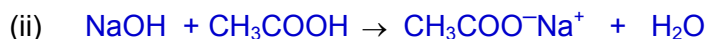


Answer ALL questions on the spaces provided.

1 (a) (i) Average initial temperature of solution = $\frac{29.0 + 29.2}{2} = 29.1^{\circ}\text{C}$

$$\begin{aligned}\text{Heat evolved} &= mc\Delta T \\ &= 100 \times 4.2 \times (37.0 - 29.1) \\ &= 3318 \\ &= 3320 \text{ J}\end{aligned}$$



$$\text{No. of moles of NaOH} = (50/1000) \times 1.30 = 0.065 \text{ mol}$$

$$\text{No. of moles of CH}_3\text{COOH} = (50/1000) \times 1.20 = 0.06 \text{ mol}$$

\therefore CH_3COOH is the limiting reagent.

$$\text{No. of moles of CH}_3\text{COOH} = \text{no. of moles of H}_2\text{O}$$

$$\begin{aligned}\text{Amount of H}_2\text{O formed} &= \frac{50}{1000} \times 1.20 \\ &= 0.0600 \text{ mol}\end{aligned}$$

$$\begin{aligned}\Delta H_{\text{neut}} &= \frac{-3318 \times 10^{-3}}{0.0600} \\ &= -55.3 \text{ kJ mol}^{-1}\end{aligned}$$

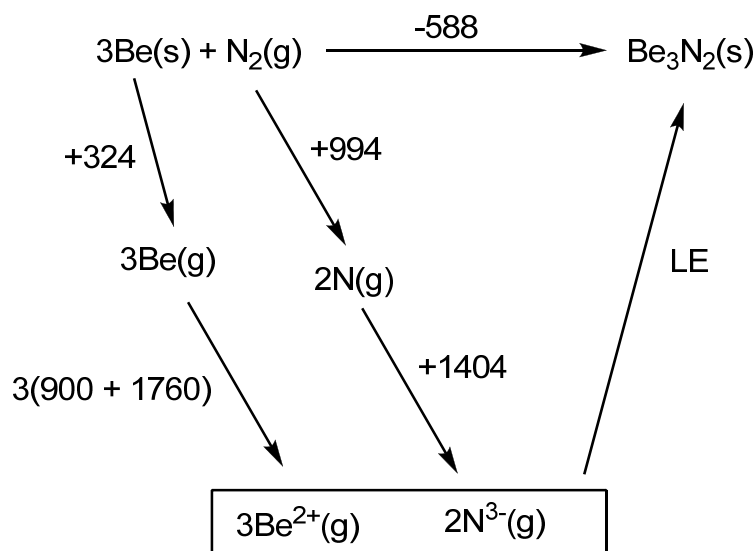
- (iii) HCl is a strong acid and undergoes full dissociation. Energy given out during neutralisation will not be absorbed to dissociate HCl . Thus, ΔH_{neut} of HCl and NaOH is more exothermic than that of CH_3COOH and NaOH .

OR

CH_3COOH is a weak acid and dissociates partially. Some of the energy released during neutralisation is absorbed to dissociate/ionise CH_3COOH completely. Thus, ΔH_{neut} of CH_3COOH and NaOH is less exothermic than that of HCl and NaOH .

[4]

(b) (i)



$$-588 = 324 + 3(900 + 1760) + 994 + 1404 + \text{LE}$$

$$\begin{aligned}\text{Lattice energy} &= -588 - (324 + 994 + 3(900 + 1760) + 1404) \\ &= -11290 \\ &= -1.13 \times 10^4 \text{ kJ mol}^{-1}\end{aligned}$$

(ii)

$$\text{LE} \propto \left| \frac{q_+ q_-}{r^+ + r^-} \right|$$

Be^{2+} has higher charge than Li^+ and N^{3-} and has higher charge than O^{2-}

OR

The product of q_+ and q_- (OR $q_+ q_-$) of Be_3N_2 ($2 \times 3 = 6$) is greater than the product of q_+ and q_- (OR $q_+ q_-$) of Li_2O ($1 \times 2 = 2$).

Since product of charges outweighs the sum of ionic radii (OR $q_+ q_-$ greater than $r^+ + r^-$), the lattice energy of Li_2O is less exothermic than Be_3N_2 .

[4]

[Total: 8]

- 2 (a) (i) Rate = $k[\text{C}_6\text{H}_5\text{CH}_2\text{C}(\text{CH}_3)_2\text{C}]$, order of reaction wrt to [(2-Chloro-2 methyl propyl) benzene] is one. Order of reaction wrt to NH_3 is zero, hence the concentration of NH_3 does not affect the initial rate.

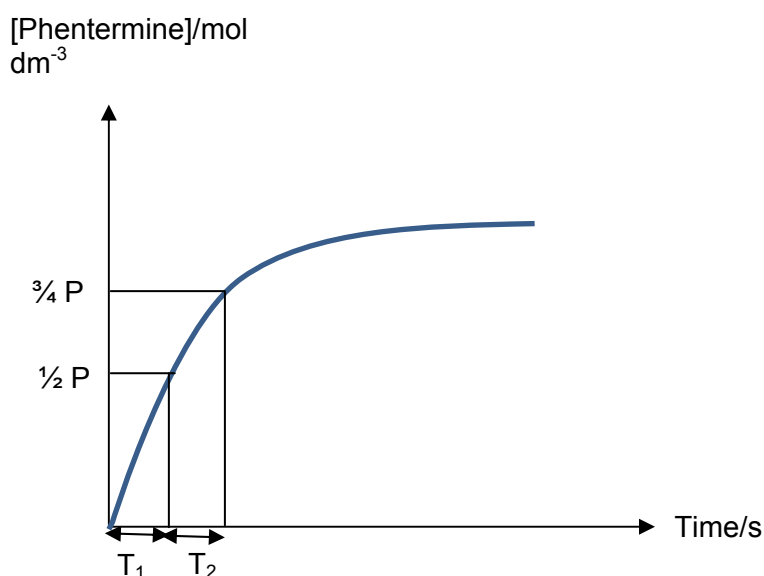
Comparing experiment 1 and 2,
When [(2-Chloro-2 methyl propyl) benzene] triples, initial rate of reaction should also triple.

$$x = 2.8 \times 10^{-7} \times 3 \\ = 8.40 \times 10^{-7} \text{ mol dm}^{-3} \text{ s}^{-1}$$

Comparing experiment 1 and 3, the initial rate of reaction increases by 4 times. Hence, [(2-Chloro-2 methyl propyl) benzene] should also increase by 4 times.

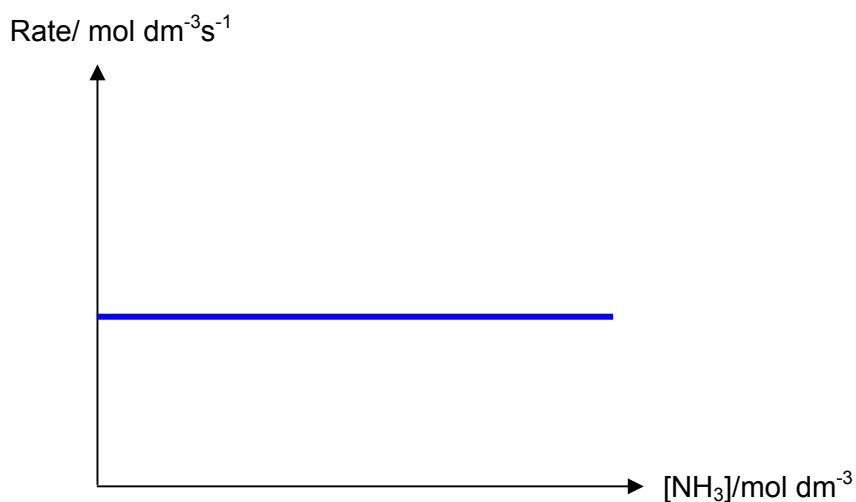
$$y = 5.0 \times 10^{-3} \times 4 \\ = 2.00 \times 10^{-2} \text{ mol dm}^{-3}$$

(ii)



upward decreasing gradient curve

T_1 and T_2 should be approximately constant (determined by marker)



[4]

- (b) (i) The 1st half-life for experiment where $[\text{KOH}] = 0.10 \text{ mol dm}^{-3}$ is 120 min and the 2nd half-life is $(230 - 120) = 110 \text{ min}$ OR

The 1st half-life for experiment where $[\text{KOH}] = 0.15 \text{ mol dm}^{-3}$ is 80 min and the 2nd half-life is $(150-80) = 70 \text{ min}$

As the half-life is a constant, the order of reaction with respect to 1-chloropropane is one.

(ii) Initial rate for $[\text{KOH}]$ at 0.15 mol dm^{-3}

$$= \frac{(0.01 - 0)}{(0 - 200)}$$

$$= 5 \times 10^{-5} \text{ mol dm}^{-3} \text{ min}^{-1}$$

Initial rate when $[\text{KOH}]$ at 0.10 mol dm^{-3}

$$= \frac{(0.01 - 0)}{(0 - 130)}$$

$$= 7.69 \times 10^{-5} \text{ mol dm}^{-3} \text{ min}^{-1}$$

[1-chloropropane] kept constant at $t = 0 \text{ min}$.

When $[\text{KOH}]$ is increased by 1.5 times, the rate increases by 1.5 times.

Thus, the order of reaction with respect to KOH is one.

(iii) Rate = $k[\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}][\text{KOH}]$

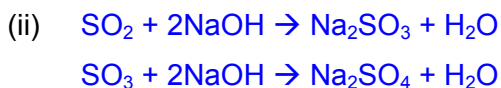
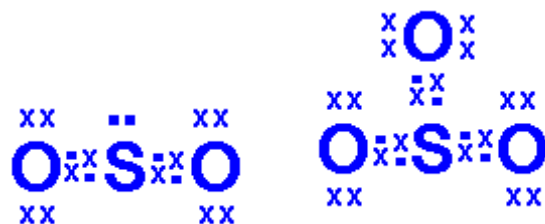
[6]

[Total: 10]

3	(a)		DO ₂	EO	FO ₂
		structure	giant covalent	giant ionic	simple covalent
		type(s) of bonding and forces of attraction	Strong covalent bonds between atoms	Electrostatic forces of attraction between oppositely charged ions	<i>intramolecular:</i> covalent bonding <i>intermolecular:</i> van der Waal's forces

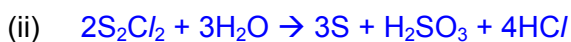
[7]

(b) (i)



[4]

(c) (i) amount of $\text{S}_2\text{Cl}_2 = 1.00/135.2 = 0.007396 \text{ mol}$
amount of $\text{S} = 0.36/32.1 = 0.01121 \text{ mol}$
mole ratio of $\text{S} : \text{S}_2\text{Cl}_2 : \text{S} = 0.007396 : 0.01121$
 $= 1 : 1.5$
 $= 2 : 3$



[3]

[Total: 14]

4 a (i) 1-chloropropane: AgCl and white ppt
1-bromopropane: AgBr and cream ppt

(ii) 1-bromopropane as it has a higher mass of precipitate formed.

(iii)

C-X bond	Bond energy (kJ mol^{-1})
C-Cl	340
C-Br	280

1-bromopropane is more reactive as the C-Br bond has a longer bond length

And its bond strength is weaker and less energy is needed to break the C-Br bond compared to the C-Cl bond.

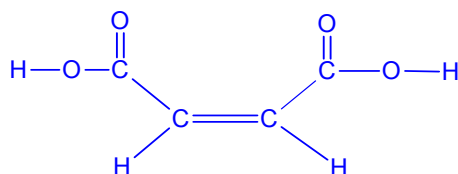
(b) Product: [6]
 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$
Type of reaction: substitution

[2]

[Total : 8]

Section B

5 (a) (i)



Must be cis and trigonal planar wrt each C bearing the C=C

- (ii) Maleic acid OR cis-isomer has intramolecular hydrogen bonding (as the two COOH groups are closer to each other).

Maleic acid should have a lower melting point as it can form less extensive intermolecular hydrogen bonds (between molecules) hence less energy is required to break the weak hydrogen bonds .

[5]

- (b) (i) Standard enthalpy change of formation of maleic acid is the enthalpy change when 1 mole of maleic acid in a specific state is formed from its constituent elements in their standard states under standard conditions of 298K and 1 atm.



- (ii) Using the data given below, calculate the standard enthalpy change of formation of maleic acid. Show your working clearly.

compound	standard enthalpy changes /kJ mol ⁻¹
maleic acid (C ₄ H ₄ O ₄)	$\Delta H_c^\theta = -1355$
H ₂ O (l)	$\Delta H_f^\theta = -285.8$
CO ₂ (g)	$\Delta H_f^\theta = -393.5$

(ii)

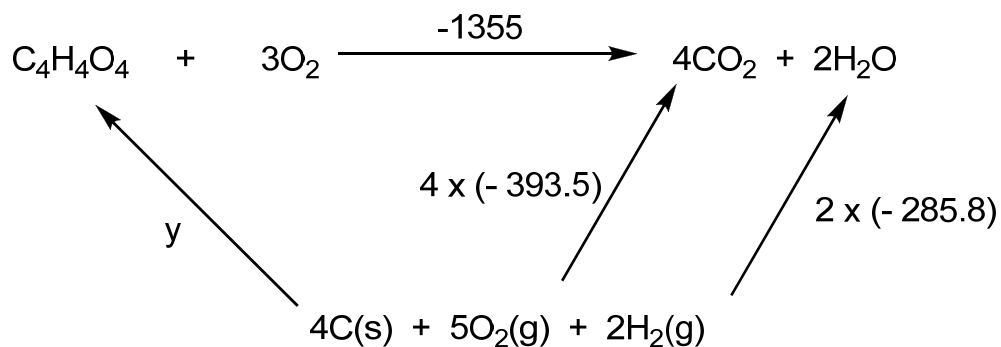
Using formula:



$$\Delta H_r = \Sigma \Delta H_f (\text{pdt}) - \Sigma \Delta H_f (\text{rxt})$$

$$\begin{aligned} -1355 &= [4 (-393.5) + 2 (-285.8)] - [\Delta H_f (\text{maleic acid})] \\ \Delta H_f (\text{maleic acid}) &= [4 (-393.5) + 2 (-285.8) + 1355] \\ &= [-1574 - 571.6] + 1355 \\ &= -790.6 \\ &= -791 \text{ kJ mol}^{-1} \end{aligned}$$

Using cycle:



Applying Hess' Law,

$$-1355 = -y + (4 \times (-393.5)) + (2 \times (-285.8))$$

$$\begin{aligned}
 Y &= -1574 - 571.6 + 1355 \\
 &= -790.6
 \end{aligned}$$

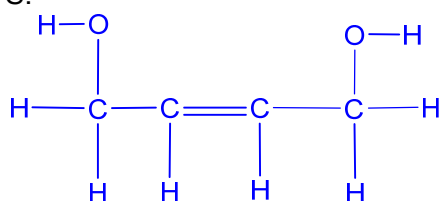
Enthalpy change of formation of maleic acid = -791 kJ mol^{-1}

[5]

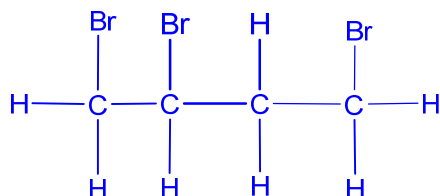
(c) (i) I : LiAlH_4 , dry ether, room temp

II : KMnO_4 , dil H_2SO_4 , reflux

(ii) S:



T:



[4]

d (i) maleic acid from W

Reagent and condition : $\text{K}_2\text{Cr}_2\text{O}_7$, dil H_2SO_4 , heat

Observation with maleic acid: Orange dichromate remains

Observation with W : Orange dichromate turns green

OR

Reagent and condition : Na_2CO_3 (s) ; room temp

Observation with maleic acid: Effervescence observed. Gas evolved will form white ppt in calcium hydroxide.

Observation with W: Effervescence not observed.

(ii) W from X

Reagent and condition : Br_2 (l) ; room temp

Observation with W: Reddish brown bromine decolorised

Observation with X : Reddish brown bromine remains

OR

Reagent and condition : Br_2 (aq) ; room temp

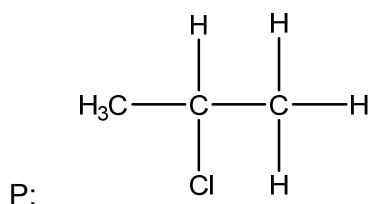
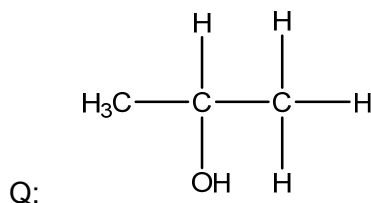
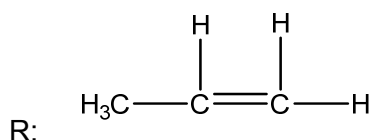
Observation with W: Orange bromine decolorised

Observation with X: Orange bromine remains

[6]

[Total: 20]

- 6 (a) P reacts via substitution to form Q.
Q has the functional group $\text{CH}_3\text{CH}(\text{OH})-$ or $\text{CH}_3\text{C}=\text{O}-$
Q reacts via mild oxidation to form a yellow ppt, CHI_3 .
Q reacts via elimination to form R, an alkene.
R reacts via addition to form the shown compound above.



[6]

- (b) (i) Reagent: KMnO_4 , dilute H_2SO_4
Condition: heat with reflux

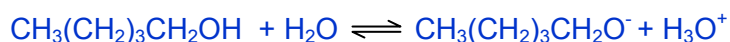
Type of reaction: oxidation

- (ii) Compound A is more acidic than pentan-1-ol.

(This is because of the powerful resonance stability of its anion, $\text{CH}_3(\text{CH}_2)_3\text{COO}^-$.)

The negative charge on the carboxylate anion can be delocalised over two electronegative oxygen atoms. This disperses the negative charge on the oxygen atom and leads to a stabilisation of the anion.

OR



For the $\text{CH}_3(\text{CH}_2)_3\text{CH}_2\text{O}^-$ anion or alkoxide ion, the electron-donating alkyl group intensifies the negative charge on the oxygen atom of the anion.

Thus, the anion is less stable. Hence pentan-1-ol is less acidic.

- (iii) Reagent: CH_3COOH
Condition: heat with reflux

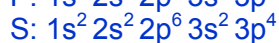
- (iv) The role of concentrated sulfuric acid is acid catalyst and dehydrating agent.

[9]

- (c) (i) First ionisation energy increases across a period.
Nuclear charge increases as the number of protons increases.
Shielding effect remains relatively constant as electrons are added to the same principal quantum shell.

The increase in nuclear charge outweighs the negligible increase in shielding effect provided by extra electron added to the same quantum shell. As a result, effective nuclear charge increases. OR Hence electrostatic attraction between the valence electrons and nucleus increases. More energy is required to remove the valence electron.

- (ii) Electronic Configuration:



For sulfur, the 2 electrons in the same 3p orbital experiences inter-electronic repulsion, hence it is easier to remove an electron from this orbital and less energy is required. First IE of S is lower than that of P.

[5]

[Total: 20]

- 7 (a) (i) Sorafenib: $\text{C}_{21}\text{H}_{16}\text{ClF}_3\text{N}_4\text{O}_3$

- (ii) mass of C:

$$\frac{12.0 \times 21}{(12.0 \times 21 + 1.0 \times 16 + 35.5 + 19.0 \times 3 + 14.0 \times 4 + 16.0 \times 3)} \times 1$$
$$= \frac{252}{464.5}$$

$$= 0.543 \text{ mg OR } 5.43 \times 10^{-4} \text{ g}$$

[3]

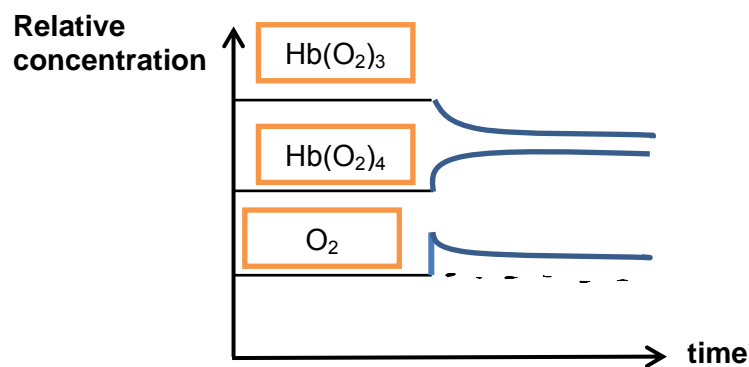
(b) (i) Le Chatelier's Principle states that if a system in equilibrium is subjected to a change which disturbs the equilibrium, the position of equilibrium will respond in such a manner as to reduce the change.

(ii) In the lungs, the concentration of oxygen is high.
According to LCP, to reduce the $[O_2]$, the system responds by shifting equilibrium position to the right increasing the $[Hb(O_2)_4]$ / oxyhaemoglobin/ any of the oxygenated Hb products and hence binding oxygen in the lungs.

In the tissues, the concentration of oxygen is low.

According to LCP, to increase the $[O_2]$, the system responds by shifting any equilibrium position to the left, increasing the $[O_2]$ and hence releasing oxygen in the tissue.

(iii)



(iv)
$$K_p = \frac{1}{(p_{O_2})^4} \text{ atm}^{-4}$$

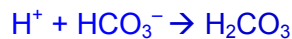
[9]

(c) (i) When one does excessive exercise, the concentration of the lactic acid will increase and as a result the pH will be lower than 7.4.

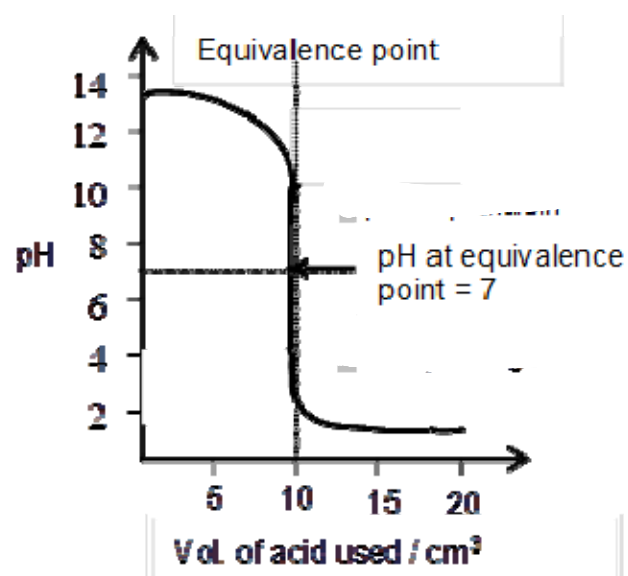
(ii) A buffer solution is a solution of which the pH does not change significantly on the addition of little acid or base.

(iii) Excessive exercise causes more lactic acid to be produced.
When the acid enters the blood, the additional H^+ ions are removed by the HCO_3^- ion acting as a base, forming CO_2 and H_2O OR H_2CO_3 or seen in eqn

Hence the pH of the blood is kept almost unchanged.



(iv)



[8]

[Total: 20]

