NATIONAL JUNIOR COLLEGE
SH2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY **8873/02**

Paper 2 Structured Questions **17 September 2024**
2 hours

Candidates answer on the Question Paper.
Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, registration number and subject class on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** the questions.

Section B
Answer **one** question.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

A1	**/7**
A2	**/12**
A3	**/20**
A4	**/11**
A5	**/10**
B6 / B7	**/20**
Paper 2	**/80**
Paper 1	**/30**

Weightage	
Paper 1 (33%)	**/33**
Paper 2 (67%)	**/67**
Overall	

This document consists of **23** printed pages and **1** blank page.

Section A

Answer **all** the questions in this section in the spaces provided.

1 The structure of the atom was the subject of much discussion by scientists in the 19th and 20th centuries. The model that is agreed upon today was largely developed by Bohr, Rutherford, Moseley and Chadwick and describes atoms as consisting of smaller particles called protons, neutrons and electrons.

(a) **(i)** Complete Table 1.1 to show the relative charge, relative mass and behaviour in an electric field of each of these three sub-atomic particles.

Table 1.1

	proton	neutron	electron
relative charge	+1	0	−1
relative mass	1	1	$\frac{1}{2000}$
Direction of deflection of particle in an electric field	To negative plate	No effect	To positive plate

[2]

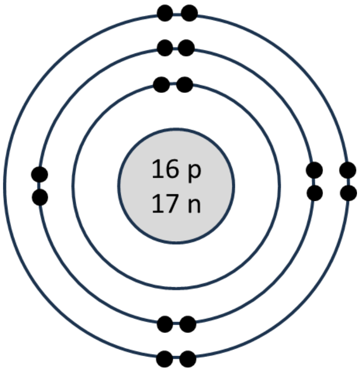
(ii) Which particle will be deflected the most in an electric field?

Electron

Note: angle of deflection $\propto \frac{charge}{mass}$

[1]

(b) An element has a proton number of 16 and a nucleon number of 33. Draw a detailed diagram to represent the arrangement of protons, neutrons and electrons in an atom of this element.



[2]

(c) The element sulfur has four naturally occurring isotopes as shown in Table 1.2.

Table 1.2

isotope	relative abundance / %
^{32}S	94.93
^{33}S	0.76
^{34}S	4.29
^{36}S	0.02

Use the relative abundance data to calculate the relative atomic mass of sulfur to 4 significant figures. Show your working.

$$A_r = \frac{(94.93 \times 32) + (0.76 \times 33) + (4.29 \times 34) + (0.02 \times 36)}{100} = 32.09 \text{ (4s.f.)}$$

[2]

[Total : 7]

2 **(a)** With reference to the *Data Booklet*, state and explain the trend in the thermal stability of hydrogen halides down the group.

Down the group, the bond strength decreases from HC*l* (431 kJ mol^{-1}) to HBr (366 kJ mol^{-1}) to HI (299 kJ mol^{-1}) [1].

Decreasing amount of energy is required to overcome H-X bond to cause decomposition to its elements. [1/2]

Thus, the thermal stability of the hydrogen halides **decreases [1/2]** down the Group.

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[2]

(b) Element **A** is from Period 4 of the Periodic Table. The first eight ionisation energies of element **A**, in kJ mol^{-1}, are

947 1798 2735 4837 6043 12310 14300 16800

(i) Identify element **A** and explain your answer.

Element A is Arsenic. There is a large difference between the 5th and 6th ionisation energies of A. The 6th electron is from an inner electronic shell. A has 5 valence electrons, hence it is from Group 15.

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[2]

(ii) Explain the difference between the first ionisation energy of element **A** compared to the element to its right on the Periodic Table.

The element to the right is Selenium. 1st ionisation energy of Se involves the removal of paired 4p electrons which experiences inter-electronic repulsion. Less energy is needed to remove the electron from Se than the unpaired 4p electron in A. Hence, the IE of Se is lower

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[2]

(c) A student mixed up the labels of a few bottles in the laboratory. The following are the labels that were mixed up:

$AlCl_3$ Al_2O_3 SiO_2 PCl_5

The following tests were then conducted to identify the bottles and the observations are recorded:
X and **Y** are insoluble in water while **W** and **Z** dissolve readily in water. When tested, the pH of the solution of **W** is lower than that of **Z**.

Y can react with both HC*l* (aq) and NaOH (aq), but **X** can only react with concentrated NaOH.

Determine the identities and provide relevant equations to support the answer.

W: PCl_5 X: SiO_2 Y: Al_2O_3 Z: $AlCl_3$
[1/2] for each positive identification

$AlCl_3(s) + 6\ H_2O(l) \rightarrow [Al(H_2O)_6]^{3+}(aq) + 3\ Cl^-(aq)$
$[Al(H_2O)_6]^{3+}(aq) \rightleftharpoons [Al(H_2O)_5(OH)]^{2+}(aq) + H^+(aq)$ [1]

$PCl_5(s) + 4\ H_2O(l) \rightarrow H_3PO_4(aq) + 5\ HCl(aq)$ [1]

$Al_2O_3(s) + 6\ HCl(aq) \rightarrow 2\ AlCl_3(aq) + 3\ H_2O(l)$
$Al_2O_3(s) + 2\ NaOH(aq) + 3\ H_2O(l) \rightarrow 2\ Na[Al(OH)_4]$ [1]

$SiO_2(s) + 2\ NaOH(concentrated) \rightarrow Na_2SiO_3(aq) + H_2O(l)$ [1]

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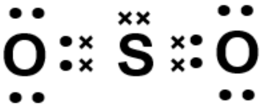
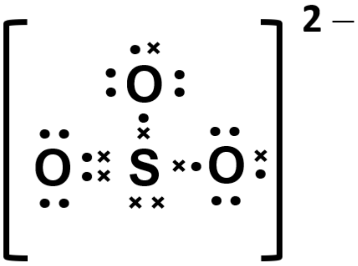
[6]

[Total : 12]

3 **(a)** Sulfur dioxide SO_2 and sulfites, SO_3^{2-}, are used as a food preservative to prevent spoilage.

(i) Draw the dot and cross diagram of SO_2 and SO_3^{2-}.





[2]

(ii) Using the Valence Shell Electron Pair Repulsion theory, state and explain the O−S−O bond angle in SO_2 and SO_3^{2-}.

The electron regions arrange themselves as far as possible to minimise repulsion.

SO_3^{2-} has 3 bond pairs and 1 lone pair with bond angle of 107 ° while SO_2 has 2 bond pairs and 1 lone pair with bond angle of 117.5°.

[3]

(b) The maximum permissible level of sulfite in wine is 250 mg per dm^3 of wine.

The amount of sulfite can be determined via titration with an oxidising agent.

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

A 25.0 cm^3 sample of a wine was acidified, warmed and titrated against $KMnO_4$ to determine its concentration. 19.00 cm^3 of 0.020 mol dm^{-3} $KMnO_4$ was needed to reach the end point.

(i) Write the overall equation for the reaction between SO_3^{2-} and MnO_4^-.

[O]: $SO_3^{2-} + H_2O \rightarrow SO_4^{2-} + 2H^+ + 2e^-$ ×5
[R]: $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ ×2

Overall: $5SO_3^{2-} + 2MnO_4^- + 6H^+ \rightarrow 5SO_4^{2-} + 2Mn^{2+} + 3H_2O$

Note: MnO_4^- is reduced to Mn^{2+} in acidic medium

[1]

(ii) Suggest why the wine sample need to be warmed before the titration?

Both SO_3^{2-} and MnO_4^- ions are negatively charged and will repel, leading to high activation energy. Hence, the heat will help to overcome the high activation energy.

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[1]

(iii) Determine the concentration in mol dm^{-3}, of SO_3^{2-} in the wine sample.

Amount of MnO_4^- used = $\frac{19.00}{1000} \times 0.0200$

$= 3.80 \times 10^{-4}$ mol

Amount of SO_3^{2-} in the sample = $\frac{5}{2} \times 3.80 \times 10^{-4}$

$= 9.5 \times 10^{-4}$ mol

Concentration of SO_3^{2-} in the sample = $\dfrac{9.5 \times 10^{-4}}{(\frac{25}{1000})}$

$= 0.038$ mol dm^{-3}

[2]

(iv) Hence, determine whether the wine is safe for consumption.

M_r of $SO_3^{2-} = 32.1 + 16.0 \times 3 = 80.1$

Concentration of SO_3^{2-} in g dm^{-3} = $0.038 \times 80.1 = 3.044$ g dm^{-3}

Concentration of SO_3^{2-} in mg dm^{-3} = $3.044 \times 1000 = 3044$ mg dm^{-3} [1]

Since the concentration of SO_3^{2-} is greater than 250 mg dm^{-3}, the wine is not safe for consumption. [1]

[2]

(c) Sulfur trioxide is formed from the reaction between SO_2 and O_2 as shown below:

$$2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3\,(g)$$

(i) With reference from the *Data Booklet*, determine the enthalpy change of the reaction.

Break 1 O=O, form 2 S=O

ΔH = Σ energy of bonds broken – Σ energy of bonds formed
= +496 – (2 × 500) [1]
= – 504 kJ mol^{-1} [1]

[2]

(ii) Write an expression for the equilibrium constant, K_c, for the reaction above, stating its units.

$K_c = \dfrac{[SO_3]^2}{[O_2]\,[SO_2]^2}$ $mol^{-1}\,dm^3$

[1]

(iii) 3 mol dm^{-3} of SO_2 and 2.3 mol dm^{-3} of O_2 were mixed in a closed vessel and allowed to reach equilibrium. The equilibrium concentration of SO_2 is found to be 2.4 mol dm^{-3}.

Calculate the K_c value.

	$2SO_2\,(g)$ +	$O_2\,(g)$ ⇌	$2SO_3\,(g)$
initial / mol dm^{-3}	3	2.3	0
change / mol dm^{-3}	–0.6	–0.3	+0.6
eqm / mol dm^{-3}	2.4	2.0	0.6

[1]

$K_c = \dfrac{[0.6]^2}{[2.0]\,[2.4]^2}$
= 0.03125
= 0.0313 $mol^{-1}\,dm^3$ [1]

[2]

The concentrations of the species were monitored over a period in the Fig 3.1:

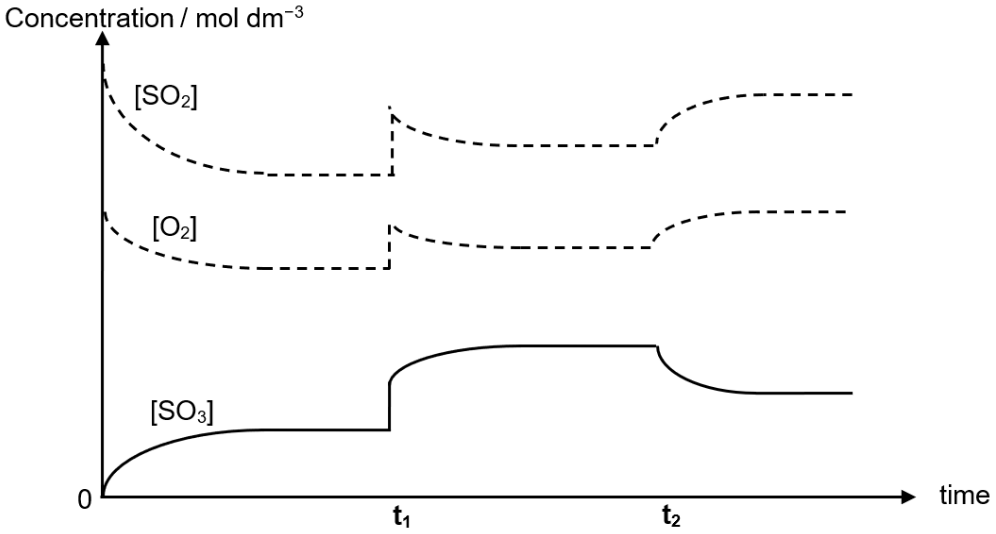

Fig 3.1

(iv) At t_1, the vessel was compressed and the total pressure increases.

Using Le Chatelier's Principle, explain the change in concentration of SO_3 between t_1 and t_2.

By Le Chatelier's Principle, the equilibrium will try to reduce the total pressure by favouring the side with lesser no. of gaseous particles. **The position of equilibrium shifts to the right** and hence concentration of SO_3 increases [1].

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[2]

(v) Considering your answer in **(c)(i)**, deduce the change in condition at t_2.

At t_2, temperature increases. The **position of equilibrium shifts left** to favour the **backward endothermic reaction [1]** to **remove some of the heat [1]**, forming more SO_2 and O_2 and reducing SO_3.

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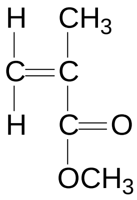
[2]

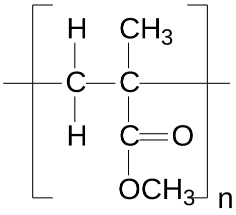
[Total: 20]

[Turn over

4 **(a)** Poly(methyl methacrylate) (PMMA) is the synthetic polymer derived from methyl methacrylate (MMA) with the structural formula $CH_2C(CH_3)COOCH_3$. It is used as an engineering plastic, and it is a transparent thermoplastic.

(i) Draw the MMA monomer and one repeating unit of the PMMA polymer.





[2]

(ii) State the type of polymerisation that MMA undergoes.

Addition polymerisation

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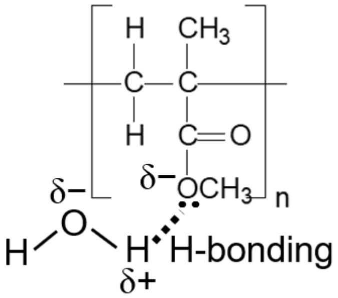
[1]

(iii) When PMMA is exposed to environments with high humidity, it absorbs water and reduces its tensile strength. With the aid of a diagram, show interaction formed between the water molecule and PMMA.



[2]

(iv) With reference to the structure, suggest why PMMA cannot be used to hold alkaline based cleaners.

The ester functional group can undergo alkaline hydrolysis.

....

[1]

(v) Explain why thermoplastics can be recycled.

Heat breaks down the weak instantaneous dipole-induced dipole interaction between the polymer chains and soften it. Upon cooling, new intermolecular forces are formed between the polymer chains and new plastic is formed.

....

[1]

(vi) Methacrylic acid, $CH_2{=}C(CH_3)COOH$, can be used to synthesize methyl methacrylate (MMA), $CH_2C(CH_3)COOCH_3$.

Suggest the reagent and condition required for this synthesis.

CH_3OH, conc H_2SO_4, heat under reflux. ……

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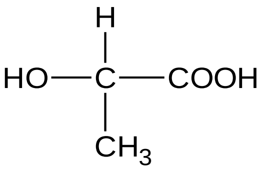
[1]

(b) Unlike PMMA, the polymer, polylactide (PLA) is biodegradable. The monomer required to produce PLA is lactic acid.

The structure of lactic acid is as shown.



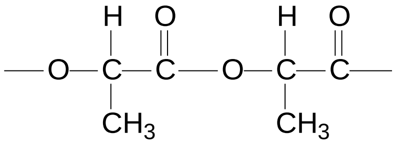
$HO{-}CH(CH_3){-}COOH$

(i) Give the IUPAC name for lactic acid.

2-hydroxypropanoic acid ……

[1]

(ii) Draw the structure of the polymer PLA, showing two repeat units.



$-O{-}CH(CH_3){-}C({=}O){-}O{-}CH(CH_3){-}C({=}O)-$

[1]

(iii) Explain why PLA is biodegradable.

PLA is a polyester, the ester linkages can undergo hydrolysis over time and hence the polymer can be broken down. ……

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………………………………………………………………………………………

[1]

[Total : 11]

5 **(a)** Butan-2-ol can undergo reaction to produce a mixture of 3 isomers, **X**, **Y** and **Z** with the molecular formula C_4H_8.

(i) State the type of reaction.

Elimination

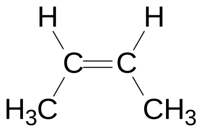
[1]

(ii) Suggest the reagent and condition required for the above conversion.

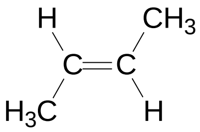
Excess concentrated H_2SO_4, heat
Or Al_2O_3, heat

[1]

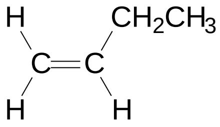
(iii) Suggest the structure of the 3 isomers and state the isomeric relationship between **X** and **Y**, and between **X** and **Z**.



X



Y



Z

X and Y are cis-trans isomers
X and Z are positional isomers.

[4]

(b) A possible source of energy for road vehicles of the future is hydrogen. One of the problems still to be solved is the storage of hydrogen in the vehicle.

(i) Suggest 2 potential issues with the storage of hydrogen in vehicle.

1) Hydrogen gas takes up a larger volume as compared to liquid fuel.
2) High pressure / low temperature is required to store liquified hydrogen.
3) Hydrogen is highly explosive, in the event of car crash, it could lead to explosion.
Accept any other sound reasoning.

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[2]

One alternative is to use a fuel tank packed with carbon nanotubes. The hydrogen in the tank would be adsorbed onto the surface of the nanotubes at a pressure no more than a few atmospheres.

(ii) Suggest an approximate width of a carbon nanotube.

Any value from 1-100nm ……………………………………………………

[1]

(iii) State the forces that are responsible for holding the hydrogen on the surface of the nanotubes.

Instantaneous dipole – induced dipole ……………………………………

[1]

[Total : 10]

Section B

Answer **one** question from this section in the spaces provided.

6 **(a)** The condensation of ethanoic acid and ethanol to form ethyl ethanoate is catalysed by acid as shown by the equation

$$CH_3CO_2H + C_2H_5OH \rightleftharpoons CH_3CO_2CH_2CH_3 + H_2O$$

To determine the orders of reaction with respect to ethanol and ethyl ethanoate, various volumes of the these were reacted and the results for the rates of the reactions are given in the Table 6.1.

Table 6.1

Expt	Vol of C_2H_5OH/cm^3	Vol of CH_3CO_2H/cm^3	Vol of H^+/cm^3	Vol of H_2O/cm^3	Rate of reaction/ mol dm^{-3} s^{-1}
1	20	10	5	35	2.5×10^{-4}
2	40	10	5	15	5.1×10^{-4}
3	40	20	5	5	1.0×10^{-3}

(i) Define the term rate of reaction.

The change in the concentration of reactants or products over time.

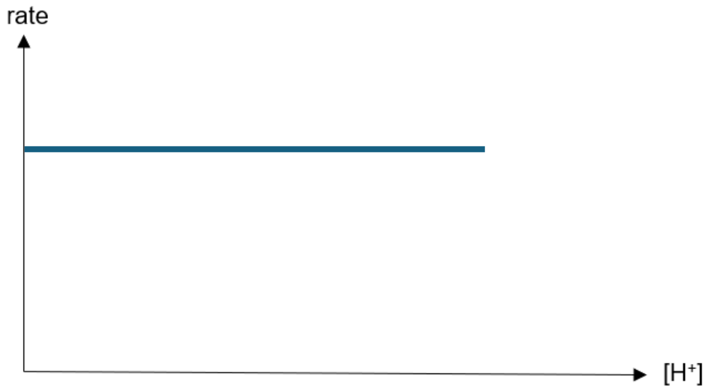
……………………………………………………………………………………… [1]

(ii) Explain why varying volumes of water were used.

To ensure the total volume of the reaction mixture between all experiments is constant such that the vol of the reactants used are directly proportional to its concentration in the final mixture.

……………………………………………………………………………………… [1]

(iii) The order of reaction with respect to H^+ is found to be zero. Sketch the graph of rate against concentration of H^+.



[1]

(iv) Deduce the order of reaction with respect to C_2H_5OH and CH_3CO_2H.

Comparing expt 1 and 2 where the volume of the CH_3CO_2H is kept constant, when the volume of the C_2H_5OH doubled, rate doubles. Hence, reaction is first order with respect to C_2H_5OH.

Comparing expt 2 and 3, when the volume of both C_2H_5OH and CH_3CO_2H is doubled, the rate quadruples. As the order of reaction for C_2H_5OH has been determined to be 1, the reaction is first order with respect to CH_3CO_2H.

[2]

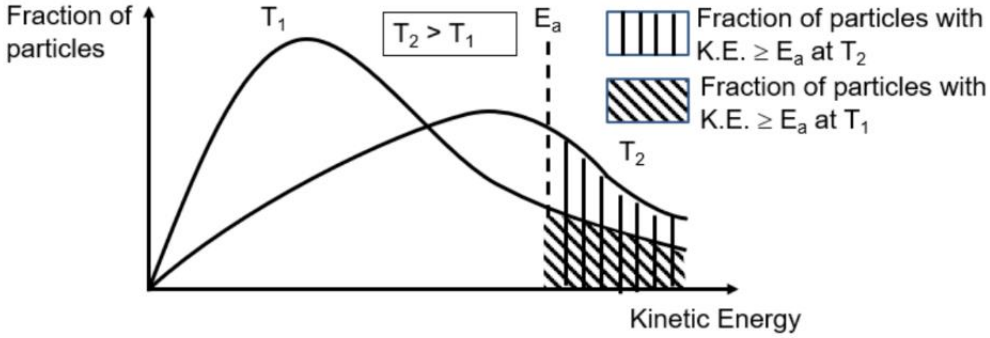
(v) Hence, state the rate equation for the condensation reaction. Deduce the units of the rate constant.

Rate = k $[CH_3CO_2H][C_2H_5OH]$

Units of k = $mol^{-1}\ dm^3\ s^{-1}$

[2]

(vi) With the aid of a Boltzmann distribution curve, explain the effect on the rate of reaction when temperature is increased.



As temperature increases, average K.E increase. The number of particles with energy greater than activation energy increases, giving rise to an increase in the frequency of effective collision. Hence, rate of reaction increases.

[3]

(b) H_2SO_4 is a strong acid while CH_3COOH is a weak acid.

(i) Calculate the pH of a 0.200 mol dm^{-3} H_2SO_4 solution.

$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$

$[H^+] = 2 \times 0.200 = 0.400$ mol dm^{-3}

pH $= -\lg[H^+] = 0.398$

[2]

(ii) Explain how a solution of CH_3COOH and CH_3COO^- can act as a buffer upon addition of small amounts of HC*l* and NaOH.

....

Large reservoir of CH_3COO^- neutralise **small amount** of H^+ added.

$CH_3COO^- + H^+ \rightarrow CH_3COOH$ [1]

Large reservoir of CH_3COOH neutralise **small amount** of OH^-

$CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$ [1]

Hence pH of the buffer solution remains approximately the same.

....

[2]

(c) Ethanol has a boiling point of 76 °C while water has a boiling point of 100 °C.

In terms of structure and bonding, explain the difference in the boiling point of the two compounds.

Ethanol and water are covalent compound with simple molecular structure. They have H−bonding and id-id between the molecules.

However, H_2O is able to form 2 H−bonding per molecule as compared to ethanol that can only form 1 H−bonding.

Hence a larger amount of energy is required to overcome the more extensive H−bonding between H_2O molecules, leading to higher boiling point.

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[2]

(d) Fig 6.1 shows an energy cycle involving the fuel ethanol.

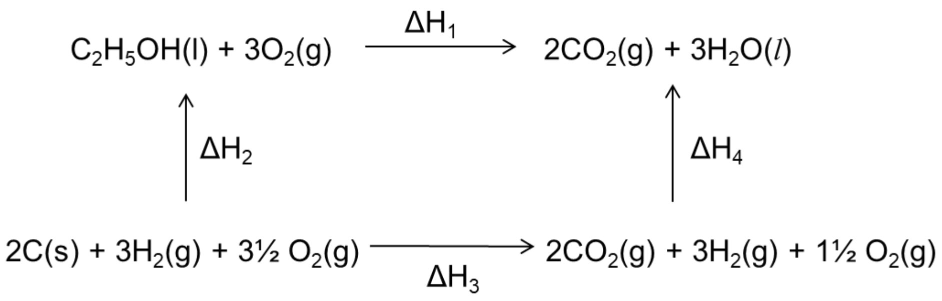


Fig 6.1

(i) In the energy cycle above, what enthalpy change is represented by ΔH_2?

Enthalpy change of formation of C_2H_5OH (l)

[1]

(ii) Write an equation that links ΔH_1, ΔH_2, ΔH_3 and ΔH_4.

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

[1]

(iii) Use the following data to calculate the standard enthalpy change of combustion of ethanol.

$\Delta H_c^\ominus$ carbon = –393 kJ mol^{-1}

$\Delta H_c^\ominus$ hydrogen = –286 kJ mol^{-1}

$\Delta H_f^\ominus$ ethanol = –277 kJ mol^{-1}

$$\Delta H_1 = -(-277) + 2 \times (-393) + 3 \times (-286)$$
$$= -1367 \text{ kJ mol}^{-1}$$

[2]

[Total : 20]

7 **(a)** A sample of pure N_2O_5 (g) is placed in an evacuated container and allowed to decompose at a constant temperature of 300K.

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

The concentration of N_2O_5 in the container is measured over a period of time, and the measurement are recorded in Table 7.1.

Table 7.1

Time (min)	$[N_2O_5]$/ moldm^{-3}
0	0.480
10	0.381
20	0.302
30	0.240
40	0.190
50	0.150

(i) With the use of the data in Table 7.1, show that the order of reaction with respect to N_2O_5 is one.

Concentration of N_2O_5 decreases with a **constant half-life of 30 mins.**
0.480 to 0.240 takes 30 mins
0.381 to 0.190 takes 30 mins

This shows that the reaction is 1st order with respect to N_2O_5.

[1]

(ii) State the rate equation for the reaction. Deduce the units of the rate constant.

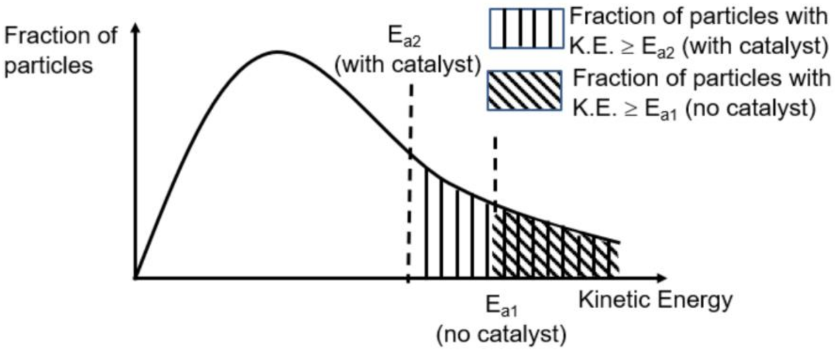
Rate = k $[N_2O_5]$
Units of k = s^{-1}

…

……..…………………………………………………………………………………….

[2]

(iii) With the aid of a Boltzmann distribution curve, explain the effect on the rate of reaction when a catalyst is added.



When a catalyst is added, the activation energy of the reaction decreases. The number of particles with energy greater than activation energy increases, giving rise to an increase in the frequency of effective collision. Hence, rate of reaction increases.

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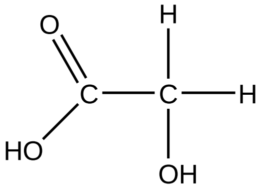
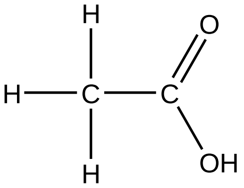
[3]

(b) Table 7.2 shows the K_a values of glycolic acid and ethanedioic acid.

Table 7.2

Acid	 glycolic acid	 ethanoic acid
K_a	1.48×10^{-4}	1.8×10^{-5}

(i) With reference to the table above, explain which acid is the stronger acid.

Glycolic acid is the stronger acid as it has a higher K_a value and hence greater extent of dissociation than ethanoic acid.

……………………………………………………………………………………………

……………………………………………………………………………………………

[1]

(ii) Write the K_a expression for the dissociation of glycolic acid. You may represent glycolic acid using RCOOH.

$$K_a = \frac{[RCOO^-][H^+]}{[RCOOH]}$$

[1]

(iii) The pH of the equivalence point of the titration between glycolic acid and NaOH is 7.6.

The working range pH of two indicators are shown in Table 7.3.

Table 7.3

Indicator	working range pH
Methyl Orange	3 – 5
Thymolphthalein	8 – 10

Explain which indicator is suitable for this titration.

Thymolphthalein as the working range pH coincides with the sharp change in pH at the equivalence point.

[1]

(iv) 50.0 cm^3 of 0.100 mol dm^{-3} NaOH(aq) are added to 25.0 cm^3 of 0.100 mol dm^{-3} of glycolic acid.

Calculate the pH of the resulting solution.

$$RCOOH + NaOH \rightarrow RCOO^-Na^+ + H_2O$$

Amount of RCOOH = $\frac{25}{1000} \times 0.100 = 0.0025$ mol

Amount of NaOH = $\frac{50}{1000} \times 0.100 = 0.0050$ mol

Amount of unreacted NaOH = 0.0050 – 0.0025 = 0.0025 mol

The pH of resulting solution is due to strong base NaOH

$NaOH \rightarrow Na^+ + OH^-$

$[OH^-] = \frac{0.0025}{(\frac{75}{1000})} = 0.03333$ mol dm^{-3}

pOH = −lg $[OH^-]$ = 1.48

pH = 14 – pOH = 12.5

[2]

(c) A reaction scheme involving glycolic acid is shown in Fig 7.1

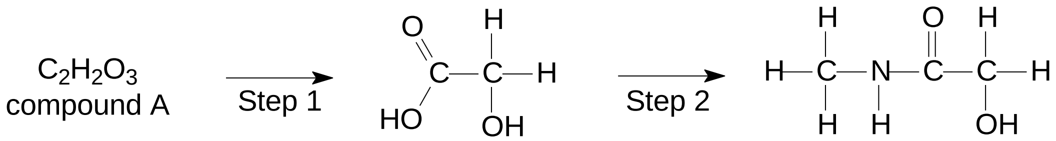


Fig 7.1

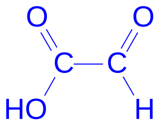
(i) State the type of reaction for Step 1 and Step 2

Step 1 : Reduction .

Step 2 : condensation .

[2]

(ii) Draw the structure of compound **A**.



[1]

(iii) Suggest the reagents and conditions for the reaction in Fig 7.1.

Step 1	$H_2(g)$, Pt(s) or $H_2(g)$, Ni(s) with high temp and pressure
Step 2	CH_3NH_2, DCC

[2]

(d) The enthalpy change of neutralisation between 1.00 mol dm^{-3} glycolic acid and 1.00 mol dm^{-3} sodium hydroxide can be determined experimentally by measuring the change in temperature when the two solutions are mixed together. Table 7.4 shows the data obtained:

Table 7.4

volume of glycolic acid used / cm^3	25.0
volume of sodium hydroxide used / cm^3	30.0
initial temperature of glycolic acid solution / °C	31.3
initial temperature of sodium hydroxide solution / °C	30.8
highest temperature rise after mixing / °C	38.7

(i) Define the term *standard enthalpy change of neutralisation*.

The amount of energy released when 1 mol of water is formed from neutralisation of acid and base under standard conditions of 298 K and 1 bar.

……..…………………………………………………………………………………[1]

(ii) When the initial temperatures of two solutions are different and mixed, the initial temperature of the mixed solution will not be an average.

The weighted average initial temperature is given below:

Weighted average initial temperature = $(\frac{\boldsymbol{V_1}}{\boldsymbol{V_1+V_2}} \times \boldsymbol{T_1}) + (\frac{\boldsymbol{V_2}}{\boldsymbol{V_1+V_2}} \times \boldsymbol{T_2})$

where $\boldsymbol{V_1}$ and $\boldsymbol{V_2}$ are the volumes of solutions 1 and 2 respectively,
$\boldsymbol{T_1}$ and $\boldsymbol{T_2}$ are the initial temperatures of solutions 1 and 2 respectively.

Calculate the weighted average initial temperature of the reaction.

Weighted average initial temperature = (25/55 × 31.3) + (30/55 × 30.8)
= 31.0 °C

[1]

(iii) Calculate the enthalpy change of neutralisation between glycolic acid and sodium hydroxide.

You should assume that the specific heat capacity of the reaction mixture is 4.18 J g^{-1} K^{-1} and the density of each solution is 1.00 g cm^{-3}.
Amount of acid used = 0.025 mol
Amount of NaOH used = 0.030 mol
Amount of H_2O produced = 0.025 mol

$$\Delta H = -\frac{m\,c\,\Delta T}{n_{H2O}} = -\frac{55\times 4.18\times(38.7-31.0)}{0.025} = -70.8\ \text{kJ mol}^{-1}$$

[2]

[Total : 20]