Answers for MCQ

Chemistry I GCE A/L 2013

1 - 5	11 - 5	21 -2	31 - 3	41 - 4
2 - 5	12 - 2	22 - 2	32 - 5	42 - 2
3 - 4	13 - 5	23 - 3	33 - 1	43 - 4
4 - 3	14 - 2	24 - 2	34 - 5	44 - 3
5 - 2	15 - 1	25 - 1	35 - 4	45 - 1/2
6 - 1	16 - 4	26 - 1	36 - 4	46 - 5
7 - 4	17 - 3	27 - 2	37 - 1	47 - 1
8 - 3	18 - 4	28 - 4	38 - 3	48 - all/3/5
9 - 1	19 - 5	29 - 2	39 - 3	49 - 3
10 - 2	20 - 2	30 - 3	40 - 4/5	50 - 5

Answers

Chemistry II GCE A/L 2013

Part A - Structured Essay

01. a) (i) $CO < CO_2 < CO_3^{2-}$

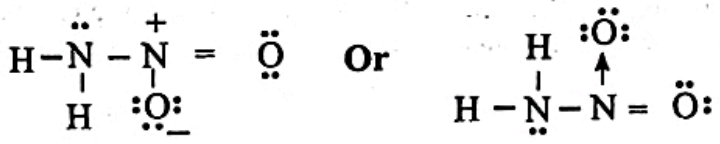
(ii) $NH_3 < NO_3^- < NO_2^+$

(iii) $BaSO_4 < MgSO_4 < CaSO_4$

(iv) $Ne < Ar < Kr$ (van der Wall forces of attraction are greater when atom/molecule gets larger)

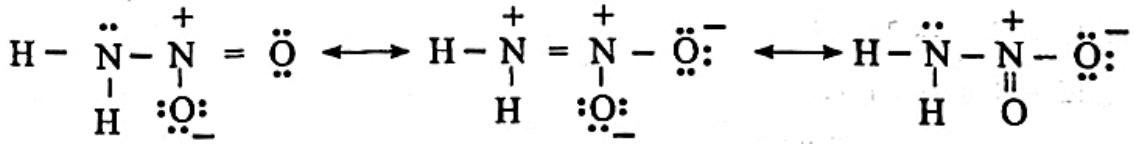
(v) $F < C\ell < S < Si$

b) (i)



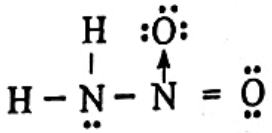
Or

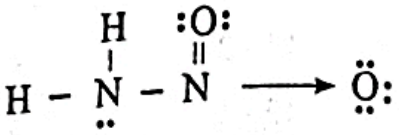
(ii)

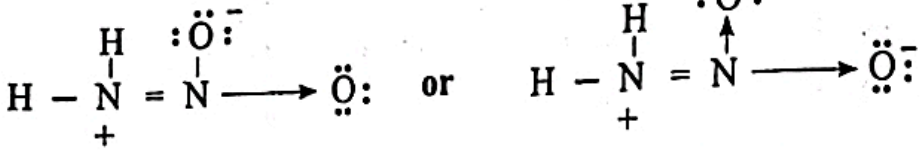


A	B	C
Stable because opposite charges on adjacent atoms, with negative charge on the more electro negative oxygen	**Unstable** because two opposite charges are on adjacent (nitrogen) atoms	**Stable** because Opposite charges are on adjacent atoms, with negative charge on the more electronegative oxygen.

Alternative answer

A 

B 

C 

(iii)

	N attached to 2 H atoms	N attached to 2 O atoms
I.....	..... tetrahedral	..... trigonal planar
II.....	..... pyramidal	..... trigonal planar
III	..... sp^3	..... sp^2 .....

(iv) Molecule is **polar.**

(v) I ..... sp^3 (hybrid orbital) + sp^3 (hybrid orbital)

II ..... sp^3 (hybrid orbital) + ls (atomic orbital)

(Type of orbital in words is not necessary. But for hydrogen, only ls is accepted.)

2. (a) (i) A = Li; B = H_2; C = Li_3N;

D = LiH; E = NH_3

(If A is incorrect, no marks for B,C,D &E)

[*Reasons* :- 1st I.E. is highest in elements at the top, at the top, as the number of screening (electron filled) shell between the nucleus and last electron, is less. So A in (s) block should be either Li or Be. But only Li gives a red flame]

(ii) $2Li + 2H_2O \longrightarrow 2\,LiOH + H_2$

$2\,LiOH \longrightarrow Li_2O + H_2O$

$6\,Li + N_2 \longrightarrow 2\,Li_3N$

$2\,Li + H_2 \longrightarrow 2\,LiH$

$Li_3N + 3H_2O \longrightarrow 3LiOH + NH_3$

(b) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3$ Or $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$

(ii) + 2 ; + 3 ; + 4 ; + 5 Or +II; + III; + IV; + V

Or 2 ; 3 ; 4 ; 5 Or II ; III ; IV; V

(iii) + 2 ... VO ... basic

+3 ... V_2O_3 basic

+ 4 ... VO_2 amphoteric

+5 ... V_2O_5 acidic (amphoteric also accepted)

(iv) VO_2^+ ...yellow, VO^{2+} ... blue

(V^{3+} and V^{2+}, are not oxocations)

(v) $[Cr(H_2O)_6]^{3+}$ ... violet or blue-violet

or $Cr^{3+}_{(aq)}$ or Cr^{3+} ... green

With Na_2CO_3 ⟶ Green precipitate or evolution of (colourless) bubbles
[evolution of CO_2 was also accepted though you cannot actually see that it is CO_2]

(vi) V is used as in steel-alloys

or used as a catalyst [as V_2O_5 in contact process for manufacture of H_2SO_4]

(vii) I ..... green precipitate (of $Cr(OH)_3$)

II ..... yellow solution (H_2O_2 Oxidises Cr of oxidation state + 3 , to + 6 in chromate. CrO_4^- is yellow

(viii) X = CrO_3 , Y = Cr_2O_3

(ix) Orange solution turus yellow

(Dichromates are converted to chromates in alkaline medium)

(x) Advantage :- Titration can be done in the presence of chloride ions.

or It is a primary standard.

Disadvantage :- Difficult to observe a sharp colour change at the end point

Or It is not a self-indicator and hence an external indicator is needed.

3. (i) Oxidation reaction: $M^{2+} \longrightarrow M^{3+}_{(aq)} + e$

Reduction reaction: $C\ell_{2(g)} + 2e \longrightarrow 2\,C\ell^-_{(aq)}$

Cell reaction : $2M^{2+}_{(aq)} + C\ell_{2(g)} \longrightarrow 2M^{3+}_{(aq)} + 2\,C\ell^-_{(aq)}$.

(ii) A : $C\ell_{2(g,1atm)}$,

B : Salt bridge

C : Volt meter / Potentiometer

D : $C\ell^-$ (aq, 1.0 mol dm^{-3})

E : Mixture of $M^{2+}_{(aq1.0\ mol\ dm^{-3})}$ and $M^{3+}_{(aq1.0\ mol\ dm^{-3})}$

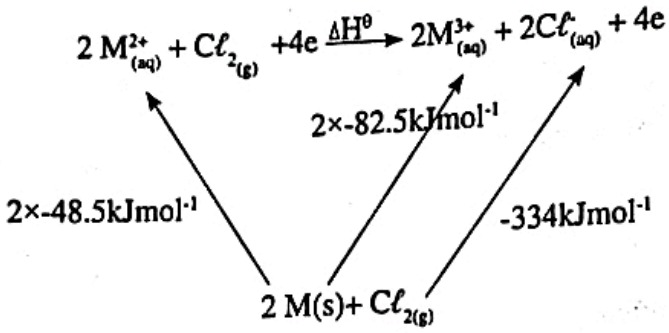
(iii) $E^{\theta}_{cell} = E^{\theta}_{RHS} - E^{\theta}_{LHS}$ or $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$

or $E^{\theta}_{cell} = E^{\theta}_{C\ell_2/C\ell^-} - E^{\theta}_{M^{3+}/M^{2+}}$ or

$E^{\theta}_{cell} = 1.36V - 0.77\ V$

$= 0.59V$

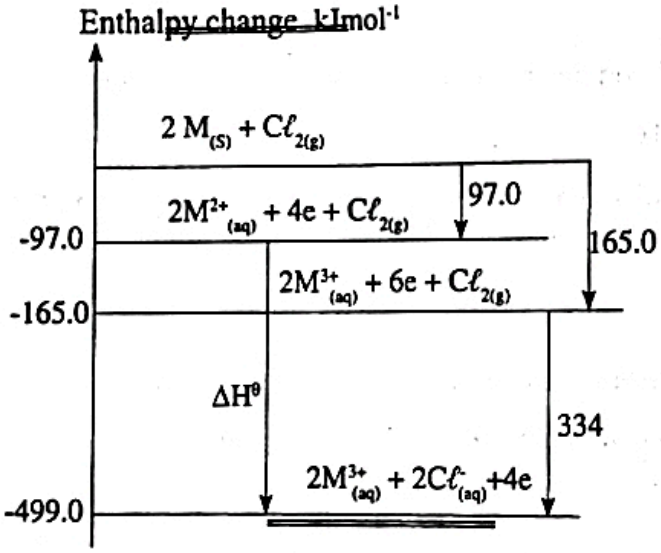
(iv)



$\Delta H^{\theta} = (2\times -82.5\ kJ\ mol^{-1}) + (-334\ kJ\ mol^{-1}) - (2 \times -48.5\ kJ\ mol^{-1})$

$= -402\ kJ\ mol^{-1}$

(iv) or



$\Delta H^{\theta} = (2 \times -82.5\ kJ\ mol^{-1}) + (-334 kJmol^{-1}) - (2 \times 48.5\ kJ\ mol^{-1})$

$= -402\ kJ\ mol^{-1}$

(v) $\Delta G^{\theta} = -k\ E^{\theta}_{cell} = (-1.93 \times 10^5\ Jmol^{-1}V^{-1}) \times 0.59\ V$

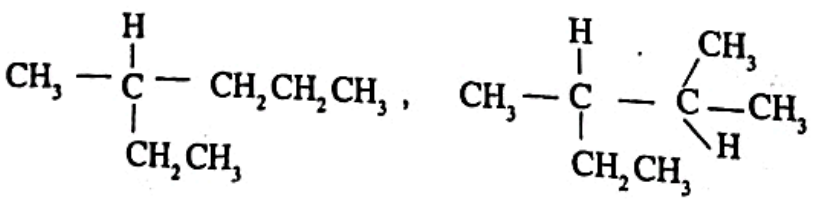
$= -1.1387 \times 10^{-5}\ Jmol^{-1} = 113.87\ kJmol^{-1}$

$\Delta G^{\theta} = \Delta H^{\theta} - T\Delta S^{\theta}$ (standard states essential)

$-113.87\ kJ\ mol^{-1} = -402 kJmol^{-1} - 298\ (K)\ \Delta S^{\theta}$

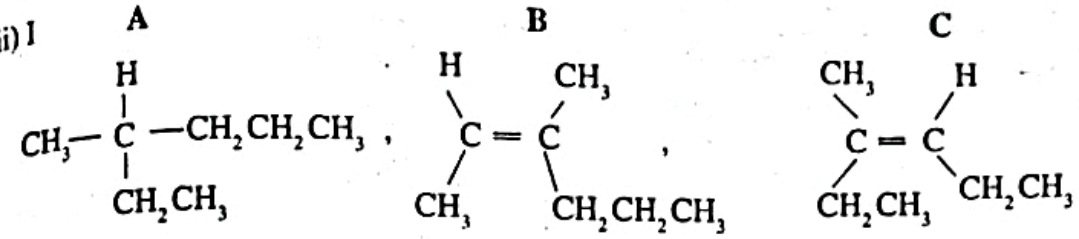
$\therefore \quad \Delta S^{\theta} = 288 kJmol^{-1} \div (-298K)$

$\Delta S^{\theta} = -0.97\ kJmol^{-1}K^{-1}$

4. (a) (i) I 

II structural isomers or chain isomers or constitutional isomers.

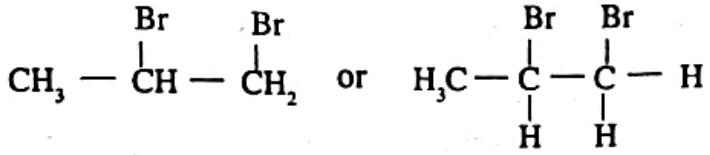
(ii) I



II B is 3 - methyl - 2 - hexene or 3 - methylhex -2 - ene

C is 3 - methyl - 3- hexene or 3 - methylhex -3 - ene

(if B & C in I are interchanged, the correct IUPAC names should be written accordingly)

(b) (i) P 

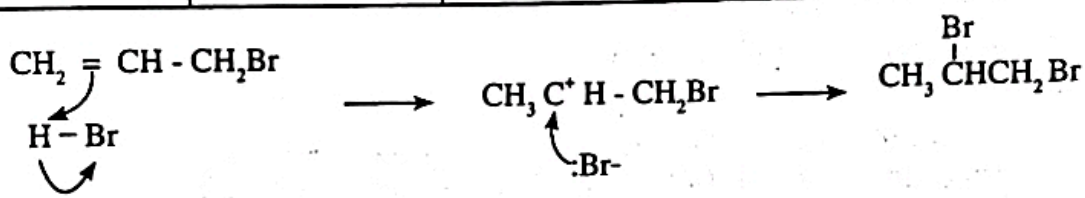
Q $CH_3C \equiv CH$ or $H_3C-C \equiv C-H$

R $CH_3C \equiv C^-Na^+$ or $CH_3C \equiv CNa$ or $H_3C-C \equiv C^-Na^+$ or $H_3C-C \equiv CNa$

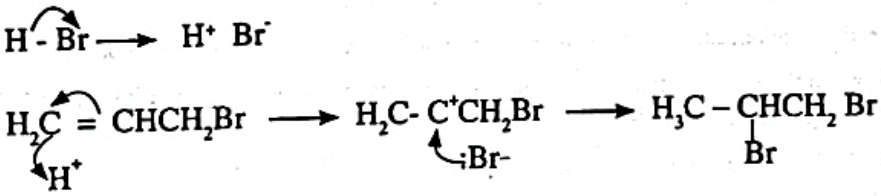
S $CH_3C \equiv C-CH_2CH_3$ or $H_3C-C \equiv C-CH_2CH_3$

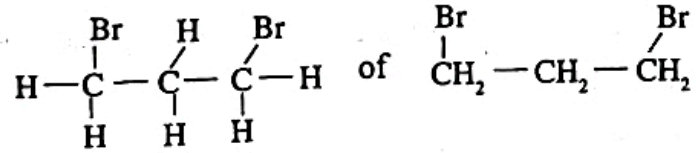
(ii)

Reaction	1	2	3	4
Reaction type	A_E	E.	AB	S_N

(iii) 

Alternate answer:



(iv) T: 

(v) The intermediate carbocation for 'P', which is $CH_3-C^+HCH_2Br$, is more stable since it is a secondary carbocation. Therefore P is formed faster.

The intermediate carbo cation for T, which is $C^+H_2-CH_2-CH_2Br$, being a primary carbocation, is less stable.

Answers

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Part B - Essay

05. a) (i) the total number of moles in the gas phase = n

Using PV = nRT

$$n = \frac{PV}{RT}$$

$$n = \frac{1.0 \times 10^3\ Pa \times 0.8314\ m^3}{8.314\ J\ mol^{-1}\ K^{-1} \times 200\ K}$$

$$n = 0.5\ mol$$

(ii) the mole fractions of A and B in the liquid phase

Number of moles of A in gas phase $= n_A$, Number of moles of B in gas phase $= n_B$, mole fraction of A in gas phase $= X_A$, mole fraction of B in gas phase $= X_B$, mole fraction of A in liquid phase $= X^1_A$, mole fraction of B in liquid phase $= X^1_B$

$$\frac{X_A}{X_B} = \frac{n_A}{n_B} = \frac{2}{3}$$

$n = n_A + n_B = 0.5$

$n_A = 0.2\ mol$

$n_B = 0.3\ mol$

Amount of A left in the liquid phase = (1.0 - 0.2) mol = 0.8 mol

Amount of B left in the liquid phase = (1.0 - 0.3) mol = 0.7 mol

$$X^1_A = \frac{0.8\ mol}{(0.8 + 0.7)\ mol} = \frac{8}{15} = 0.533$$

$$X^1_B = \frac{0.7\ mol}{(0.8 + 0.7)\ mol} = \frac{7}{15} = 0.467$$

(The steps can be combined)

(iii) The saturated vapour pressures of A and B.

Partial pressure of A = P_A, Partial pressure of B = P_B, Saturated vapour pressure of A = P^0_A saturated vapour pressure of B = P^0_B

Applying Daltons law.

$P_A = P \times X_A = 1.0 \times 10^3 \text{ Pa} \frac{0.2 \text{ mol}}{0.5 \text{ mol}}$

$P_A = 4.0 \times 10^2 \text{ Pa}$

Similarly

$P_B = P \times X_B = 1.0 \times 10^3 \text{ Pa} \frac{0.3 \text{ mol}}{0.5 \text{ mol}}$

$P_B = 6.0 \times 10^2 \text{ Pa}$

Applying Raoults law

$P_A^\theta = \frac{P_A}{X_A} = \frac{4.0 \times 10^2 \text{ Pa}}{8/15}$

$= 7.5 \times 10^2 \text{ Pa}$

$P_B^\theta = \frac{P_B}{X_B} = \frac{6.0 \times 10^2 \text{ Pa}}{7/15}$

$= \underline{1.286 \times 10^3 \text{ Pa}}$

(b) (i) $Mn(OH)_2(s) \rightleftharpoons Mn^{2+}(aq) + 2OH^-(aq)$ ..... (physical states required)

$K_{SP} = [Mn^{2+}(aq)]\,[OH^-(aq)]^2$ ..... (physical states required)

$K_{SP} = 1 \times 10^{-5} \text{ mol dm}^{-3} \times (2 \times 10^{-5} \text{ mol dm}^{-3})^2$

$K_{SP} = 4 \times 10^{-15} \text{ mol}^3 \text{ dm}^{-9}$

(ii) $NH_4OH(aq) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$ ..... (physical states required)

$K_b = \frac{[NH_4^+(aq)]\,[OH^-(aq)]}{[NH_4OH(aq)]}$ ..... (physical states required)

Since NH_4OH is a weak base, amount dissociated is very small

$[NH_4^+(aq)] = [OH^-(aq)]$ or $[NH_4OH] = 0.01 \text{ mol dm}^3$

$1.6 \times 10^{-5} \text{ mol dm}^{-3} = \frac{[OH^-(aq)]^2 (\text{mol dm}^{-3})^2}{0.01 \text{ mol dm}^{-3}}$

$[OH^-(aq)] = 4.0 \times 10^{-4} \text{ mol dm}^{-3}$

(iii) $K_{SP} = [Mn^{2+}(aq)]\,]OH^-(aq)]^2$

$4 \times 10^{-15} (\text{mol}^3\text{dm}^{-9}) = 10^{-3} (\text{mol dm}^{-3}) \times [OH(aq)]^2$

$[OH\text{-}(aq)]^2 = \frac{4 \times 10^{-15} (mol^3\ dm^{-9})}{10^{-3} (mol\ dm^{-3})} = 4 \times 10^{-12} (\text{mol dm}^{-3})^2$

$[OH]^-(aq) = 2 \times 10^{-6} \ mol\ dm^{-3}$

The $[OH^-(aq)]$ necessary to just precipitate $Mn(OH)_2 = 2\times10^{-6}$ mol dm^{-3} assume that the concentration of NH_4OH necessary to provide $[OH^-(aq)] = 2 \times 10^{-6}$ mol dm^{-3} is x

$NH_4OH(aq) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$ ($NH_4OH_{(aq)}$ is a weak base)

$x - 2 \times 10^{-6}$ mol dm^{-3} $\quad 2 \times 10^{-6}$ mol dm^{-3} 2×10^{-6} mol dm^{-3}

$$1.6 \times 10^{-5} \text{ mol dm}^{-3} = \frac{[2 \times 10^{-6}]^2 (\text{mol dm}^{-3})^2}{x - 2 \times 10^{-6} \text{ mol dm}^{-3}}$$

$$x = 2.25 \times 10^{-6} \text{ mol dm}^{-3}$$

or

(As dissociation is very slight $[NH_4OH]_{(aq)}$ is assumed to be constant)

$$1.6 \times 10^{-5} \text{ mol dm}^{-3} = \frac{[2 \times 10^{-6}]^2 (\text{mol dm}^{-3})^2}{x}$$

$$x = 2.5 \times 10^{-7} \text{ mol dm}^{-3}$$

(iv) Mol Wt. of $NH4C_4 = 14.0 + 1.0 \times 4 + 35.5 = 53.5$ g mol^{-1}

Therefore the moles of $NH_4Cl = 5.35$ g $\div$ 53.5g mol^{-1} $= 0.1$ mol

Since NH_4Cl is completely dissociated in aqueous medium. (salt)

$[NH_4^+aq] = 0.1$ mol dm^{-3}

If the concentration of NH_4OH as C mol NM^{-3} the degree of dissoclation as $\propto$

$NH_4OH(aq) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

at equllbrlum

C (1-$\propto$) mol dm^{-2} $\quad C\propto$ mol dm^{-2} $C\propto$ mol dm^{-2}

$[NH_4^+(aq)] = (0.1+c\propto)$ mol dm^{-3} $= 0.1$ mol dm^{-3}

$[NH_4OH(aq)] = (1.0 - c\propto)$ mol dm^{-3} $= 1.0$ mol dm^{-3}

Note; If written as statements also, correct

$$1.6 \times 10^{-5} \text{ mol dm}^{-3} = \frac{0.1 \text{ mol dm}^{-3} [OH^-(aq)] \text{ moldm}^{-3}}{1.0 \text{ mol dm}^{-3}}$$

$$[OH^-(aq)] = 1.6 \times 10^{-4} \text{ mol dm}^{-3}$$

Mol. Wt. of NH_4Cl = $14.0 + 1.0 \times 4 + 35.6 = 53.5\ g\ mol^{-1}$

Therefore the amount of NH_4Cl = $5.35\ g / 53.5\ g\ mol^{-1} = 0.1\ mol$

Since NH_4Cl is completely dissociated in aqueous medium

$[NH_4^+(aq)] = 0.1\ mol\ dm^{-3}$

$NH_4^+(aq) = (0.1\ C\alpha)\ mol\ dm^{-3} = 0.1\ mol\ dm^{-3}$

$NH_4OH(aq) = (0.1\ C\alpha)\ mol\ dm^{-3} = 0.1\ mol\ dm^{-3}$

Note: If written as statements also, full marks can be earned.

$$pOH = pk_a + \log_{10}\left(\frac{[salt]}{[base]}\right)$$

$$pOH = -\log_{10}(1.6 \times 10\text{-}5) + \log_{10}\left(\frac{[0.1\ mol\ dm^{-3}]}{}\right)$$

$pOH = 3.796$

$[OH^-] = 1.6 \times 10^{-4}\ mol\ dm^{-3}$

(v) The $[Mg(NO_3)_2(aq)]$ in the final solution

$$= \frac{0.02\ mol\ dm^{-3} \times 0.50\ dm^3}{1.0\ dm^3} = 0.01\ mol\ dm^{-3}$$

To avoid the precipitation of $Mg(OH)_2(s)$ in the final mixture, the following criteria should be satisfied

$Mg(NO_2)_2$ is completely dissociated to Mg^{2+} and NO_3^- ions

Therefore $[Mg^{2+}(aq)]$ in the final solution = $0.01\ mol\ dm^{-3}$

in order for $Mg(OH)_2$ not to precipitate,

K_{sp} of $Mg(OH)_2 \geq [Mg^{2+}(aq)]\ [OH^-(aq)]^2$

That is solubility product of $Mg(OH)_2 \geq$ its ionic product

$1 \times 10\text{-}10\ (mol^{-3}\ dm^{-9}) \propto 10^{-2}\ (mol\ dm^{-3}) \times [OH\text{-}(aq)]^2$

$$[OH^-(aq)]^2 \leq \frac{1 \times 10^{-10}\ (mol^2\ dm^{-9})}{1\ 0^{-2}\ (mol\ dm^{-3})} = 1 \times 10^{-8}\ (mol\ dm^{-3})^2$$

$[OH\text{-}(aq)] \leq \times 1 \times 10^{-4}\ mol\ dm^{-3}$

The $[NH_4OH(aq)]$ in the final solution

$$= \frac{0.20\ \text{mol}\ dm^{-3} \times 0.50 dm^3}{1.0\ dm^3} = 0.01\ mol\ dm^{-3}$$

Let the required concentration of NH_4Cl to keep $[OH^-(aq)]$at 1×10^{-4} mol dm^{-3} be y

Since amount dissociated from NH_4OH is very small, $[NHCl\ (aq)] = y$

Salt is completely dissociated

$$\therefore\ 1.6 \times 10^{-5}\ mol\ dm^{-3} = \frac{y\ (\text{mol}\ dm^{-3}) \times 1 \times 10^{-4}\ (\text{mol}\ dm^{-3})}{0.1\ mol\ dm^3}$$

$y = 1.6 \times 10^{-2}$ mol dm^{-3}

The amount of NH_4Cl necessary to prevent $Mg(OH)_2$

precipitation $= 1.6 \times 10^{-2}\ mol\ dm^{-3} \times 1.0\ dm^3 = \underline{\underline{1.6 \times 10^{-2}\ mol}}$

(vi) In group separation to avoid the precipitation of $Mg(OH)_2$ in group III (Or other cations that may precipitate as hydroxides) NH_4Cl is added before adding NH_4OH.

6. (a) (i) Rate = $K[M]^m[N]^n$

(ii) I According to the first graph, the rate of the reaction is independent of [M]. Therefore the order of the reaction with respect to M must be zero (m = 0). Therefore, Rate = $k[N]^n$

II From second graph, when [N] = 0.1 mol dm^{-3}, Rate = 10 mol dm^{-3} s-1 , When [N] 0.2 mol dm^{-3} Rate = 40 mol dm^{-3} s^{-1}

When the concentration is doubled rate increased four times, therefore the order with respect to N is 2 (concentration $\times\ 2' \rightarrow$ rate $\times\ 2^2$)

or

Using data tor any two points.

10 mol dm^{-3} s^{-1} k (0.1 mol dm^{-3})^n ---------- (1)

40 mol dm^{-3} s^{-1} = k (0.2 mol dn^{-3})^n ---------- (2)

$\frac{(2)}{(1)}$, $\frac{40\ \text{mol}\ dm^{-3}\ s^{-1}}{10\ \text{mol}\ dm^{-3}\ s^{-1}} = \left(\frac{0.2\ \text{mol}\ dm^{-3}}{0.1\ \text{mol}\ dm^{-3}}\right)$

$4 = 2^n$

$n = 2$

Note : For obtaining n = 2 only by argument, eg. curved shape of the graph means order = 2, only half the marks are given

III Overall order = $n + m + 2 + 0 = \underline{\underline{2}}$

(iv) From equation (1)

$$k = \frac{10\ mol\ dm^{-3}\ s^{-1}}{(0.1\ mol\ dm^{-3})^2}$$

$$= \underline{1000\ mol\ dm^3\ s^{-1}}$$

or

From equation (2)

$$k = \frac{40\ mol\ dm^{-3}\ s^{-1}}{(0.4\ mol\ dm^{-3})^2}$$

$$= \underline{1000\ mol\ dm^3\ s^{-1}}$$

(b) (i)

	AB(g)	⇌	A(g)	+	B(g)
At t = 0	1.0 mol		0		0
at equilibrium	(1 -x) mol		x mol		xmol
or *concentration at equilibrium* (*mol dm^{-3}*)	$\frac{1-x}{V}$		$\frac{x}{V}$		$\frac{x}{V}$

$$K_c = \frac{(x/V)(x/V)}{((1-x)/V)} = \frac{x^2}{(1-x)V}$$

$$K_c V(1-x) = x^2$$

After opening the tap the volume is increased to 3V. The amount dissociated is 'y' mol

	AB(g)	⇌	A(g)	+	B(g)
at equilibrium	(1 -x) mol		y mol		y mol
or *concentration at equilibrium* (*mol dm^{-3}*)	$\frac{1-y}{3V}$		$\frac{y}{3V}$		$\frac{y}{3V}$

$$K_c = \frac{(y/V)(y/V)}{((1-y)/3V)} = \frac{y^2}{(1-y)3V}$$

$$\underline{3K_c V(1-y) = y^2}$$

(ii) Equilibrium constant K_c in both occasions is the same because there is no change in temperature.

$$K_c = \frac{x^2}{(1-x)v} = \frac{x^2}{(1-y)3v}$$

if $y = 0.5\ mol$

$$\frac{x^2}{(1-x)v} = \frac{(0.5\ mol)^2}{(1.0\ mol - 0.5mol)3v}$$

$$\frac{x^2}{(1-x)} = \frac{(0.5\ mol)^2}{3(0.5mol)} = \frac{0.5\ mol}{3}$$

$$3x^2 - 0.5\ mol\ (1-x) = 0$$

$$(3x - 1\ mol)\ (2x + 1\ mol) = 0$$

$$x = \frac{1}{3}\ mol \text{ Or}$$

$$X = -\frac{1}{2}\ mol\ Or \text{ (cannot be accepted as it is a negative value.}$$

$$\therefore\ x = 0.33\ mol$$

(iii) When volume is V, the amount dissociated = 0.33 mol, when the volume is increased to 3V the amount dissociated = 0.5 mol. increasing of volume decreases the pressure of the system, more AB(g) is dissociated to counter this change

(iv) Applying PV = nRT to second equilibrium,
y = 0.5 mol
n = 1 + y = 1.5 mol
Volume = 3V and T = 400K

$$P_2 = \frac{1.5 \times R \times 400}{3V}$$

When the temperature is increased to 600K
Pressure = $P_1 = 1.7\ P_2$
Apply PV = nRT for third equilibrium

$n = (1 + z)\ mol$
$v = 3V$ and T = 600K

$$P3 = 1.7\left(1.5\ \frac{R \times 400K}{3V}\right) = \frac{(1+z)\ R \times 600K}{3V}$$

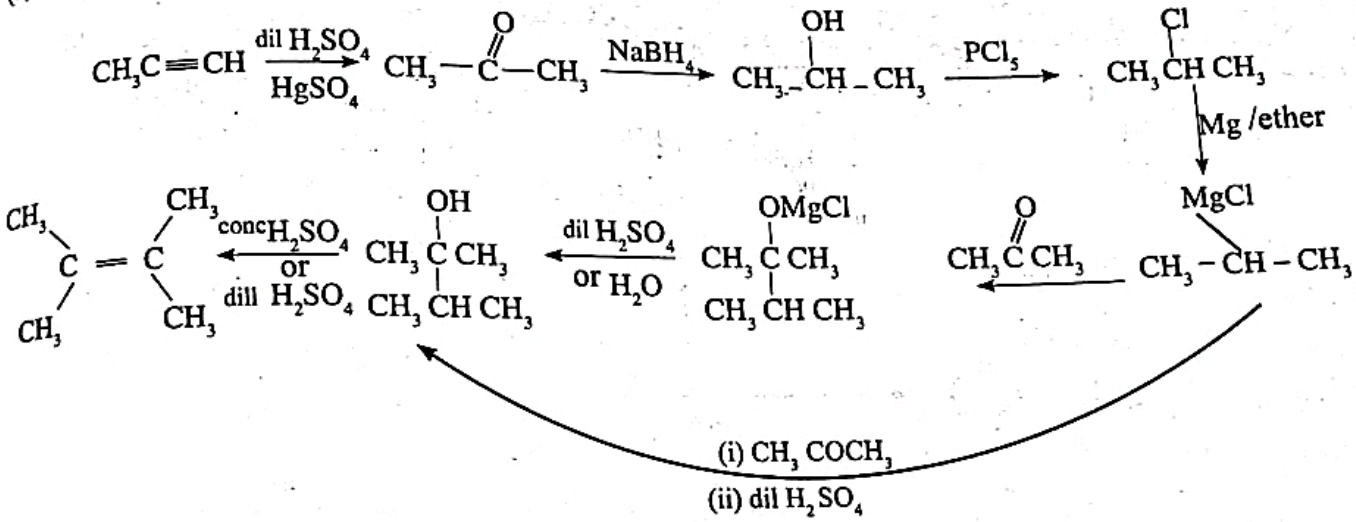
$$1 + z = \frac{1.5 \times 400K \times 1.7}{600K} = 1.7$$

$$z = 0.7\ mol$$

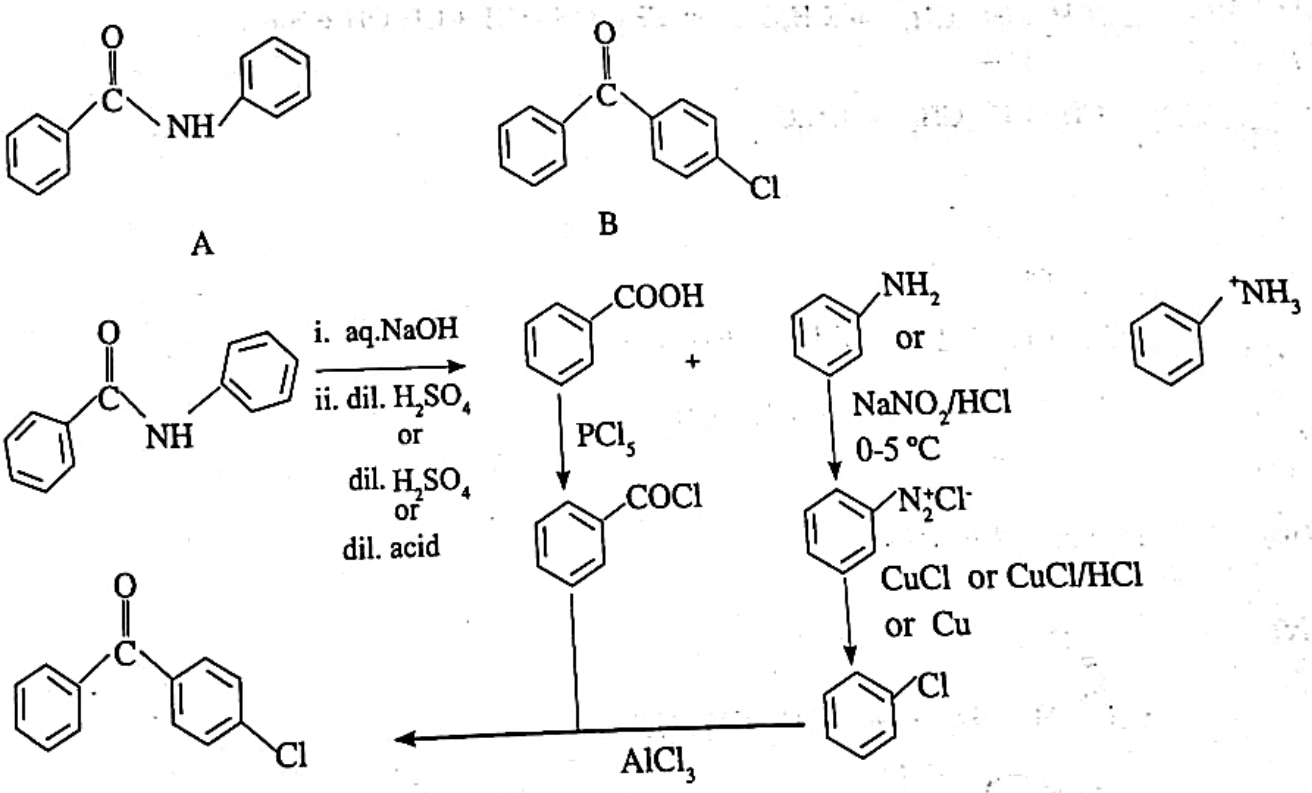
6. (b) (v) Increasing of temperature from 400 K to 600 K (at constant volume) has increased the amount dissociated. Therefore, supply of heat has driven the forward reaction. Therefore, the forward reaction must be endothermic.

(vi) Assumption made in the calculations All the gasses behave as ideal gasses.

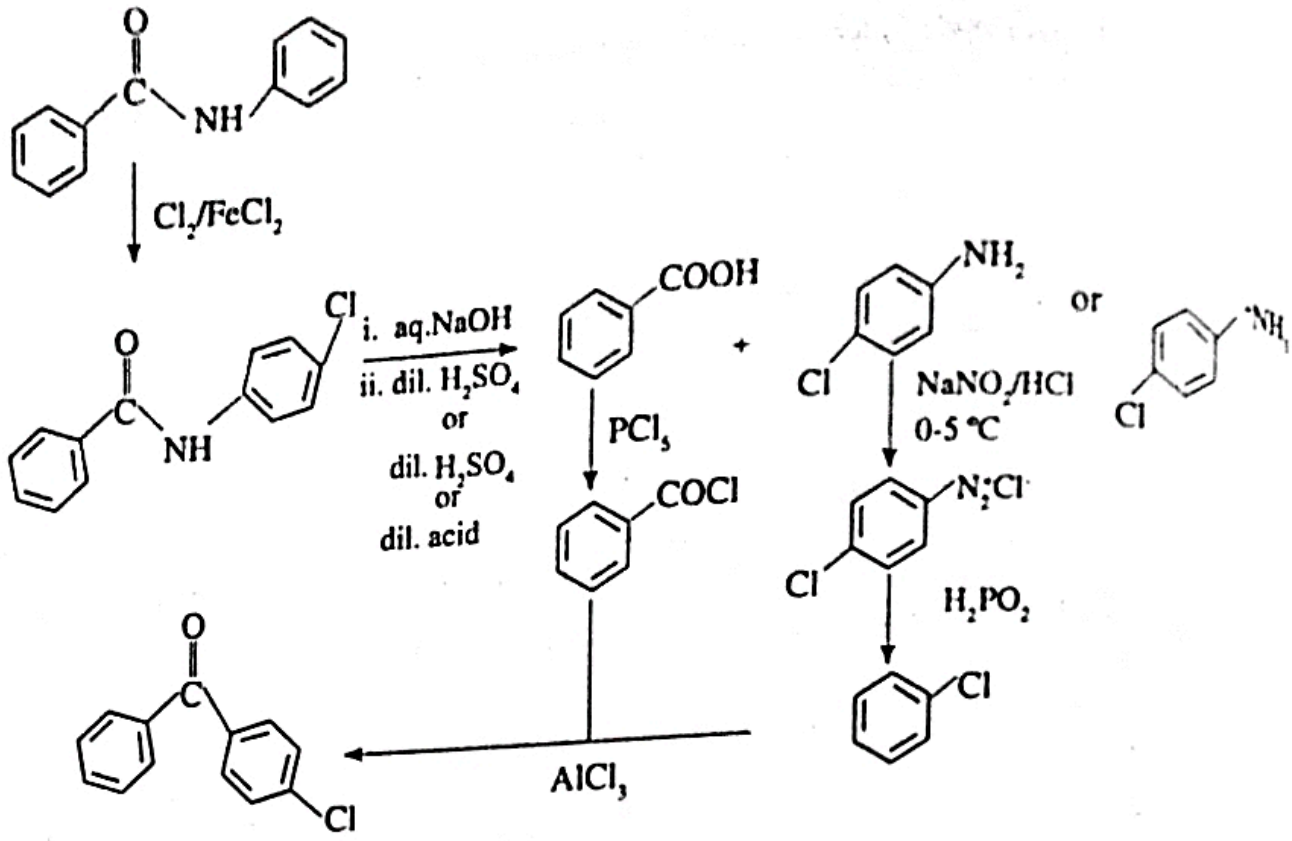
7. (a)



(b)



Alternative answer



7. (c) (i) $CH_3\text{-}\underset{\underset{Cl}{|}}{CH}\text{-}CH_3 + CH_3O^-$ or $CH_3\text{-}\underset{\underset{Cl}{|}}{CH}\text{-}CH_3 + CH_3OH + Na$

$CH_3\text{-}\underset{\underset{O-}{|}}{CH}\text{-}CH_3 + CH_3Cl$

(ii) $CH_3\text{-}\underset{\underset{Cl}{|}}{CH}\text{-}CH_3 + CH_3O^-$ reactants

$Y = CH_3CH=CH_2$

(iii) Elimination reaction

(iv) $CH_3\text{-}\overset{\overset{Cl}{\curvearrowleft}}{CH}\text{-}CH_3 \longrightarrow CH_3\text{-}\overset{+}{C}H\text{-}CH_3 + Cl^-$

$CH_3\text{-}\overset{+}{C}H\text{-}CH_3 \; {}^-OCH_3 \longrightarrow CH_3\text{-}\underset{\underset{OCH_3}{|}}{CH}\text{-}CH_3$

8. (a) $A = ZnCO_3$, $B = ZnO$, $C = CO_2$ } Yellow when hot, white when cold, is ZnO

$\therefore$ $ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2$ Colourless - lime water milky

D = Zn^{2+} or a soluble Zn salt like $ZnCl_2$

E = ZnS is the white precipitate formed in Gp. IV of the qualitative analysis reactions and sulphides dissolve in dil. acids. Also $Zn(OH)_2$ is a gelatinous while precipitate which dissolves both in NH_4OH and NaOH. Other amphoteric hydroxides like $Al(OH)_3$ do not dissolve in NH_4OH.

F = $Zn(OH)_2$

G = Na_2ZnO_2 or $Na_2Zn(OH)_4$ or $Zn(OH)_4^{2-}$ or ZnO_2^{2-}

H = $[Zn(NH_3)_4]^{2+}$ or $[Zn(NH_3)_6]^{2+}$

8. (b) (i) SO_2

(ii) $3(SO_2 + 2H_2O \longrightarrow SO_4^{2-} + 4H^+ + 2e)$

$Cr_2O_7^{2-} + 14H^+ + 6e \longrightarrow 2Cr^{3+} + 7H_2O$

$Cr_2O_7^{2-} + 2H^+ + 3SO_2 \longrightarrow 2Cr^{3+} + 3SO_4^{2-} + H_2O$

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

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

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

$H_2SO_4 + BaCl_2 \longrightarrow BaSO_4\downarrow + 2HCl$ or $SO_4^{2-} + BaCl_2 \longrightarrow BaSO_4\downarrow + 2Cl^-$

Alternate answer (I)

$3(H_2SO_3 + 2H_2O \longrightarrow SO_4^{2-} + 4H^+ + 2e)$

$Cr_2O_7^{2-} + 14H^+ + 6e \longrightarrow 2Cr^{3+} + 7H_2O$

$Cr_2O_7^{2-} + 2H^+ + 3H_2SO_3 \longrightarrow 2Cr^{3+} + 3SO_4^{2-} + H_2O$

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

$H_2SO_3 + H_2O \longrightarrow SO_4^{2-} + 4H^+ + 2e$

$H_2SO_3 + H_2O_2 \longrightarrow SO_4^{2-} + 2H^+ + H_2O$

$H_2SO_4 + BaCl_2 \longrightarrow BaSO_4\downarrow + 2HCl$ or $SO_4^{2-} + BaCl_2 \longrightarrow BaSO_4\downarrow + 2Cl^-$

Alternate answer (II)

$3(SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2e)$

$Cr_2O_7^{2-} + 14H^+ + 6e \longrightarrow 2Cr^{3+} + 7H_2O$

$Cr_2O_7^{2-} + 8H^+ + 3SO_3^{2-} \longrightarrow 2Cr^{3+} + 3SO_4^{2-} + 4H_2O$

$$H_2O_2 + 2H^+ + 2e \longrightarrow 2H_2O$$
$$SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2e$$
$$SO_3^{2-} + H_2O_2 \longrightarrow SO_4^{2-} + H_2O$$

$$H_2SO_4 + BaCl_2 \longrightarrow BaSO_4\downarrow + 2HCl \text{ or } SO_4^{2-} + BaCl_2 \longrightarrow BaSO_4\downarrow + 2Cl^-$$

Note :

If equations are no balanced - No marks

If the half reactions are not given but the correct complete reaction is given full marks are given.

(iii) I. Q = H_2S

II. $2H_2S + SO_2 \longrightarrow 3S\downarrow + 2H_2O$

8. (c) (i) $IO_3^- + 5I^- + 6H^+ \longrightarrow 3I_2 + 3H_2O$ --------- (1)

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

moles of $S_2O_3^{2-}$ = $\frac{0.50}{1000} \times 12.50$

moles of I_2 = $\frac{0.50}{1000} \times 12.50 \times \frac{1}{2}$

moles of H^+ = $\frac{0.50}{1000} \times 12.50 \times \frac{1}{2} \times 2$

$[H^+]$ = $\frac{0.50}{1000} \times 12.50 \times \frac{1}{2} \times 2 \times \frac{1000}{25.0}$

= 0.25 mol dm^{-3}

Note : The relationship $H^+ \equiv S_2O_3^{2-}$ can also be used in the above calculation

(ii) $NaOH + HCl \longrightarrow NaCl + H_2O$

$NaCO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$

moles of HCl required to react with NaOH & Na_2CO_2 $= \frac{0.25}{1000} \times 32.0$

moles of HCl required to react with NaOH $= \frac{0.25}{1000} \times 24.0$

Therefore, moles of HCl required to react with Na_2CO_2

$= \frac{0.25}{1000} \times 32.0 - \frac{0.25}{1000} \times 24.0$

$= 0.008 - 0.006 = 0.002$ mol

Therefore, moles of Na_2CO_2 in 25.0cm $= \frac{0.002}{2}$

Moles of Na_2CO_3 in 500.0 cm_3 $= \frac{0.002 \times 500}{2 \times 25} = 0.002 \times 10$

$= 0.02$

molecular mass of Na_2CO_3 $= 106g\ mol^{-1}$

mas of Na_2CO_3 $= 0.02 \times 106 = 2.12g$

% Na_2CO_3 in sample $= \frac{212}{42.4} \times 100\ \%$

$= \underline{5.0\%}$

(iii) Assumptions - all the carbonate in the solution is precipitated as $BaCO_3$ on the addition of excess $BaCl_2$

9 (a) (i) I $S(s) + O_2(g) \xrightarrow{\Delta} SO_2(g)$

$$2SO_2(g) + O_2(g) \underset{1\text{-}2\ atm,\ V_2O_5}{\overset{450^\circ C}{\rightleftharpoons}} 2SO_3(g)$$

$$SO_3(g) + H_2SO_4(l) \longrightarrow H_2S_2O_7(l)$$
$$H_2S_2O_7(l) + H_2O(l) \longrightarrow 2H_2SO_4(aq)$$

Other methods in producing SO_2 are also acceptable

e.g. $2PbS(s) + 3O_2(g) \xrightarrow{\Delta} PbO(s) + 2SO_2(g)$

$2ZnS(s) + 3O_2(g) \xrightarrow{\Delta} ZnO(s) + 2SO_2(g)$

$2H_2S(g) + 3O_2(g) \xrightarrow{\Delta} 2H_2O(g) + 2SO_2(g)$
(H_2S in crude oil bumed in air)

$2CuFeS_2(s) + 4O_2(g) \xrightarrow{\Delta} Cu_2S(s) + 2FeO(s) + 3SO_2(g)$
(copper pyrites)

$4CuFeS_2(s) + 11O_2(g) \xrightarrow{\Delta} 2\,Cu_2O(s) + 4FeO(s) + 8SO_2(g)$

$4FeS_2(s) + 11O_2(g) \xrightarrow{\Delta} 2Fe_2O_3(s) + 8SO_2(g)$

Note: Physical states are not required

9 (i) II
- The reaction between SO_2 and O_2 is reversible
- and exothermic
- and the number of molecules decreases in the forward reaction
- According to the Le Chatelier principle
- the forward reaction will be favoured
- by low temperature
- and high pressure
- The small advantage gained in this reaction by using high pressure is more than offset by the greater cost of equipment that would be needed
- Hence, 1-2 atm pressure is used.
- At low temperatures, the rate of reaction is low
- Hence, a temperature of $450C^0$ is used to get an acceptable rate
- A catalyst, (V_2O_5) is used to speed up the rate of the reaction
- and achieve the equilibrium condition faster

Any 9 points out of the 13 given

Uses of sulphuric acid

(i) (III)

- Manufacture of fertilizer
- Production of dyes
- Production of explosives
- Production of detergents
- Oxidizing agent
- Manufacture of synthetic fibres
- Manufacture of paints & pigments
- Drying agent(gases)
- Manufacture of chemicals
- Production of drugs
- In automobile batteries/ battery acid
- Processing of metal ores
- Dehydrating agent
- Manufacture of plastics.
- Used in petroleum refining

(any two) out of the is uses given above

(ii) I $CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$

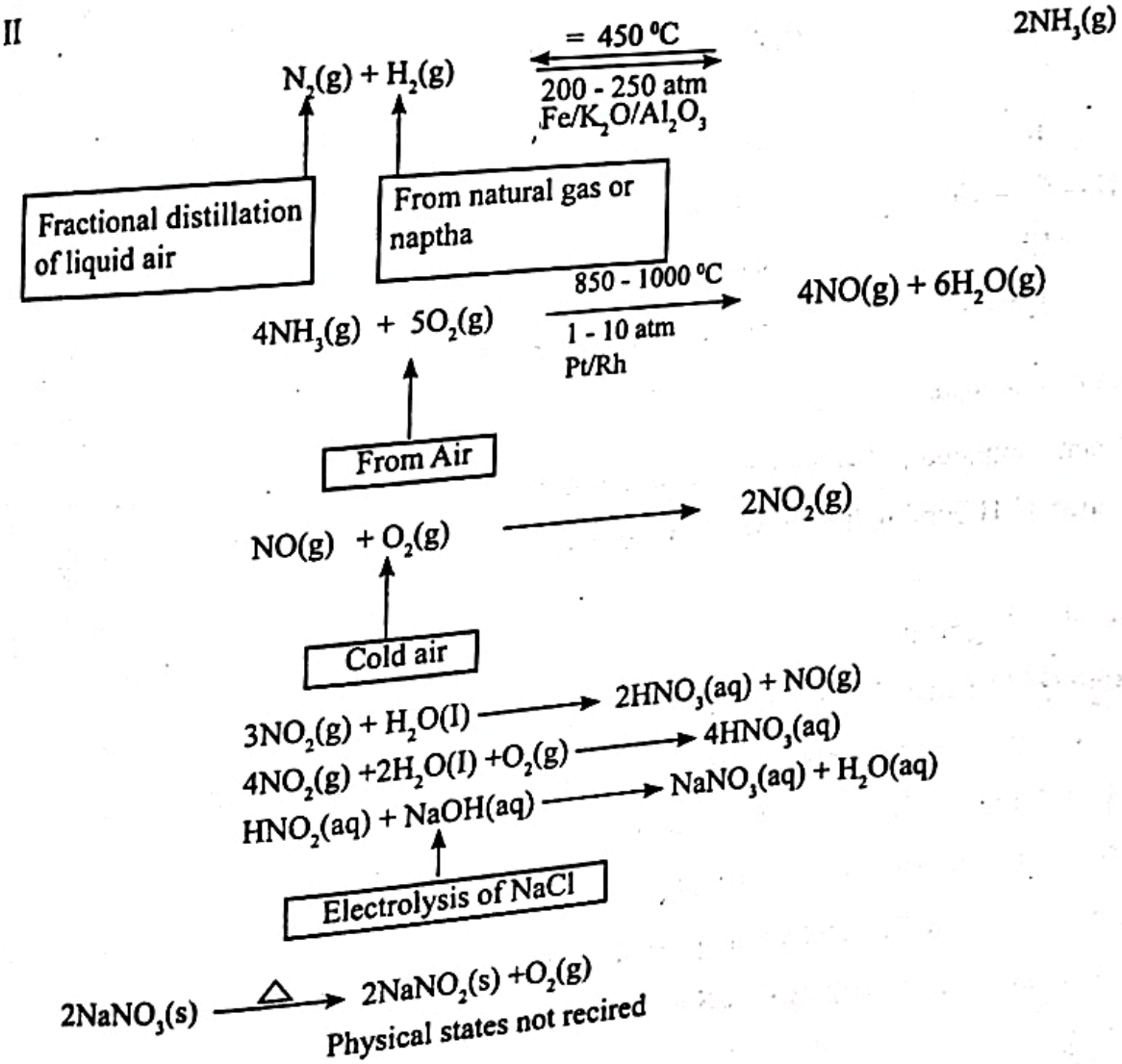
$CaO(s) + 3C(s) \xrightarrow{\Delta} CaC_2(s) + CO(g)$

or

$2CaO(s) + 5C(s) \xrightarrow{\Delta} 2CaC_2(s) + CO_2(g)$

$CaC_2(s) + 2H_2O(I) \longrightarrow Ca(OH)_2(aq) + C_2H_2(g)$

II



$2NaNO_3(s) \xrightarrow{\Delta} 2NaNO_2(s) + O_2(g)$

Physical states not recired

9 (a) (iii) I Brine (concentrated NaCl solution), NH_3 and CO_2

II Brine - from sea water

NH_3 - from the Haber process

CO_2 - from lime stone (by burning)

III $CaCl_2$

IV to precipitate $NaHCO_3$

to dissolve gases in brine

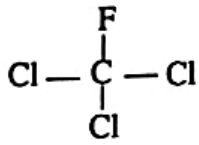
V manufacture of glass, detergents, soap, sodium silicate and paper to soften hard water, as washing soda in detergents (any two)

VI $CaCl_2$ is added to remaining mother liquor after precipitating NaCl from sea water.

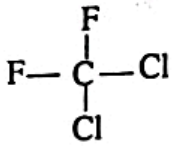
Good source of SO_4^{2-}

$CaCl_2 + SO_4^{2-} \longrightarrow CaSO_4 2H_2O$ (gypsum)

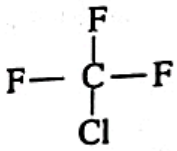
9 (b) (i)



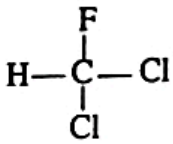
CFC



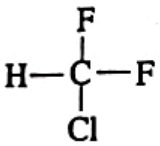
CFC



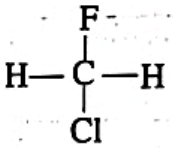
CFC



HCFC



HCFC



HCFC

(ii)
- Statement is correct
- When compared to C-F and C - Cl bounds, the C-H bond is weaker
- Hence C-H bond will react with chemicals in the environment.

(iii)
- Problem is global warming.
- Both HCFCs one CFC s are green house gases
- That contribute to the rise in atmospheric temperature.
- The lifetime of HCFC s in the air is shorter as they are more reactive
- Hence, The contributions by HCFCS to global warming, is less

Or
- Since CFCS are les reactive, they remain longer in the atmosphere
- and so the contribution by CFCS to global warming, is more

(iv) Three properties of CFCs that make them suitable for use as refrigerants.

Chemically inert - No damage to the food

Physiological inert	-	no health problems even if consumed
Nonflammable	-	safety
Easily compressible and expandable	-	effective coiling
Less viscosity	-	easily mobile
Low boiling points	-	gaseous at room temperature
High specific heat	-	effective cooling using a lesser mass of CFC

(v)
- CFCs at higher elevations / upper atmosphere, get exposed to UV radiations. This UV, breaks or cleaves C-Cℓ or C-F bonds.
- generating chlorine free radicals / flourine free radicals / $\dot{C}\ell$ or $\dot{F}$
- The ($\dot{C}\ell$) chlorine free radicals or ($\dot{F}$) fluorine free radicals
- catalyse the destruction of O_3 molecules
- and reduce or deplete ozone levels in the upper atmosphere.

$CFCl_3 \xrightarrow{UV\ (or\ hv)} \dot{C}FCl_2 + \dot{C}l$ (any CFC can be used)

$\dot{C}l + O_3 \longrightarrow \dot{O}Cl + O_2$

$O_2 \xrightarrow{hv} 2O$

$\dot{O}Cl + O \longrightarrow \dot{C}l + O_2$

(vi) Depletion of ozone layer allows the penetration of high energy UV to the ground.

Penetrated UV can contribute to following problems.

Elevate the atmospheric temperature

Produce ozone at the ground level

Cataract

Skin Carcinoma - Skin cancer

(Adverse) effect on vegetation (any three)

10 (a) (i) $H_2O_2(aq) + PbS(s) \longrightarrow$

$4H_2O_2 + PbS \longrightarrow PbSO_4 + 4H_2O$

oxidizing agent or undergoes reduction

(ii) $MnO_4^-(aq) + H_2O_2(aq) + H^+(aq) \longrightarrow$

$2MnO_4^- + 5H_2O_2 + 8H^+ \longrightarrow 2Mn^{2+} + 8H_2O + 5O_2$

Reducing agent or undergoes oxidation

(iii) $Cr_2O_7^{2-}(aq) + H_2S(aq) + H^+(aq) \longrightarrow$

$Cr_2O_7^{2-} + 3H_2S + 8H^+ \longrightarrow 2Cr^{3+} + 3S + 7H_2O$

Reducing agent or undergoes oxidation

(iv) $Cu(s) + H_2S(s) \xrightarrow{\Delta}$

$Cu + H_2S \xrightarrow{\Delta} CuS + H_2$

Oxidizing agent or undergoes reduction or acts as an acid

(v) $C(s) + \text{conc } HNO_3 \xrightarrow{\Delta}$

$C + 4HNO_3 \longrightarrow CO_2 + 4NO_2 + 2H_2O$

Oxidizing agent or undergoes reduction

10 (b) **Method 1**

Half reaction taking place:

$5(Fe^{2+} \longrightarrow Fe^{3+} + e)$

$5(C_2O_4^{2-} \longrightarrow 2CO_2 + 2e)$

$3(MnO_4^- + 8H^+ + 5e \longrightarrow Mn^{2+} + 4H^2O)$

$3MnO_4 + 5C_2O_4^{2+} + 5Fe^{2+}\ 24H^+ \longrightarrow 5Fe^{3+} + 10CO_2 + 12H_2O + 3Mn^{2+}$

molar mass of $FeC_2O_4 = 144$ g

moles of $Fe\ C_2O_4 = \frac{0.300g}{144g}$

moles of Fe^{2+} = moles of $CrO_4^{2-} = \frac{0.300g}{144g} = 2.08 \times 10^{-3}$

Let the volume of $KMnO_4$ be V cm^3

moles of $MnO_4^- = \frac{0.025}{1000} \times V$

Therefore, moles of Fe^{2+} = moles of $C_2O_4^{2-} = \frac{0.025}{1000} \times V \times \frac{5}{3}$

$\frac{0.025}{1000} \times V \times \frac{5}{3} = 2.08 \times 10^{-3} \quad \therefore V = 49.92\ \Omega\ 50$

$\therefore$ V = 50.0 cm^3

Method 2

$5(Fe^{2+} \longrightarrow Fe^{3+} + e)$

$MnO_4^- + 8H^+ + 5e \longrightarrow Mn^{2+} + 4H_2O$

$5Fe^{2+} + MnO_4^- + 8H^+ \longrightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$ ——— (1)

$5(C_2O_4^{2-} \longrightarrow 2CO_2 + 2e)$

$2(MnO_4^- + 8H^+ + 5e \longrightarrow Mn^{2+} + 4H_2O)$

$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$ ——— (2)

moles of Fe^{2+} = moles of $C_2O_4^{2-}$ = $\frac{0.300g}{144g} = 2.08 \times 10^{-3}$

Let the volume of MnO_4^- for reacion (1) be V_1 cm³

Moles of MnO_4^- = $\frac{0.025}{1000} \times V_1$

Therefore, moles of Fe^{2+} = $\frac{0.025}{1000} \times V_1 \times 5$ (as $MnO_4^- : Fe^{2+} = 1 : 5$)

$\frac{0.025}{1000} \times V_1 \times 5 = 2.08 \times 10^{-3}$

$V_1 = 16.67cm^3 = 16.7cm^3$

Let the volume of MnO_4^- for reaction (2) be $V_2 cm^3$

moles of MnO_4^- = $\frac{0.025}{1000} \times V_2$

moles of $C_2O_4^{2-}$ = $\frac{0.025}{1000} \times V_2 \times \frac{5}{2}$ (as $MnO_4^- : C_2O_4^{2-}$) = 2 : 5

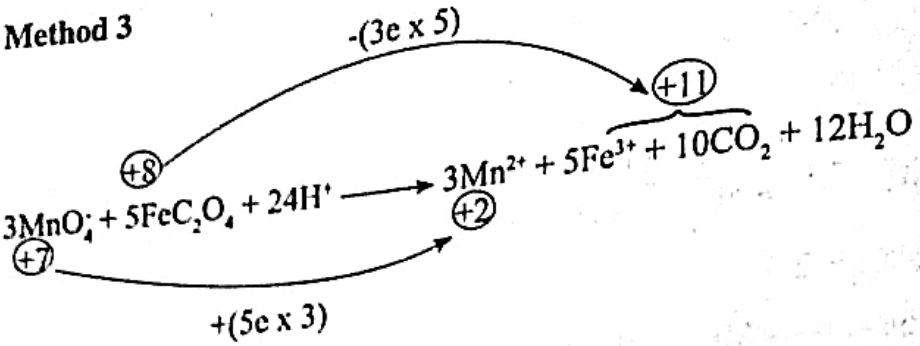
$\frac{0.025}{1000} \times V_2 \times \frac{5}{2} = 2.08 \times 10^{-3}$

$V_2 = 33.28cm^3 = 33.3\ cm^3$

Total volume = $16.7\ cm^3 + 33.3\ cm^3$

= $\underline{50.0\ cm^3}$

10 (b) **Method 3**



moles of $FeC_2O_4 = \frac{0.300g}{144g} = 2.08 \times 10^{-3}$

Let volume of MnO_4^- for the reaction be V cm^3

moles of $MnO_4^- = \frac{0.025}{1000} \times V$

5 moles of FeC_2O_4 = 3 moles of $KMnO_4$

$$\frac{0.300}{144} x3 = \frac{0.025 \; x \; V \; x \; 5}{1000}$$

or $$\frac{2.08 \times 10^{-3} \times 10^3}{0.025} \times \frac{3}{5} = V$$

V = 50.0 cm^3

10. (c) (i) Burning of propane

$2H_2(g) + 1/2O_2(g) \longrightarrow H_2O(l)$ $\quad \Delta H_1 = -286$ kJ mol^{-1} - (1)

$C(graphite) + O_2(g) \longrightarrow CO_2(g)$ $\quad \Delta H_2 = -394$ kJ mol^{-1} - (2)

$3C(graphite) + 4H_2(g) \longrightarrow C_3H_8(g)$ $\quad \Delta H_3 = -104$ kJ mol^{-1} - (3)

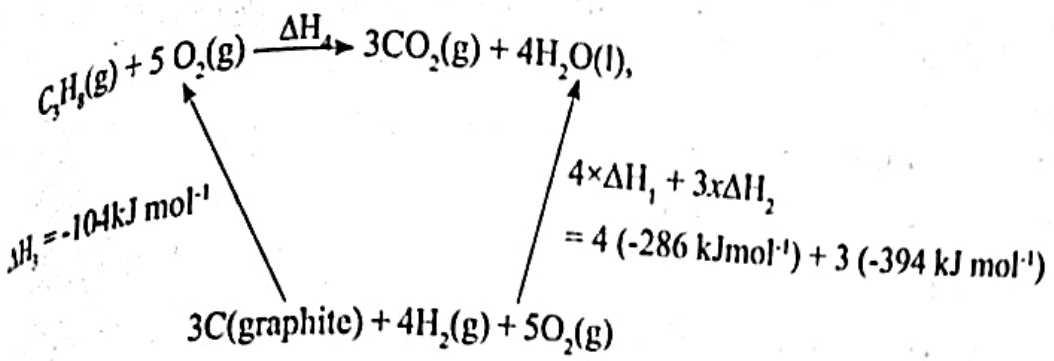
$C_3H_8(g) + 5\,O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l)$ $\quad \Delta H_4 =$ - (4)

$\Delta H_4 = 4 \times \Delta H_1 + 3 \times \Delta H_2 - \Delta H_3$

$\Delta H_4 = 4(-286 \text{ kJ mol}^{-1}) + 3(-394 \text{ kJ mol}^{-1}) - (-104 \text{ kJ mol}^{-1})$

$= -2222$ kJ mol^{-1}

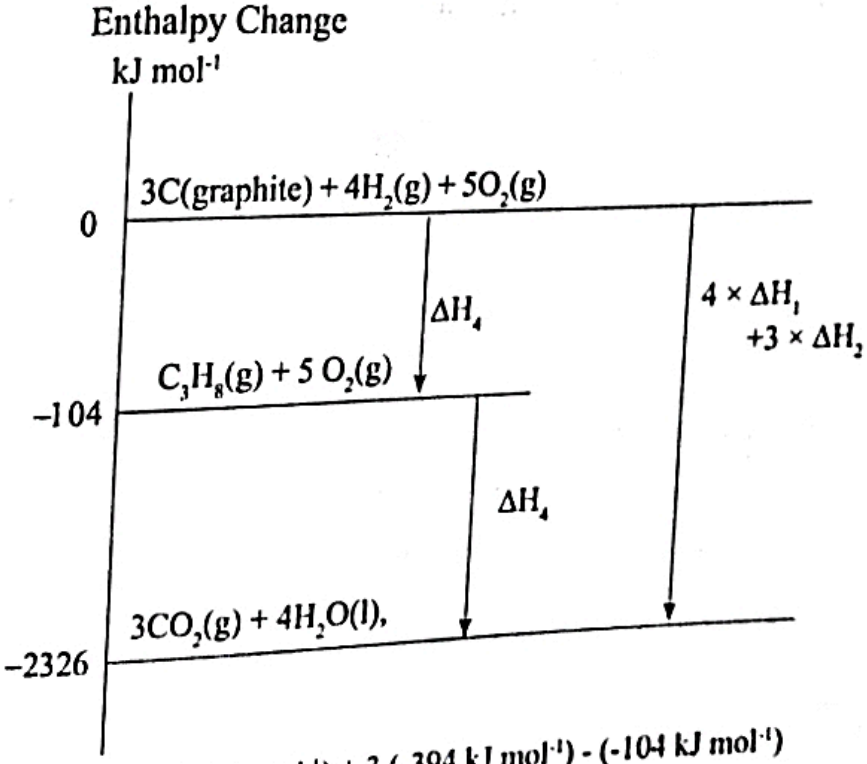
OR



$\Delta H_4 = 4\times\Delta H_1 + 3\times\Delta H_2 - \Delta H_3$

$= \underline{-2222\ kJ\ mol^{-1}}$

OR



$\Delta H_4 = 4(-286\ kJ\ mol^{-1}) + 3\ (-394\ kJ\ mol^{-1}) - (-104\ kJ\ mol^{-1})$

(or correct enthaipy on the diagram)

$\Delta H_4 = \underline{-2222\ kJ}\ mol^{-1}$

Burning of butane

$2H_2(g) + 1/2O_2(g) \longrightarrow H_2O(l)$ $\quad \Delta H_1 = -286\ kJ\ mol^{-1}$ - (1)

$C(graphite) + O_2(g) \longrightarrow CO_2(g)$ $\quad \Delta H_2 = -394\ kJ\ mol^{-1}$ - (2)

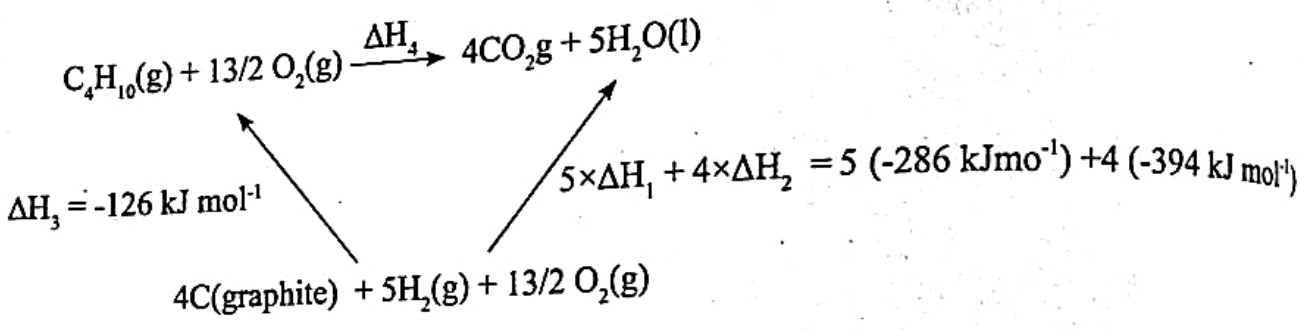
$4C(graphite) + 5H_2(g) \longrightarrow C_4H_{10}(g)$ $\quad \Delta H_3 = -126\ kJ\ mol^{-1}$ -(3)

$C_4H_{10}(g) + 13/2\ O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$ $\quad \Delta H_4$ – (4)

$\Delta H_4 = 5\times\Delta H_1 + 4\times\Delta H_2 - \Delta H_3$

$\Delta H_4 = 5\ (-286\ kJ\ mol^{-1}) + 4\ (-394\ kJ\ mol^{-1}) - (-126\ kJ\ mol^{-1})$

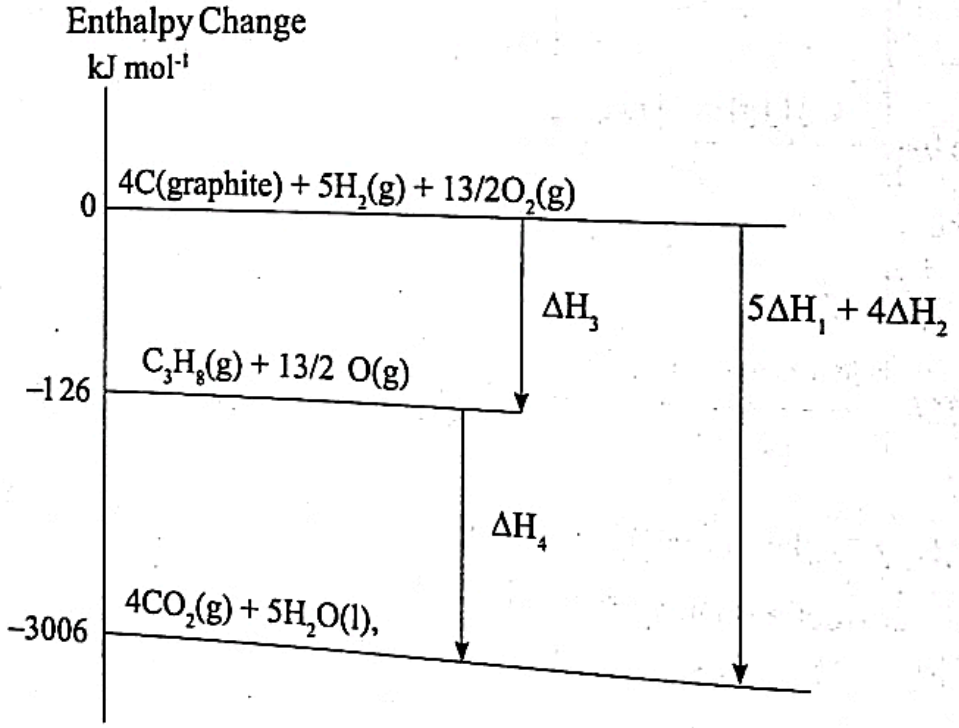
$= \underline{\underline{-2880\ kJ\ mol^{-1}}}$



$\Delta H_4 = 5\times\Delta H_1 + 4 \times \Delta H_2 - \Delta H_3$

$= \underline{\underline{-2880\ kJmol^{-1}}}$

OR



$\Delta H_4 = 5\ (-286\ kJ\ mol^{-1}) + 4\ (-394\ kJ\ mol^{-1}) - (-126\ kJ\ mol^{-1}) = \underline{\underline{2880\ kJmol^{-1}}}$

(c)(ii) Heat needed to raise the temperature of 400g of water from 25°c to 85°C = qkJ

$q = 400_g \times 4.2\ J_g^{-1}\ {}^oC^{-1} \times (85 - 25)^oC$

$= \underline{100.8kJ}$

(iii) Amount of propane needed to produce the amount of heat in (ii)

$= 1/2222\ kJ\ mol^{-1} \times 100.8\ kJ$

$= 4.54 \times 10^{-2}\ mol$

Amount of CO_2 emitted

$= 4.54 \times 10^{-2}\ mol \times 3$

$= 1.36 \times 10^{-1}\ mol$

Mass of CO_2 emitted

$= 1.36 \times 10^{-1}\ mol \times 44g\ mol^{-1}$

$= 5.98g$

Amount of butane needed to produce the amount of heat in (ii)

$= 1/2880\ kJmol^{-1} \times 100.8\ kJ$

$= 3.50 \times 10^{-2}\ mol$

Amount of CO_2 emitted

$= 3.50 \times 10^{2}\ mol \times 4$

$= 1.40 \times 10^{-1}\ mol$

Mass of CO_2 emitted

$= 1.40 \times 10^{-1}\ mol \times 44\ g\ mol^{-1}$

$= \underline{6.16g}$

(iv) Propane emits less CO_2 when compared to butane for the same amount of heat produced. Hence propane is more environmentally friendly.