VICTORIA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME ………………………………………………………………..

CT GROUP ……………………………..

CHEMISTRY

9729/02

Paper 2 Structured Questions

12 September 2024

Candidates answer on the Question Paper.

2 hours

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name and CT group in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.
The use of an approved scientific calculator is expected, where appropriate.

A Data Booklet is provided.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 20
2	/ 22
3	/ 16
4	/ 17
Total	/ 75

This document consists of **18** printed pages and **2** blank pages

1 **(a)** The Pauling electronegativity values, E_N, for the elements in the first two periods of the Periodic Table range from 1.0 to 4.0. The elements **X**, **Y** and **Z** are all in the first two periods of the Periodic Table. Their E_N values are shown in Table 1.1.

Table 1.1

element	E_N
X	1.0
Y	2.1
Z	4.0

Substances exist with formulae **XZ**, **YZ** and **Z_2**.

(i) Use Table 1.1 to deduce the group of the Periodic Table that **X** and **Z** belong to.

X belongs to Group **1**

Z belongs to Group **17**

[1]

1m: both correct

(ii) Suggest the structure and bonding present in **XZ**.

- **XZ has a giant ionic structure with ionic bonds (OR electrostatic forces of attraction) between oppositely charged ions.**

[1]

(iii) Arrange **XZ**, **YZ** and **Z_2** in order of increasing melting point.

- **Z_2 < YZ < XZ**

[1]

(b) **(i)** Write the full electronic configuration of an aluminium atom.

- **$1s^22s^22p^63s^23p^1$**

[1]

(ii) Write an equation to show the third ionisation energy of aluminium.

- **$Al^{2+}(g) \rightarrow Al^{3+}(g) + e^-$ (state symbols)**

[1]

(iii) Explain why the third ionisation energy of aluminium is greater than the first ionisation energy of sodium.

- **Al^{2+} has a greater nuclear charge than Na due to greater number of protons. The shielding effect is constant for both Al^{2+} and Na as they have the same electronic configuration (OR number of electrons) and involve the removal of the single electron in 3s orbital.**
- **Hence, Al^{2+} has a greater effective nuclear charge and more energy is required to remove the third electron, leading to greater third ionisation energy than the first ionisation energy of sodium.**

[2]

(c) Two Period 3 elements, **U** and **V**, burn separately in oxygen to form solid oxides. The oxide of **U** is insoluble in water. The oxide of **V** dissolves in water to form solution **W**. Solution **W** reacts with the oxide of **U** at room temperature and dissolves it. **V** has a larger atomic radius than **U**.

(i) Identify **U** and **V**.

- **U** is **aluminium (OR Al)**
- **V** is **sodium (OR Na)**

[2]

(ii) Write an equation for the reaction between oxide of **U** and solution **W**.

- **$Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \rightarrow 2NaAl(OH)_4(aq)$ (no ecf)**

[1]

(d) **(i)** State the total numbers of protons, neutrons and electrons in the NO_3^- ion.

Total number of protons: **31**

Total number of neutrons: **31**

Total number of electrons: **32**

[1]

(ii) Similar to carbonate salts, copper(II) nitrate, $Cu(NO_3)_2$, and barium nitrate, $Ba(NO_3)_2$, decompose when heated. Compare the decomposition temperatures of these two compounds. Explain your answer.

- **Both Cu^{2+} and Ba^{2+} have the same charge but Cu^{2+} has a smaller radius than Ba^{2+}. Hence, Cu^{2+} has a greater charge density and higher polarising power than Ba^{2+}.**
- **Cu^{2+} distorts the electron cloud of NO_3^- more than Ba^{2+}, making $Cu(NO_3)_2$ less stable to heat as the N–O covalent bond within the NO_3^- anion is more weakened. $Cu(NO_3)_2$ has a lower decomposition temperature than $Ba(NO_3)_2$.**

[2]

(iii) Sketch the shape of and label a filled orbital in Cu^{2+}(aq) ion with the highest energy in Fig. 1.1.

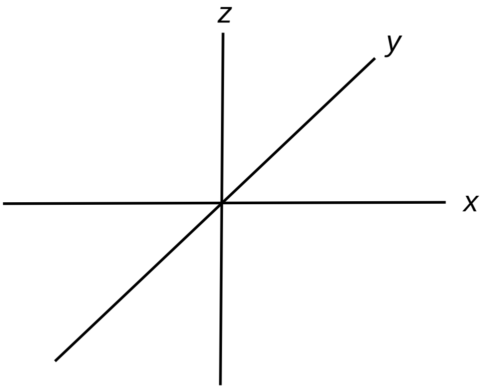
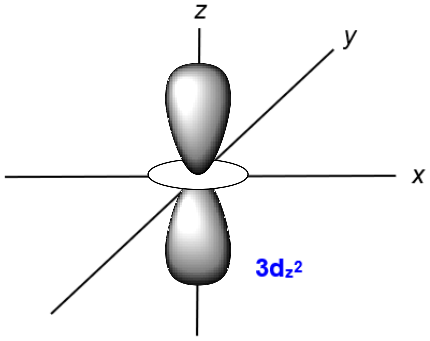
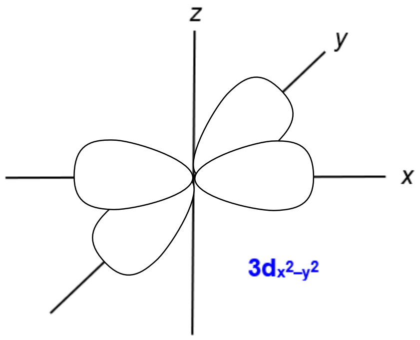


Fig. 1.1

[1]



OR



(iv) Compound **T**, an anhydrous Group 2 bromide, is dissolved in water and titrated against aqueous silver nitrate.

A solution containing 0.250 g of **T** requires 33.65 cm^3 of 0.0500 mol dm^{-3} $AgNO_3(aq)$ for complete reaction. Identify **T**. Show your working.

Amount of $AgNO_3$

$$= 0.0500 \times \frac{33.65}{1000}$$

$$= 1.68 \times 10^{-3} \text{ mol}$$

Let T be MBr_2.

$$MBr_2 + 2AgNO_3 \rightarrow M(NO_3)_2 + 2AgBr$$

Amount of T

- $= \frac{1}{2} \times 1.68 \times 10^{-3} = 0.250 \div M_r(T)$

$M_r(T) = 297.2$

$A_r(M) = 297.2 - 2(79.9) = 137.4$

- **T is $BaBr_2$.**

[2]

(e) HC*l* is a product of several different reactions. Some of these are shown in Fig. 1.2.

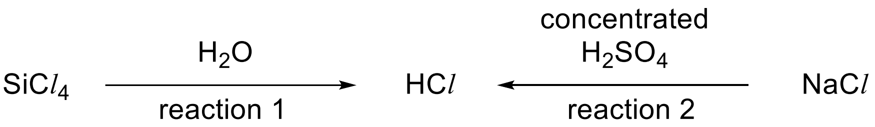


Fig. 1.2

(i) Describe the reaction of $SiCl_4$ with water in reaction 1. Write an equation for the reaction and state the pH of the resultant mixture.

- **$SiCl_4$ reacts violently with water and it undergoes complete <u>hydrolysis</u> in water to give a strongly acidic solution of <u>pH 2</u> (accept pH 1-3). A white ppt is also formed.**
  $SiCl_4(l) + 2H_2O(l) \rightarrow SiO_2(s) + 4HCl(aq)$

[1]

In reaction 2, NaC*l* reacts with concentrated H_2SO_4 to form HC*l* and $NaHSO_4$ only. Similarly, NaBr reacts with concentrated H_2SO_4 to form HBr and $NaHSO_4$. HBr reacts further with concentrated H_2SO_4 to form Br_2 and SO_2.

(ii) State the types of reaction that occur when NaBr reacts with concentrated H_2SO_4 and when HBr reacts with concentrated H_2SO_4.

reactants	type of reaction
NaBr and concentrated H_2SO_4	**acid-base**
HBr and concentrated H_2SO_4	**redox**

[1]

1m: both correct

(iii) Write an equation for the reaction of HBr with concentrated H_2SO_4.

- **$2HBr + H_2SO_4 \rightarrow Br_2 + SO_2 + 2H_2O$**

[1]

(iv) Suggest an explanation for the difference in the reactions when HC*l* and HBr react with concentrated H_2SO_4.

- **HBr is a stronger reducing agent than HC*l*. HC*l* is unable to reduce H_2SO_4 as there is no change in the oxidation state of S in $NaHSO_4$. HBr is able to reduce H_2SO_4 as the oxidation state of S changes from +6 to +4 in SO_2.**

[1]

[Total: 20]

2 **(a)** The reaction between iron(III) ions, $Fe^{3+}(aq)$, and iodide ions, $I^-(aq)$, occurs as shown.

$$Fe^{3+}(aq) + I^-(aq) \rightarrow Fe^{2+}(aq) + \tfrac{1}{2}I_2(aq)$$

The rate of this reaction can be followed by the change in the $I^-(aq)$ concentration as given in the graph in Fig. 2.1. The initial concentration of $Fe^{3+}(aq)$ is 0.150 mol dm^{-3}.

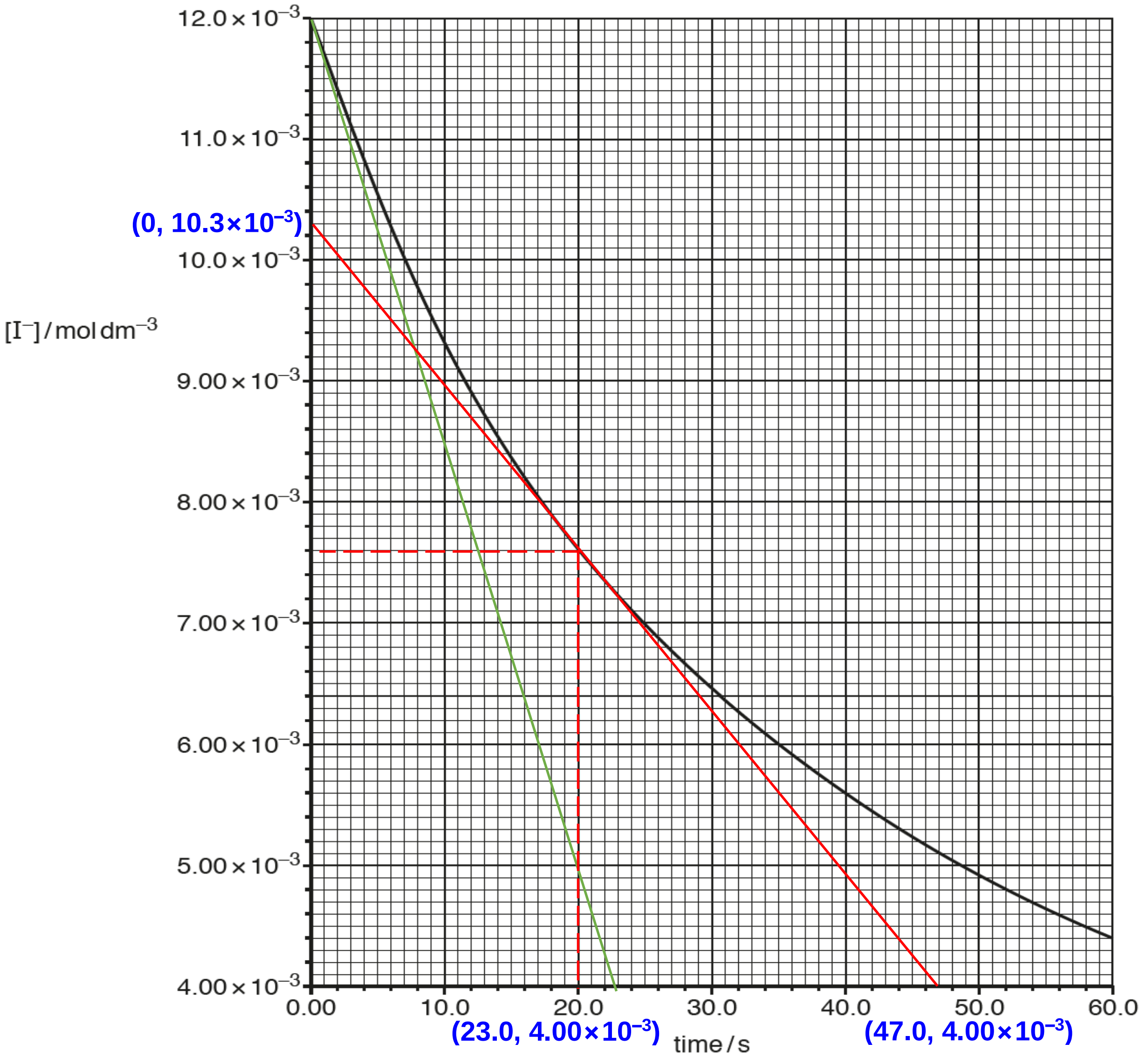


Fig. 2.1

(i) Use Fig. 2.1 to calculate the initial rate of reaction and the rate of reaction at 20 s. Show your working on the graph.

Initial rate of reaction at 0 s

$$= -\frac{12.0 \times 10^{-3} - 4.00 \times 10^{-3}}{0 - 23.0}$$

- $= 3.48 \times 10^{-4}$ mol dm^{-3} s^{-1}

Rate of reaction at 20 s

$$= -\frac{10.3 \times 10^{-3} - 4.00 \times 10^{-3}}{0 - 47.0}$$

- $= 1.34 \times 10^{-4}$ mol dm^{-3} s^{-1}

[2]

(ii) Hence, determine the order of reaction with respect to the concentration of iodide ions. Show your working.

Let n be the order wrt $[I^-]$.

$$\frac{\text{initial rate}}{\text{rate at 20 s}} = \frac{3.48 \times 10^{-4}}{1.34 \times 10^{-4}} = \left(\frac{12.0 \times 10^{-3}}{7.60 \times 10^{-3}}\right)^n \text{ (ecf)}$$

$$n\lg\left(\frac{12.0}{7.60}\right) = \lg\left(\frac{3.48}{1.34}\right)$$

- **$n = 2.09 \approx 2$ (no ecf)**

[1]

(iii) Explain why it is important that the concentration of Fe^{3+}(aq) is in large excess compared to the concentration of I^-(aq) in this experiment.

- **This is to keep the concentration of Fe^{3+}(aq) approximately constant so that the rate is changed by the concentration of I^-(aq) only.**

[1]

(iv) It is found that the reaction is first order with respect to the concentration of Fe^{3+}(aq). Write the rate equation for the reaction between Fe^{3+}(aq) and I^-(aq).

- **Rate = $k[Fe^{3+}][I^-]^2$ (ecf)**

[1]

(v) Use the rate equation and the initial rate you have determined in **(a)(i)** to calculate the rate constant, stating the units.

Rate = $k[Fe^{3+}][I^-]^2$
$3.48 \times 10^{-4} = k(0.150)(12.0 \times 10^{-3})^2$

- **$k = 16.1\ mol^{-2}\ dm^6\ s^{-1}$ (ecf)**

[2]

1m: correct units

(vi) A new experiment of the same reaction was carried out at a different temperature. The value of the rate constant was found to be 2.10. Deduce whether the new experiment was carried out at a higher or lower temperature than the original experiment.

- **Since the rate constant of the new experiment is lower than that in the original experiment, the new experiment was carried out at a lower temperature. (ecf)**

[1]

(b) The halogens, chlorine and bromine, are moderately soluble in water, while iodine is sparingly soluble. The dissolution of chlorine in water occurs with the two equilibria as shown.

$$Cl_2(g) \rightleftharpoons Cl_2(aq) \quad \text{--- (I)}$$
$$Cl_2(aq) + 2H_2O(l) \rightleftharpoons H_3O^+(aq) + Cl^-(aq) + HOCl(aq) \quad \text{--- (II)}$$

(i) Describe the effect of the presence of aqueous hydroxide ions on the solubility of chlorine in water.

- **Hydroxide ions react with H_3O^+ (OR $HOCl$). $[H_3O^+]$ (OR $[HOCl]$) decreases and position of equilibrium (II) shifts to the right. This, in turn, decreases $[Cl_2(aq)]$ and position of equilibrium (I) shifts to the right. Hence, solubility of chlorine increases.**

[1]

(ii) Complete Table 2.1 by describing the covalent bonds formed and the types of interactions that are overcome and formed for the various **chlorine species** in equilibrium (II) when chlorine is dissolved in water. An example is shown below.

Table 2.1

covalent bond broken	$Cl–Cl$ bond in Cl_2
covalent bond formed	**HO–C*l* bond in HOC*l***
type of interactions overcome	**permanent dipole-induced dipole interactions between Cl_2 and water molecules**
types of interactions formed	(1) **hydrogen bonding between HOC*l* and water** (2) **ion-dipole interactions between Cl^- and water molecules**

[2]

1m for any 2 correct, max 2m

(c) The oxyacids of chlorine are shown in Table 2.2.

Table 2.2

HOC*l*	HOC*l*O	HOC*l*O_2	HOC*l*O_3
chloric(I) acid	chloric(III) acid	chloric(V) acid	chloric(VII) acid

(i) State how the values of the acid dissociation constant, K_a, change from chloric(I) acid to chloric(VII) acid. Explain your answer in terms of the delocalisation of electrons.

$HA + H_2O \rightleftharpoons H_3O^+ + A^-$

- **Due to the delocalisation of the lone pair of electrons on O^- into $Cl=O$, the number of resonance structures increases from ClO^- to ClO_4^-, leading to greater dispersal of the negative charge on O, making the anion more stable.**
- **The K_a value increases from chloric(I) acid to chloric(VII) acid as the strength of acid increases.**

[2]

(ii) 1.00 g of a sodium salt of an oxyacid of chlorine is dissolved in 100 cm^3 of water. 10.0 cm^3 of the solution requires 11.25 cm^3 of 0.25 mol dm^{-3} acidified H_2O_2 for complete reaction. The only chlorine-containing product formed in the reaction is Cl^-. Deduce the formula of the sodium salt. Show your working.

Amount of H_2O_2

$$= 0.25 \times \frac{11.25}{1000}$$

- **= 0.0028125 mol**

$H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$
Amount of e^-
= 0.0028125 × 2
= 0.005625 mol

Let the sodium salt be $NaClO_y$.

$$ClO_y^- + 2yH^+ + 2ye^- \rightarrow Cl^- + yH_2O$$

Amount of ClO_y^- in 10.0 cm^3 of solution

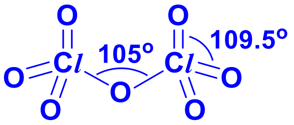
- $= \dfrac{0.005625}{2y} = \dfrac{1.00}{23.0 + 35.5 + 16.0y} \times \dfrac{10.0}{100}$

  $y = 2.99 \approx 3$

- **The sodium salt is $NaClO_3$ (OR $NaOClO_2$).**

[3]

(iii) The chlorate(VII) ion, ClO_4^-, can be produced from the reaction of Cl_2O_7 with alkali. Given that the Cl_2O_7 molecule is non-cyclic and symmetrical, draw the structure of the molecule, indicating the bond angles around C*l* and O atoms.



[2]

1m: correct shape (accept wedge formula without double bonds)
1m: correct bond angles

(d) Two solutions are prepared as described below.

Solution **P** is made by mixing 50.0 cm^3 of 2.00×10^{-3} mol dm^{-3} HCl(aq) with 50.0 cm^3 of 2.00 mol dm^{-3} $NaCl$(aq) and has a pH of 3.00. If 1.0 cm^3 of 1.00 mol dm^{-3} HNO_3(aq) is added to **P**, the pH changes to 1.96.

Solution **Q** is made by mixing 50.0 cm^3 of 0.100 mol dm^{-3} HF(aq) with 50.0 cm^3 of 0.100 mol dm^{-3} NaF(aq) and has a pH of 3.20. If 1.0 cm^3 of 1.00 mol dm^{-3} HNO_3(aq) is added to **Q**, the pH changes to 3.02.

(i) Use the data given about solution **P** to prove that HC*l*(aq) is a strong acid.

[HC*l*] in solution P

$$= \frac{50.0 \times 10^{-3} \times 2.00 \times 10^{-3}}{100 \times 10^{-3}}$$

- **$= 1.00 \times 10^{-3}$ mol dm^{-3}**

  Since solution P has a pH of 3.00, $[H^+] = 1.00 \times 10^{-3}$ mol dm^{-3}
- **Since $[HCl] = [H^+]$, HC*l* is <u>completely dissociated</u> and is a strong acid.**

[2]

(ii) Use the data given about solution **Q** to calculate the pH of 0.100 mol dm^{-3} of HF(aq).

Solution Q is a buffer at maximum buffering capacity, i.e. $[HF] = [F^-]$, $pH = pK_a$

$K_a = [H^+]$
$= 10^{-3.20}$

- $= 6.31 \times 10^{-4}$ mol dm^{-3}

$K_a = \frac{[H^+][F^-]}{[HF]}$

$[H^+] = (6.31 \times 10^{-4} \times 0.100)^{1/2}$

$= 7.94 \times 10^{-3}$ mol dm^{-3}

pH $= -\lg(7.94 \times 10^{-3})$

- $= 2.10$

[2]

[Total: 22]

3 **(a)** **(i)** State two basic assumptions of the kinetic theory as applied to an ideal gas.

The gas particles have negligible intermolecular forces of attraction.
The gas particles are of negligible size and occupy negligible volume compared to the volume of the container.
Collisions between gas particles are perfectly elastic, i.e. the gas particles bounce apart with no loss in kinetic energy on collision.

[1]

1m: any 2 correct

(ii) Explain why a real gas will deviate more from ideality at a lower temperature.

- **At a lower temperature, the average kinetic energy of the gas particles decreases and they have less energy to overcome the intermolecular forces of attraction. Hence, intermolecular forces of attraction between particles become more significant.**

[1]

(iii) Calculate the concentration, in mol dm^{-3}, of a gaseous bromine sample with a partial pressure of 23.3 kPa at 298 K.

$pV = nRT$

$\frac{n}{V} = \frac{p}{RT}$

$= \frac{23.3 \times 10^3}{8.31 \times 298}$ **(must be in SI units)**

$= 9.41$ mol m^{-3}

- $= 9.41 \times 10^{-3}$ mol dm^{-3}

[1]

(b) Pyridinium tribromide can be used in the synthesis of mono-brominated anilide. There are two possible routes to this synthesis starting from phenylamine as shown in Fig. 3.1.

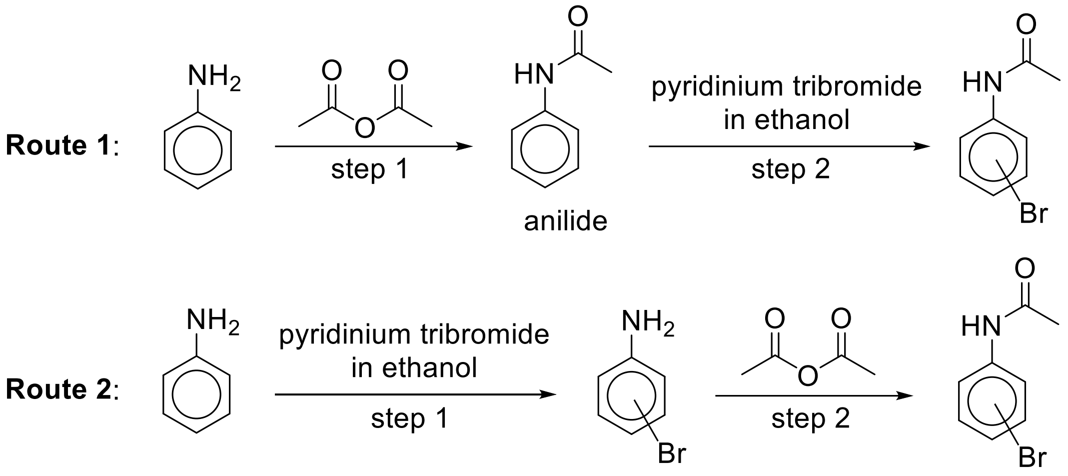
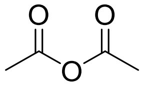


Fig. 3.1

You may assume pyridinium tribromide in ethanol has the same reactivity as aqueous bromine. The line connecting Br to the benzene ring in Fig. 3.1 indicates that Br is attached to one of the carbon atoms in the benzene ring.

Ethanoic anhydride, , is used as a safer alternative to ethanoyl chloride in reactions.

(i) Suggest the type of reaction for step 1 and step 2 of **Route 1**.

- step 1: **condensation (OR nucleophilic substitution)**
- step 2: **electrophilic substitution**

[2]

(ii) **Route 1** is the preferred route for the synthesis because it produced mostly mono-brominated anilide while **Route 2** produced mostly multi-brominated anilide. Suggest an explanation for this observation.

- **In Route 1, the electron density of the benzene ring in anilide is lower than that in phenylamine because the –NHCOCH$_3$ group is less electron-donating due to the delocalisation of the lone pair of electrons on N into the –C=O group.**
  OR
- **In Route 2, the lone pair of electrons on N in phenylamine delocalised into the benzene ring and increases the electron density in benzene. The benzene ring is more susceptible to electrophilic attack, and able to undergo further bromination to give multi-brominated anilide.**

[1]

(iii) The major product obtained in step 2 of **Route 1** is 4-bromoanilide instead of 2-bromoanilide. Suggest an explanation for this yield.

- **The bulky –NHCOCH$_3$ group posed steric hindrance to electrophilic attack at the 2–position. Hence, substitution occurs mainly at the 4–position.**

[1]

(c) Acyl chlorides react with sodium carboxylates to form acid anhydrides as shown in Fig. 3.2.

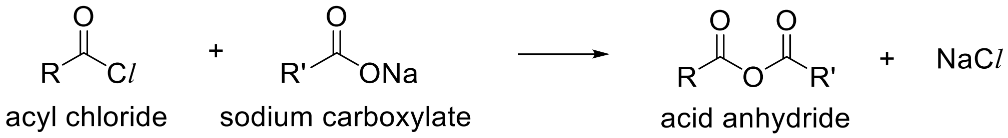


Fig. 3.2

The condensation polymers, polyanhydride and polyester, are formed by similar methods. One repeat unit for a polyanhydride is shown in Fig. 3.3.

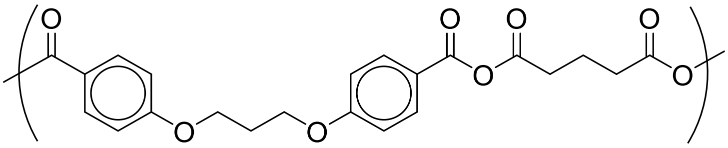
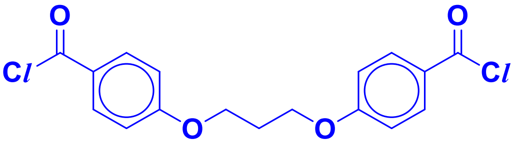
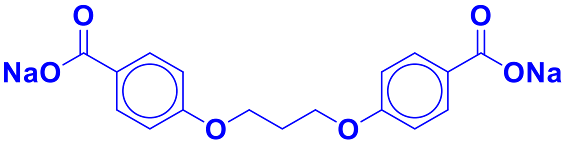
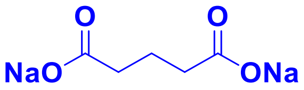
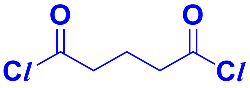


Fig. 3.3

Use Fig. 3.2 and Fig. 3.3 to suggest the structures of the two monomers used to make this polyanhydride.

 **OR**  monomer 1	  monomer 2

[2]

1m each

(d) Equilibrium systems involving tribromide have been studied extensively, one of which is shown below.

reaction 1 $Br_2(aq) + Br^-(aq) \rightleftharpoons Br_3^-(aq)$ $K_c = 100$ at 298 K

Reaction 1 is considered as *virtually complete* if more than 95% of the limiting reagent is reacted. When 32.0 mg of bromine was dissolved in 250 cm^3 of 0.500 mol dm^{-3} sodium bromide solution, the reaction *might be* virtually complete.

(i) Calculate the initial concentration of Br_2 in the mixture.

Amount of Br_2 used

$$= \frac{32.0 \times 10^{-3}}{79.9 \times 2}$$

= 2.00 × 10^{-4} mol

Initial $[Br_2]$

$$= 2.00 \times 10^{-4} \div \frac{250}{1000}$$

- $= 8.00 \times 10^{-4}$ mol dm^{-3}

[1]

(ii) Give **two** reasons why reaction 1 *might be* virtually complete.

- **The value of $K_c >> 1$ which shows that the equilibrium is product-favoured.**
- **The concentration of Br^- is much higher than that of Br_2. The large excess of Br^- will shift the position of equilibrium to the right, such that reaction 1 is almost complete.**

[2]

(iii) Write the expression for equilibrium constant K_c for reaction 1.

- $$K_c = \frac{[Br_3^{\,-}]}{[Br_2][Br^-]}$$

[1]

(iv) Determine the concentration of Br_2 in the mixture at equilibrium. Show your working. Hence, conclude if reaction 1 is *indeed* virtually complete.

	$Br_2(aq)$	+	$Br^-(aq)$	$\rightleftharpoons$	$Br_3^-(aq)$
Initial / mol dm^{-3}	8.00×10^{-4}		0.500		0
Change / mol dm^{-3}	– a		– a		+ a
Equilibrium / mol dm^{-3}	8.00×10^{-4} – a		0.500 – a		a

$$K_c = \frac{[Br_3^{\,-}]}{[Br_2][Br^-]}$$

- $$100 = \frac{a}{(8.00 \times 10^{-4} - a)(0.500 - a)}$$

$$\approx \frac{a}{(8.00 \times 10^{-4} - a)(0.500)} \qquad \text{since } a << 0.500$$

$a = 7.843 \times 10^{-4}$

- $[Br_2]_{eqm} = 8.00 \times 10^{-4} - (7.843 \times 10^{-4})$ **(ecf)**
  $= 1.57 \times 10^{-5}$ mol dm^{-3}

$$\frac{[Br_2]_{eqm}}{[Br_2]_{initial}} \times 100\% = \frac{1.57 \times 10^{-5}}{8.00 \times 10^{-4}} \times 100\% = 1.96\%$$

Percentage of limiting reagent, Br_2, reacted
= 100 – 1.96

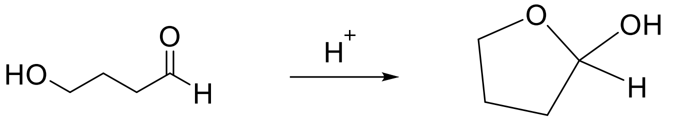
- **= 98.04% > 95%**

Hence, reaction 1 is indeed virtually complete.

[3]

[Total: 16]

4 **(a)** 4-hydroxybutanal forms a cyclic hemiacetal in the presence of an acid catalyst as shown in Fig. 4.1.



4-hydroxybutanal cyclic hemiacetal

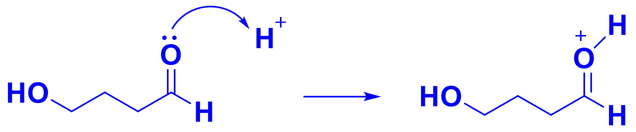
Fig. 4.1

(i) The mechanism involves three steps.

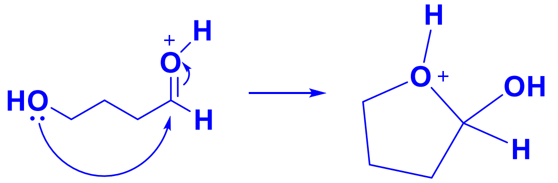
Step 1: The aldehyde is protonated by the acid catalyst to form a non-cyclic intermediate.
Step 2: Nucleophilic attack by the alcohol to form a cyclic intermediate.
Step 3: Deprotonation of the cyclic intermediate to form the product.

Suggest the three-step mechanism for this reaction. Show all charges, relevant lone pairs, curly arrows and the structures of intermediates formed.

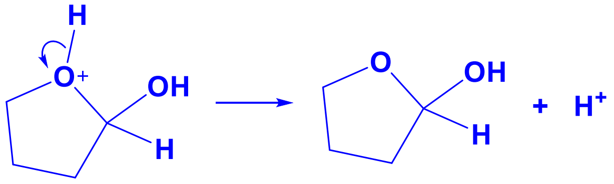
- **Step 1:**



- **Step 2:**



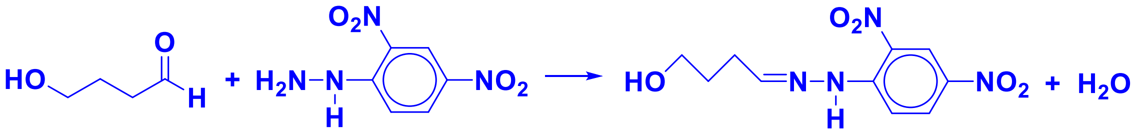
- **Step 3:**



[3]

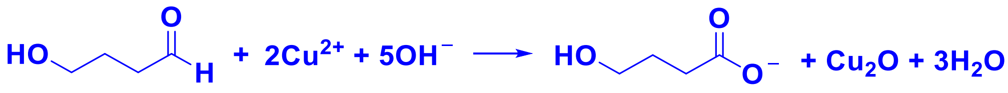
(ii) Describe a simple chemical test to distinguish 4-hydroxybutanal from cyclic hemiacetal as shown in Fig 4.1. Include the reagents and conditions and the expected observations with each compound. Write an equation for the reaction that occurs.

- **Add 2,4-DNPH to each compound. An orange ppt. is observed with 4-hydroxybutanal only.**

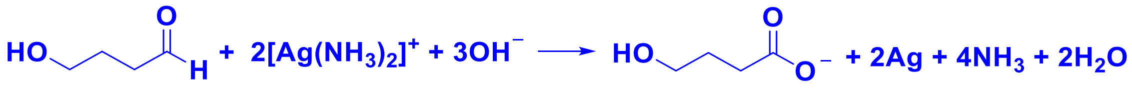
- 

OR

- **Add Fehling's solution with warming to each compound. A brick-red ppt. is observed with 4-hydroxybutanal only.**

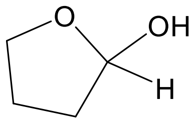
- 

OR

- **Add Tollens' reagent with warming to each compound. A silver mirror is observed with 4-hydroxybutanal only.**
- 

[2]

(iii) The cyclic hemiacetal shown below exists as a mixture of stereoisomers. State the number of stereoisomers and suggest how their physical properties differ.



cyclic hemiacetal

- **Number of stereoisomers = 2**
- **The enantiomers have <u>identical physical properties except in the direction in which they rotate plane-polarised light</u>.**

[2]

(b) Compound **W** has the molecular formula C_7H_7OCl. It is an aromatic compound which contains two functional groups.
Data about the reactions of **W** are given in Table 4.1.

Table 4.1

reaction	reagent	result
1	$AgNO_3$(aq), warm	white solid formed which is soluble in an excess of NH_3(aq)
2	excess Br_2(aq)	white solid formed which has M_r = 379.2
3	acidified MnO_4^-, heat under reflux	MnO_4^- is decolourised; one organic product formed with M_r = 138
4	Na	colourless gas evolved; white solid formed which is soluble in H_2O
5	NaOH(aq) at room temperature	colourless solution formed

(i) Name the functional group that reaction 1 shows to be present in **W**.

- **chloroalkane (OR halogenoalkane)**

[1]

(ii) Based only on reaction 4, give the names of two different functional groups that could be present in **W**.

- **alcohol and phenol**

[1]

(iii) Which of the functional groups you have named in **(b)(ii)** is confirmed by reaction 5? Explain your answer.

- **Phenol. Phenol is a stronger acid than alcohol. Therefore, phenol will react with NaOH(aq) to form sodium phenoxide which is soluble in water to give a colourless solution.**

[1]

(iv) Deduce the molecular formula of the organic product formed in reaction 3.

- **$C_7H_6O_3$**

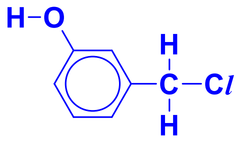
[1]

(v) Identify the **two** reactions that confirm **W** is aromatic.

- **Reactions 2 and 3 confirm W is aromatic.**

[1]

(vi) Draw the displayed formula of **W**.

- 

[1]

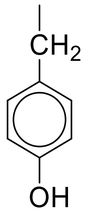
(vii) Explain clearly why you have placed **one** of the two functional groups in that particular position.

- **–OH in phenol is a strongly activating and 2,4–directing group. In reaction 2, the electrophilic substitution of three H atoms by three Br atoms as a result of the phenol group indicates that positions 2, 4 and 6 in W are occupied by H atoms. Hence, $-CH_2Cl$ group must be at position 3 with respect to phenol in W.**
  OR
- **The Cl atom in W is in the aliphatic side chain and not attached to the benzene ring as from reaction 1, chloroalkane is present. Chlorobenzene, with partial double bond character in C–Cl, does not undergo hydrolysis with $AgNO_3$(aq) to form a white solid, AgCl.**

[1]

(c) A polypeptide **H** was analysed and found to contain the following amino acids as shown in Table 4.2.

Table 4.2

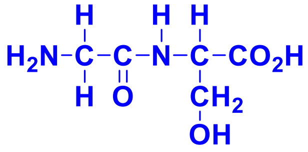
amino acid	aspartic acid	glycine	serine	tyrosine	valine
abbreviation	asp	gly	ser	tyr	val
R group	$-CH_2CO_2H$	–H	$-CH_2OH$		$-CH(CH_3)_2$

number of residues	1	1	2	1	1

Analysis of polypeptide **H** gave the following results.

- The N-terminus was shown to be ser.
- On reaction with the enzyme chymotrypsin, which hydrolyses at the carboxylic acid end of tyr, **H** gave two tripeptides.
- On reaction with a reagent which digests at the carboxylic end of val, **H** gave two peptides. One of these two was a dipeptide of sequence gly–ser.

(i) Draw the structure of dipeptide gly–ser.

- 

$H_2N{-}CH_2{-}C({=}O){-}NH{-}CH(CH_2OH){-}CO_2H$

[1]

(ii) Explain why a sample of serine has a high melting point.

- **It is a zwitterion. A large amount of energy is required to overcome the strong ionic bonds (OR electrostatic forces of attraction) between the ions.**

[1]

(iii) Determine the amino acid sequence of polypeptide **H**. You should use the same 3–letter abbreviations as shown in Table 4.2 to write out the amino acid sequence.

- **ser–asp–tyr–val–gly–ser**

[1]

[Total: 17]