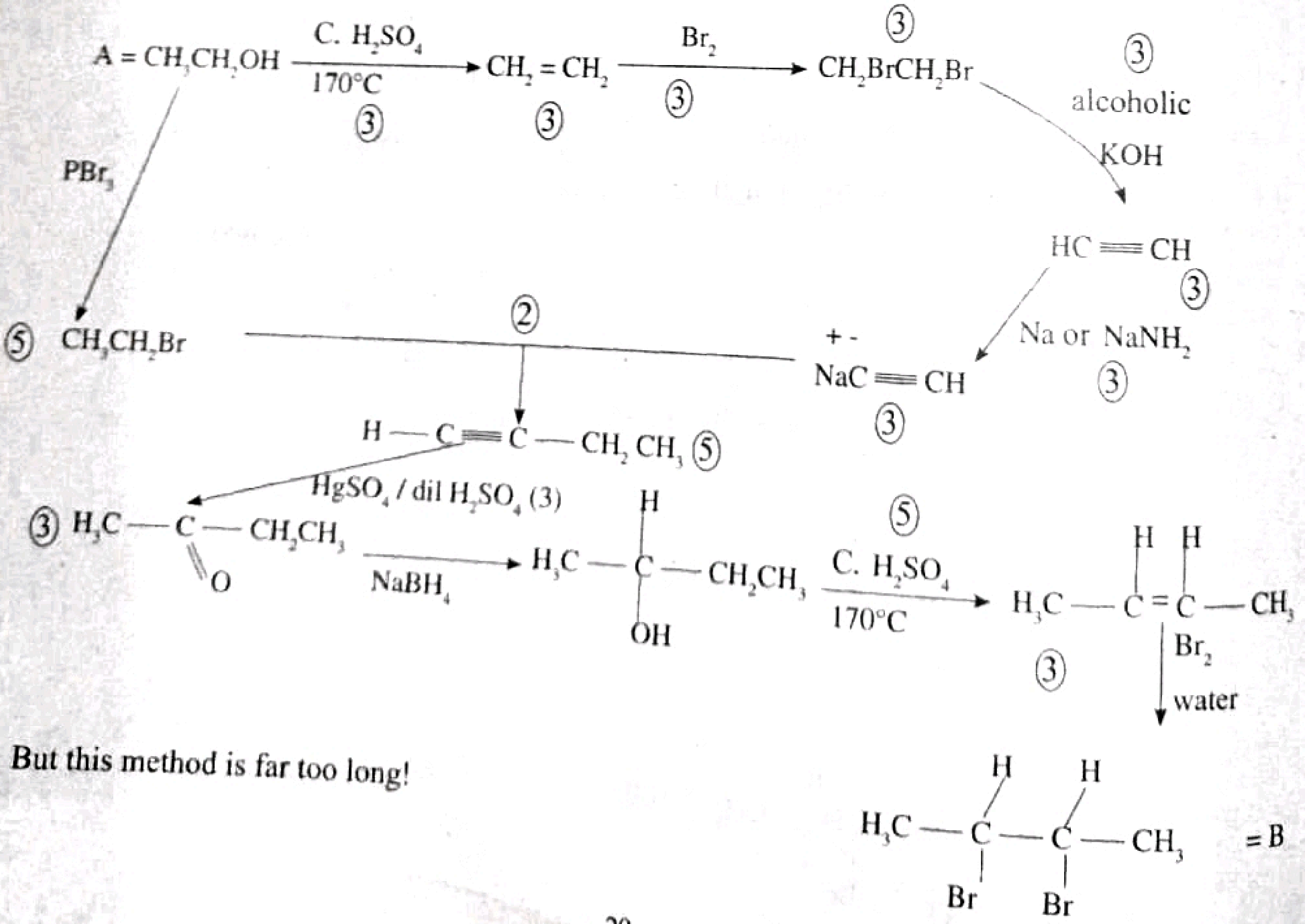
7. b) Alternative method for the above conversition



- Alternative paths with more steps, have been sugested, but they may not earn any marks at future exams! Alternative pathway to make CH_3 CHO



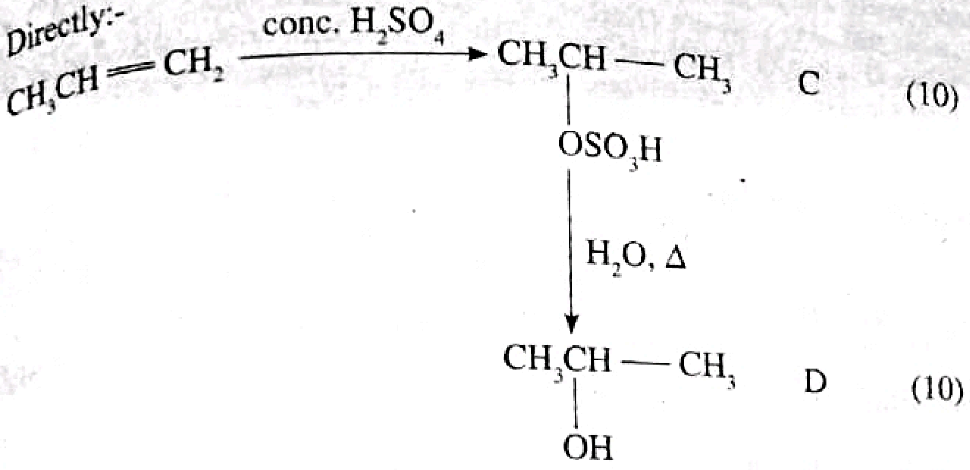
Another alternative pathway for A ⟶ B , which is much longer is as follows:-



But this method is far too long!

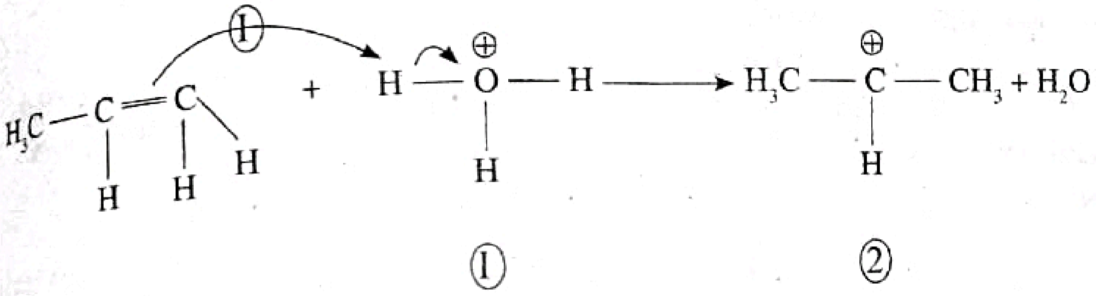
Directly:-

c)

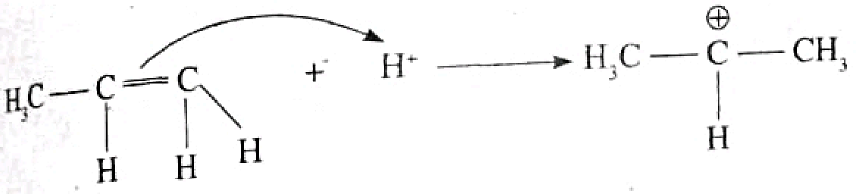


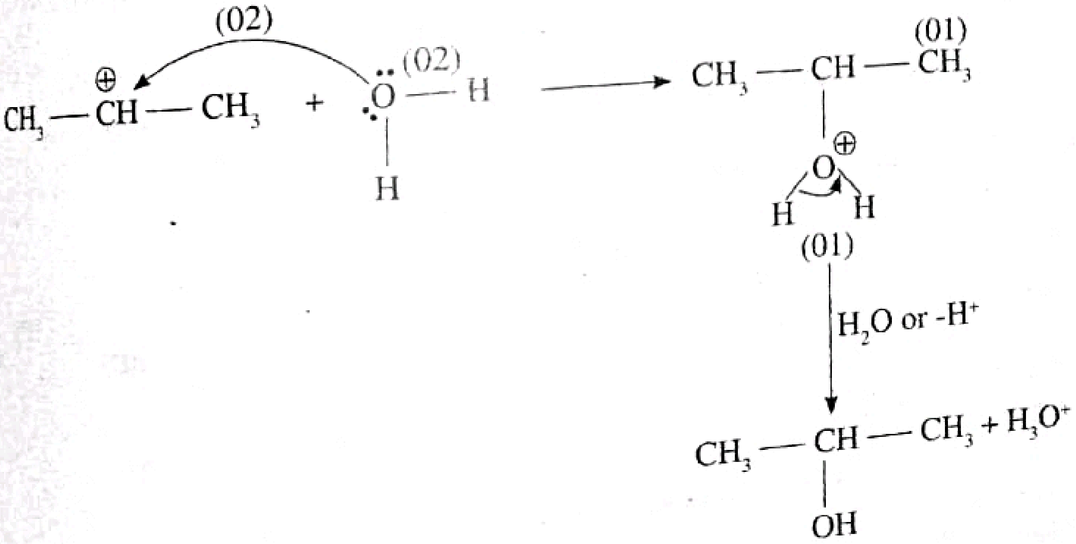
Reaction of CH_2 $CH = CH_2$ with dilute H_2SO_4 :

$$H_2O + H_2SO_4 \longrightarrow H_3\overset{\oplus}{O} + HSO_4^-$$



or





Statement only

The water in dilute H_2SO_4 can act as a mucleophile and react with the $CH_3-\overset{\oplus}{C}H-CH_3$ carbocation and form the alcohol

Note: If structure of carbocation is not given, No Marks for statement

(7 (c) 30 Marks)

8\. a) Reddish brown gas could be either NO_2 or Br_2. But Br_2 is not formed when a substancae is reacted with dil HCl ∴ S has to be NO_2, which is formed when a nitrite reacts with dil acid. ∴ Q is a nitrite. T giving a yellow flame means that it is a Na-salt - Nacl, as Q is reacted with a chloride, Hence Q is $NaNO_2$. So P must be $NaNO_3$ which decomposes when heated to give $NaNO_2$ and oxygen, which is the colourless gas R.

Y which turns phenolphthalein pink, must be an alkali and X is MgO as R is O_2. Hence Y is $Mg(OH)_2$

$$\underset{Q}{NaNO_2} + NH_4C\ell \xrightarrow{\Delta} \underset{T}{NaC\ell} + \underset{U}{N_2} + 2H_2O$$

$$3Ca + \underset{U}{N_2} \xrightarrow{\Delta} \underset{W}{Ca_3N_2} \text{ (white solid)}$$

Nitrides react with water to form ammonia ∴ V is NH_3

$$\therefore \underset{W}{Ca_3N_2} + 6H_2O \longrightarrow \underset{V}{2NH_3} + 3Ca(OH)_2$$

$$\underset{R}{3O_2} + \underset{V}{4NH_3} \xrightarrow{\Delta} \underset{U}{2N_2} + 6H_2O_{(g)}$$

$$2Mg + \underset{R}{O_2} \xrightarrow{\Delta} \underset{X}{2\,MgO}\,;\quad \underset{X}{MgO} + H_2O \longrightarrow \underset{Y}{Mg(OH)_2}$$

$P = NaNO_3$ $S = NO_2$ $V = NH_3$ $Y = Mg(OH)_2$

$Q = NaNO_2$ $T = NaC\ell$ $W = Ca_3N_2$

$R = O_2$ $U = N_2$ $X = MgO$

(05 × 10)

8 (a) 50 marks

8 b) (i) Z is H_2O_2 *(10)*

Reasons :- MnO_2 will oxidize H_2O_2 into $O_2(g)$. and pink manganese salt is formed.

H_2O_2 oxidises H_2S to pale yellow solid sulphur, H_2O_2 oxidises SO_2 in aqueous solution into sulphate. SO_4^{2-} gives a white precipitate of $BaSO_4$, which is insoluble in dil. HCl

ii) $MnO_2 + 4H^+ + 2e \longrightarrow Mn^{2+}\ 2H_2O$

$H_2O_2 \longrightarrow 2H^+ + O_2 + 2e$

or

$MnO_2 + H_2O_2 + 2H^+ \longrightarrow Mn^{2+} + 2H_2O + O_2$

$H_2S \longrightarrow S + 2H^+ + 2e$

$H_2O_2 + 2H^+ + 2e + 2H_2O$

or

$H_2O_2 + H_2S \longrightarrow S + 2H_2O$

$SO_2 + 2H_2O \longrightarrow SO_4^{2-} + 4H^+ + 2e$

$H_2O_2 + 2H^+ + 2e \longrightarrow 2H_2O$

or

$H_2O_2 + SO_2 \longrightarrow 2H^+ + SO_4^{2-}$ (or H_2SO_4)

$H_2SO_4 + BaC\ell_2 \longrightarrow BaSO_4\downarrow + 2HC\ell$

iii) Uses:
- As an antiseptic
- As a bleaching agent
- As a reducing agent
- As an oxidising agent

(iv) Hydrogen bonding / H - bonding

8 c) (i) I $2Cr^{3+} + 3S_2O_8^{2-} + 7H_2O \longrightarrow Cr_2O_7^{2-} + 6SO_4^{2-} + 14H^+$ *(04)*

II $6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \longrightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$ *(04)*

8 c) (ii)

Let the thickness of the chromium layer be y cm *(01)*

Area of the rectangular sample = $8.0 \times 5.0 = 40\ cm^2$ *(01 + 01)*

Volume of chromium layer = $40 \times y\ cm^3$ *(01 + 01)*

Mass of chromium layer = $40y \times 7.2$ g *(01 + 01)*

Moles of chromium in the layer = $\dfrac{40.0y \times 7.2}{52}$ = 5.54 *(02)*

Molar mass of $Fe(NH_4)_2(SO_4)_2.6H_2O$ = 392 g mol^{-1} *(02)*

Therefore, moles of Ferrous (Fe^{2+}) = $\dfrac{3.10}{392} = 7.908 \times 10^{-3}$ *(02)*

Moles of $K_2Cr_2O_7$ used to titrate excess Fe^{2+} = $\dfrac{0.05}{1000} \times 8.5$

$6Fe^{2+} : 1\ Cr_2O_7^{2-}$ *(03)*

∴ Moles of excess $Fe^{2+} = \dfrac{0.05}{1000} \times 8.5 = 2.55 \times 10^{-3}$ *(03)*

Therefore, moles of Fe^{2+} reacted with $Cr_2O_7^{2-}$ formed as a result of dissolution of chromium layer in the sample

$$= \left(\frac{3.10}{392}\right) - \left(\frac{6 \times 0.05 \times 8.5}{1000}\right)$$

$$= (7.908 \times 10^{-3}) - (2.55 \times 10^{-3}) = 5.358 \times 10^{-3}$$ *(03)*

Therefore, moles of $Cr_2O_7^{2-}$ due to dissolution of chromium layer *(03)*

$$= \frac{1}{6} \times 5.38 \times 10^{-3}$$

Therefore, moles of Cr^{3+}

$$= \frac{1}{6} \times 5.358 \times 10^{-3} = 1.786 \times 10^{-3}$$ *(03)*

$$\frac{40.0 \times y \times 7.2}{52} = 1.786 \times 10^{-3}$$ *- (03) + (03)*

$$y \underline{= 3.2 \times 10^{-4} (cm)}$$ *(05)*

Alternative Answer

Let the thickness of the chromium layer be y cm (01)

Molar mass of $Fe(NH_4)_2(SO_4)_2\,6H_2O$ = $392\ g\ mol^{-1}$ (02)

Initial moles of Ferrous (Fe^{2+}) = $\frac{3.10}{392}$ (02)

Moles of $K_2Cr_2O_7$ used to titrate exess Fe^{2+} = $\frac{0.05}{1000} \times 8.5$ (03)

$Fe^{2+} : Cr_2O_7^{2-}$ = 6 : 1

Moles of excess (unreacted) Fe^{2+} = $6 \times \frac{0.05}{1000} \times 8.5$ (03)

Therefore, moles of Fe^{2+} reacted with $Cr_2O_7^{2-}$ formed as a result of dissolution of chromium layer in the sample

$$= \left(\frac{3.10}{392}\right) - \left(6 \times \frac{0.05}{1000} \times 8.5\right)$$

$$= (7.908 \times 10^{-3}) - (2.55 \times 10^{-3}) = 5.358 \times 10^{-3}$$

(03 + 03)

chromium layer = $\frac{1}{6} \times 58 \times 10^{-3}$ (03)

Therefore moles of Cr layer = $2 \times \frac{1}{6} \times 5.358 \times 10^{-3} = 1.786 \times 10^{-3}$ (03 +03)

Mass of Cr layer = $1.786 \times 10^{-3} \times 52\ g$ (03)

∴ Volume of Cr layer = $\frac{1.786 \times 10^{-3} \times 52\ cm^3}{7.2}$ (03)

$= 0.01288\ cm^3$

$y\ cm \times 8.0\ cm \times 5.0\ cm = 0.01288$ cm3 (03)

$y = \frac{0.01288}{40}$

$= 3.224 \times 10^{-4} cm$ <u>Ω 3.2×10^{-4} cm</u> (05)

8c Total = 50

9 a) (i) hematite -Fe_2O_3 **Or** Magnetite - Fe_3O_4 (02

coke - C

limestone - $CaCO_3$ **Or** dolomite - $CaCO_3 . MgCO_3$ (02 +

(ii) Coke

(1) Coke burns in air to give CO_2 **(01)** with liberation of a large amount of heat **(01)** This helps to keep the temperature of the furnace very high **(01)** at the bottom **(01)**

$C + O_2 \longrightarrow CO_2$ + heat **(01)**

(2) The CO_2 formed reacts with C to give CO **(01)** which is the main reducing agent (01) in the conversion of iron oxide to iron

$CO_2 + C \longrightarrow 2CO$ **(01)**

(3) To reduce FeO directly by C **(01)**

$2FeO + C \longrightarrow 2Fe + CO_2$ **(01)**

<u>CaCO₃</u>

This is used to remove impurities (01) such as sand / silicates (01), alumina (01) from the ore by slag formation (01).

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$ (02)

$CaO + SiO_2 \longrightarrow CaSiO_3$ (slag) (02)

$CaO + Al_2O_3 \longrightarrow Ca(AlO_2)_2$ (slag) (02)

or $CaO + P_2O_5 \longrightarrow Ca_3(PO_4)_2$

Slag is obtained in the molten state **(01)** and is less dense than the molten iron **(01)** Therefore, slag floats on top of the iron (01) prevents atmospheric oxidation **(01)**, mainly due to the hot air blown at the bottom

(iii) $3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$ *(01)*

$Fe_3O_4 + CO \longrightarrow 3FeO + CO_2$ *(02)*

$FeO + CO \longrightarrow Fe + CO_2$ *(03)*

Or $2FeO + C \longrightarrow 2Fe + CO_2$ *(04)*

** Note: Marks will be awarded only once*

(iv) Pig iron

Composition : Fe (01); 3 - 4% C (01); Si, P, S, Mn (any **three**) *(02)*

(v) (1) Reduce carbon content *(01)*

(2) Remove Si, Mn, P as slag *(02)*

(3) Add alloying elemcents or adding Cr/ Ni *(02)*

Heat with air or O_2 **or** Blow hot air **or** O_2 to molten iron *(02)*

(vi)(1) From part (iii) , Add eq. (1) + (2) × 2 + (3) × 6 **or** otherwise to give *(02)*

$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

To produce 2 moles of Fe, require 3 moles of CO *(05)*

to produce 2 × 56 g of Fe, require 3 × 28 g of CO *(01)*

Therefore, to produce 2000 kg of Fe, require *(01)* $\frac{3 \times 28 \;\; 2000}{3 \times 50}$ kg of CO

$= \underline{\underline{1500 \text{ kg}}}$

or Combining equation (2) and equation (3) × 3 in part (iii),

$Fe_3O_4 + 4CO \longrightarrow 3Fe + 4CO_2$

1 : 4 3 : 4

3 moles of Fe is obtained from 4 moles of CO

∴ 2000 kg of Fe from $\frac{4 \times (12 + 16) \times 10^{-3}}{56 \times 3 \times 10^{-3}} \times 2000$ kg

$= \underline{\underline{1333 \text{ kg of Co}}}$

CO_2+ CO, N_2

(viii) Predominant species : N_2

(01 + 01 + 01)

(02)

9 (a) 75 marks

(a) I Atmosphere - CO_2, CH_4, volatile hydrocarbons (other than CH_4) CO,Carbon or soot particles.

II Lithosphere - fossil fuels, graphite, diamond, coke, minerals containing carbonates and bicarbonates.\

III Hydrosphere - (dissolved in water of sea, rivers, lakes etc) CO_2 As H_2CO_3 carbonates,bicarbonates.

(02 + 02) × 3

(ii) Processes that remove CO_2

- Photosynthesis
- CO_2 dissolving in water of sea, rivers, lakes etc
- CO_2 combining with hydroxides or oxides resulting in carbonate deposits lite corals, limestone etc.

Processes that release CO_2 :-

- Respiration by all living organisms
- Ruminant animals produce CH_4 in their digestive systems during fermentation of their food, by anaerobic get bacteria.
- Volcanic eruptions and natural fires (Bush fires) give out CO_2, along with other species of carbon
- Bacterial decomposition of dead organic matter, releases CO_2 and CH_4 This means that microorganisms can get the carbon in dead plants and animals, back into the atmosphere.

(any 5 × 04)

(iii)
- Deforestation :- Green leaves absorb CO_2 for photosynthuis. Extensive cutting down of trees greatly reduces removal of CO_2 from air.
- Volatile carbon compounds can be formed during synthesis of halogenated hydrxocarbons.
- Animal husbandary (animal farming / live stock release CH_4 Also, wetland based agriculture like paddy cultivation contributes to CH_4 release.
- Extensive burning of fossil fuels releases CO_2, CO and soot particles, along with unburnt hydrocarbon vapours, into the atmosphere.

(any 3) (3 × 04)

(iv)
- Depletion of ozone layer - from CFC s
- Global warming - by green-house gases released.
- Photochemical smog - Various chemical reactions occur in the upper atmosphere, initiated by solar energy. Among these is the formation methanal and other molecules which combine to form larger particles. These particles, and brown colour of NO_2, give the air a dirty, smoggy appearance.

(any 2 × 5) (3 04)

(v) • CO_2 ; CH_4 ; hydrocarbons ; NO ; (NO_2) , halogenated hydrocarbons or CFC, HCFC, HFC; PAN (peroxy acety / nitrate) ; aldehydos ; ketones.

(any 3 × 03)

(iv) **Photochemical smog -**

- Causes eye - irritation
- Vision gets impaired
- Toxic and causes respiratory diseases

Global warming -

- Increase in global temperature
- Extensive snowing
- Frequent tornadoes /whirl winds.
- Desertification of arable land.
- Drying up of fresh -water - bodies.
- Extinction of certain species
- Melting of polar ice caps/glaciers causing a rise in sea level
- Change in rainfall patterns
- Long term droughts.
- Frequently occuing warm air currents
- Epidemics

Ozone layer depletion

- Skin cancers
- Respiratory diseases
- Cataract (in eyes)
- Death by heat stroke.

(2 effects × problems 3 × 2 + 3 × 2)

10 a) (i) $1\,ClO^-_{(aq)} + 2H^+ + Cl^-_{(aq)} \longrightarrow Cl_{2(g)} + H_2O$ (given)

$Cl_2 + 2I^- \longrightarrow I_2 + 2Cl^-$ (02)

or

$ClO^- + 2H^+ + 2I^- \longrightarrow I_2 + Cl^- + H_2O$ (06)

Alternate answer:

$ClO^-_{(aq)} + 2H^+ + 2e \longrightarrow Cl^- + H_2O$ (02)

$2I^- \longrightarrow I_2 + 2e$ (02)

or

$ClO^- + 2H^+ + 2I^- \longrightarrow I_2 + Cl^- + H_2O$ (06)

$I_2 + 2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2I^-$ (02)

(II) Moles of $S_2O_3^{2-}$ = $\frac{0.3 \times 19.0}{1000}$ (02)

Moles of I_2 = $\frac{1}{2} \times \frac{0.3 \times 19.0}{1000}$ (02)

Moles of ClO^- = $\frac{1}{2} \times \frac{0.3 \times 19.0}{1000}$ (02)

= 2.85×10^{-3} (02)

Moles of ClO^- in 250 cm^3 = $2.85 \times 10^{-3} \times 10$ (02)

= 2.85×10^{-2} (02)

∴ No. of moles of Cl_2 that can be used = 2.85×10^{-2} (02)

Mass of Cl_2 in 250.0 cm^3 = $2.85 \times 10^{-2} \times 71$g (02)

Mass of bleach solution = 25.0×1.2 (02)

= 30 g (01)

% Cl_2 that can be used = $\frac{\text{Mass of usable } Cl_2 \text{ in } 250.0\ cm^3 \times 100}{\text{mass of bleach solution}}$ (03)

∴ % of useable Cl_2 = $\frac{2.85 \times 10^{-2} \times 71}{30} \times 100\%$ (01)

= $\underline{\underline{6.8\%}}$

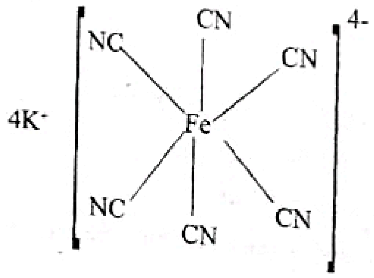
(Answers between 6.7 6.8% can be given) (04)

10 a) ii) I $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^6\,4s^2$ or $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,3d^6$ (05)

II +2; +3 or +II; + III (05 + 05)

III $4K^+\,[Fe(CN)_6]^{4-}$ or $K_4\,[Fe(CN)_6]$ (05)

Alternate answer for 10 a (iii)



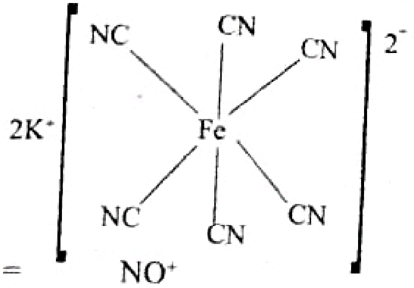
potassium hexacyanoferrate (II)

IV Or potassium hexacyanido ferrate (II)

$K_2[Fe(CN)_5NO]$ or $K_2[Fe(NO)(CN)_5]$ or (05)

V $2K^+[Fe(CN)_5(NO)]^{2-}$ or $2K^+[Fe(NO)(CN)_5]^{2-}$

Alternate answer for 10 a (ii)



(05)

VI Entering Group = NO^+

(05)

Leaving group = CN^-

(05)

(10 (a)75 marks

10) b) i) Amount of D in 1.0 dm³ of waster water = $0.001\ mol\ dm^{-3} \times 1.0\ dm^3$ (04 + 01)

= 0.001 mol (04 + 01)

Amount of electrons released when the above amount of D is oxidized

= 0.001 mol × 2

= 0.002 mol (04 + 01)

Amount of electricity (charge) needed

= $96500\ C\ mol^{-1} \times 0.002\ mol$ (04 + 01)

Time required of complete oxidation of D in 1.0 dm³ waste water

$$= \frac{96500\ C\ mol^{-1} \times 0.002\ mol}{100 \times 10^{-3}\ Cs^{-1}}$$ (04 + 01)

= $\underline{1.93 \times 10^3\ s}$ **or** $\underline{32.16\ min}$ **or** 0.536h

(04 + 01)

ii) At 25⁰C,

During the electrochemical process OH^- is produced.

$[OH^-]$ = $0.001\ mol\ dm^{-3} \times 2$ (04 + 01)

pOH = $-\log_{10}[OH^-]$; ∴ pOH = -log (0.002) (04 + 01)

= 2.698

pH = pkw - pOH ∴ pH = 14.0 - 2.698 (04 + 01)

pH = $\underline{\underline{11.3}}$ (04 + 01)

iii) When waste water is released continuously, current must be supplied to the cell continuously.

Current needed to be supplied = $0.001\ mol\ dm^{-3} \times 2 \times 96500\ C\ mol^{-1} \times 10.0\ dm^3\ s^{-1}$ (04 + 01) × 3

(08+02)

= $\underline{\underline{1930\ C\ s^{-1}\ \text{or}\ 1930\ A}}$ (10(b) 75 maks)