ANDERSON SERANGOON JUNIOR COLLEGE

2025 JC 2 Preliminary Paper

NAME:_____ ( ) **CLASS:** 25 / ___

CHEMISTRY **8873/02**

Higher 1 **27 August 2025**

2 hours

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number in the spaces provided at the top of this page.
Write in dark blue or black pen.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **one** question.

The use of an approved scientific calculator is expected, where appropriate.
The number of marks is given in brackets [ ] at the end of each question or part question.

Section A	**1**	**/12**	**Section B**	**7/8**	**/ 20**
	2	**/9**	**Paper 1**		**/ 30**
	3	**/13**	**Paper 2**		**/ 80**
	4	**/12**	**Percentage Overall**		
	5	**/10**			
	6	**/4**	**Grade**		

This document consists of 24 printed pages.

Section A

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

1 **(a)** Two Period 3 elements react with an excess of oxygen at room pressure.

(i) Complete Table 1.1.

Table 1.1

Period 3 element	Physical state of oxide at room temperature and pressure	Approximate pH of solution made when oxide is added to water
Na		
S		

[2]

(ii) The solutions made from oxides of sodium and sulfur of Table 1.1 are mixed together.
Name the type of reaction that occurs.

……[1]

(b) Aluminium oxide, Al_2O_3 is amphoteric.

(i) Explain what is meant by amphoteric.

……...

……[1]

(ii) Aluminium oxide is added to separate samples of dilute sulfuric acid and aqueous sodium hydroxide.

Write two equations to describe the reactions that occur.

……...

……...

……[2]

(c) Chorine gas reacts with oxygen to form chlorine dioxide. When used in small quantities, chlorine dioxide can disinfect water.

(i) Complete the electronic configurations of C*l*.

C*l*: $1s^2$ …… [1]

(ii) State the total number of outer shell electrons in one molecule of C*l*O_2 and explain why this is an unusual number.

……...

……..[2]

(iii) C*l*O_2 contains two double bonds in the molecule.

Draw a 'dot-and-cross' diagram for the molecule C*l*O_2.

[1]

(iv) Deduce whether C*l*O_2 is a polar molecule. Explain your answer.

……...

……...

……..[2]

[Total:12]

2 Atmospheric carbon dioxide can dissolve in seawater.

The three inorganic carbon-containing species present in the seawater are:

- dissolved $CO_2(g)$
- $CO_3^{2-}(aq)$
- $HCO_3^-(aq)$.

Increasing levels of $CO_2(g)$ in the atmosphere can change the proportions of these inorganic carbon-containing species present in sea water. This can lead to a series of chemical reactions resulting in the increase of concentration of hydrogen ions. This is ocean acidification. This process also causes carbonate ions to be less abundant.

Equilibrium 1 $CO_2 + H_2O \rightleftharpoons HCO_3^- + H^+$
Equilibrium 2 $HCO_3^- \rightleftharpoons CO_3^{2-} + H^+$

When changes to the amount of dissolved carbon dioxide in the ocean occur, the pH of seawater remains approximately constant between pH 7.5 and 8.5. This is due to $CO_3^{2-}(aq)$ and $HCO_3^-(aq)$ acting as a buffer.

(a) Write the expression for the equilibrium constant, K_c, for equilibrium 2.

[1]

(b) Approximately 200 years ago, the average pH of sea water taken from the ocean surface was 8.2. At present, this is 8.1.

Calculate the hydrogen ion concentrations of the sea water taken from the ocean surface at 8.2 and 8.1.

Hence, calculate the percentage increase in hydrogen ion concentration of the sea water taken from the ocean surface at present compared with 200 years ago.

[3]

(c) Using equilibrium 1 and 2, explain how the increase in dissolved $CO_2(g)$ leads to a lower abundance of $CO_3^{2-}(aq)$.

……

……

……

……[2]

(d) Suggest an impact on the ecology in the sea due to the decrease in concentration of carbonate ions.

……

……[1]

(e) K_c of equilibrium 2 for a sample of sea water collected increases when temperature is increased.

State the nature of equilibrium 2 as either endothermic or exothermic. Explain your answer.

……

……

……

……[2]

[Total: 9]

3 **(a)** $NaBiO_3$ is an oxidising agent with similar properties to $KMnO_4$.
Fig 3.1 shows an example of the use of $NaBiO_3$ as an oxidising agent.

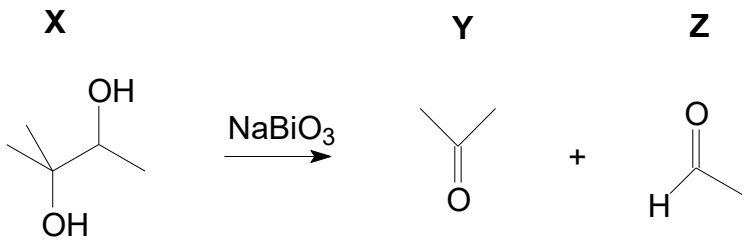


Fig. 3.1

(i) Explain why the reaction in Fig 3.1 is considered an oxidation reaction.

……

……[1]

(ii) Identify the functional groups present in **X**, **Y** and **Z**.

X: ……

Y: ……

Z: ……

[3]

(iii) Compound **X** can be synthesised from 2,3-dibromo-2-methylbutane.

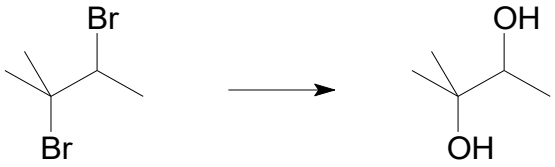


Fig. 3.2

Suggest the reagents and conditions for the reaction shown in Fig 3.2.

……[1]

(iv) Suggest a simple chemical test to distinguish 2,3-dibromo-2-methylbutane and **Y**. State the observations clearly.

……

……

……

……[2]

(b) $NaBiO_3$ can be used to determine the concentration of $Mn^{2+}(aq)$. The ionic equation for the reaction is shown below.

$$2Mn^{2+} + 5BiO_3^- + 14H^+ \longrightarrow 2MnO_4^- + 5Bi^{3+} + 7H_2O$$

A student uses the following procedure in an experiment.

- Add 100.0 cm^3 of a saturated solution of $Mn^{2+}(aq)$ to a graduated flask.
- Add distilled water to the flask to make a 1.00 dm^3 diluted solution.
- Titrate a 25 cm^3 sample of the diluted solution with 0.100 mol dm^{-3} $NaBiO_3(aq)$.

The 25 cm^3 sample of the diluted solution of $Mn^{2+}(aq)$ reacts completely with exactly 21.50 cm^3 of 0.100 mol dm^{-3} $NaBiO_3(aq)$.

Calculate the concentration, in mol dm^{-3}, of $Mn^{2+}(aq)$ in the saturated solution.

Show your working.

[3]

(c) The accuracy of an experiment can be improved by using a measuring apparatus with lower percentage error incurred during its measurement.

This percentage error incurred for a **single** measurement of a volume of solution can be calculated by the following relationship.

$$\text{percentage error} = \pm\frac{\text{error of apparatus}}{\text{quantity measured}} \times 100\%$$

The smaller the percentage error incurred by the apparatus, the more accurate the measurement is, hence the more accurate the experiment is.

Table 3.1

Measuring apparatus	Error of each reading / cm^3	Number of readings done to measure the volume
pipette	±0.06	1
burette	±0.05	2

(i) Calculate the percentage error involved in measuring 25 cm^3 of $Mn^{2+}(aq)$ using a pipette.

[1]

(ii) Calculate the percentage error involved in measuring 25 cm^3 of $Mn^{2+}(aq)$ using a burette.

[1]

(iii) Use your answer in **(c)(i)** and **(c)(ii)** to explain if it is better to use a burette to measure 25.0 cm^3 of $Mn^{2+}(aq)$.

……....

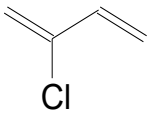
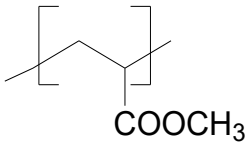
……..…...[1]

[Total: 13]

4 This question is about nylon 6, neoprene and acrylate polymer

(a) Complete the boxes in Table 4.1.

Table 4.1

Polymer	Nylon 6	Neoprene	Acrylate polymer
Name of monomer	6-aminohexanoic acid	2-chlorobuta-1,3-diene	methyl prop-2-enoate
Structural formula of monomer(s)	$H_2N(CH_2)_5COOH$		
Structural Repeat unit of polymer			
Type of reaction used to form polymer		addition	
Reagents and condition			uv light

[7]

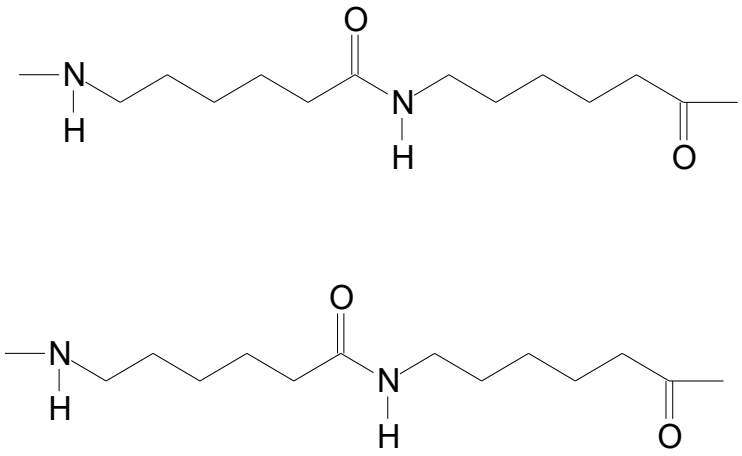
(b) Suggest an advantage of using nylon 6 to make sportwear?

……..[1]

(c) The melting point of nylon 6 is high at 218 °C.

Complete the diagram below with relevant lone pair and partial charges, to explain its high melting point.

State the type of interaction between the two polymeric chains.



[2]

(d) Neoprene is a synthetic latex. In a sample of neoprene, the average molecular mass of a polymer is 10000.

Using the information in Table 4.1, calculate the molecular mass of the monomer and hence calculate number of moles of monomers required to form an average polymer.

[2]

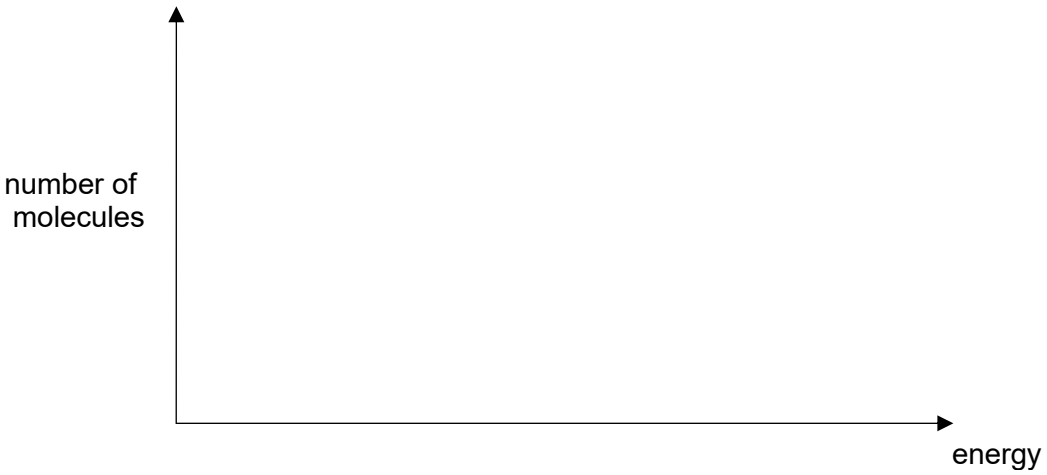
[Total: 12]

5 **(a)** Hydrogen and chlorine react violently to form hydrogen chloride gas.

$$H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$$

(i) Draw a Boltzmann distribution curve for the molecular energies of the above gaseous reaction mixture at 293 K.

Label the curve **P**. Label the activation energy E_a.



[2]

(ii) On the same axes, draw a second Boltzmann distribution curve for the molecular energies of the same gaseous reaction mixture at 350 K.

Label the curve **Q**. [1]

(iii) State what happens to the rate of the reaction when the temperature is increased.

Explain your answer using the curves drawn in **(a)(i)** and **(ii)**.

……

……

……

……

……

……[2]

(b) Alkenes undergo hydrogenation, an example of which is shown with styrene.

Styrene is an aromatic hydrocarbon that is a precursor to polystyrene, an important synthetic material that is used in the making of many substances such as, rubber, insulation and fiberglass.

The diagram below shows an energy cycle involving hydrogenation of styrene.

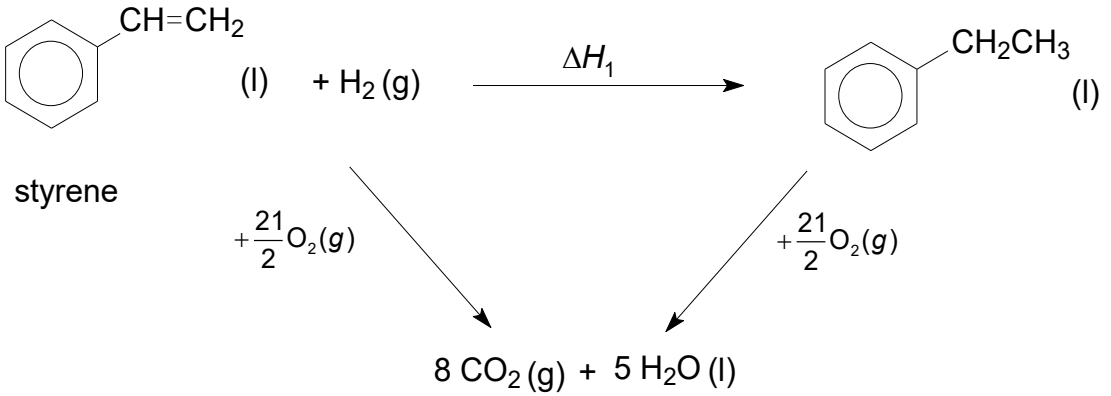


Fig. 5.1

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

……

……..……[1]

(ii) Use the following data and Fig 5.1 to calculate the standard enthalpy change of hydrogenation of styrene, ΔH_1.

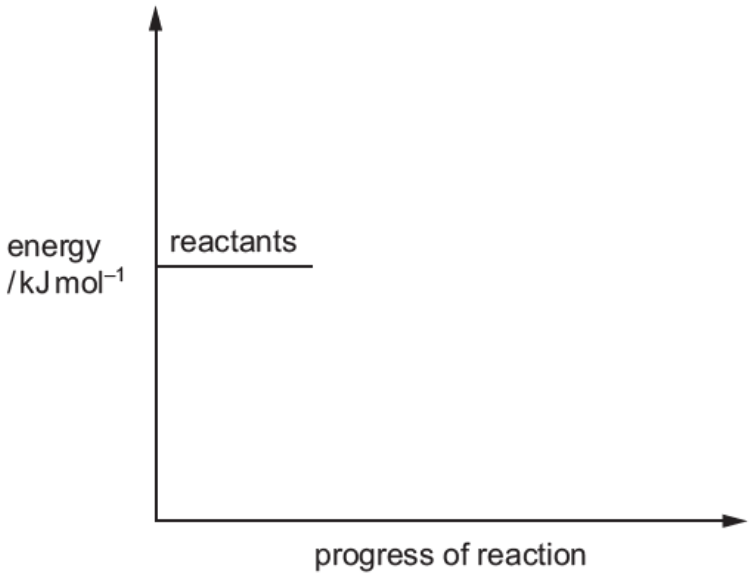
$\Delta H_c^{\ominus}$ hydrogen	=	–286 kJ mol^{-1}
$\Delta H_c^{\ominus}$ styrene	=	–4393 kJ mol^{-1}
$\Delta H_c^{\ominus}$ ethylbenzene	=	–4562 kJ mol^{-1}

[2]

(iii) Hydrogenation of alkenes is a one-step reaction.

Using your answer in **(c)(ii),** complete the reaction pathway diagram for the reaction of styrene and hydrogen.

Label the E_a and ΔH_1 clearly in your diagram.



[2]

[Total: 10]

6 Carbon can exist as graphene and nanotubes.

Graphene is one atom thick and it can be rolled into carbon nanotubes. These nanotubes can be used as biosensors implanted in the human body due to its high electrical conductivity, high durability, low density and are free of toxic metals. The current way to manufacture graphene involves separating carbon thin layers by chemical or mechanical exfoliation, forming a dry powder.

Graphene and nanotubes are considered *nanomaterials*.

(a) Suggest what is meant by the term *nanomaterials*.

……

……[1]

(b) Explain the properties of a single carbon nanotube.

- As a good conductor of electricity

……

……[1]

- Has high durability

……

……[1]

(c) Suggest a disadvantage of using graphene on a large scale.

……

……[1]

[Total: 4]

Section B

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

7 **(a)** A thermometric titration was carried out to determine the enthalpy change of reaction of $NaHCO_3$ and NaOH, $\Delta H_{reaction}$.

$$NaHCO_3(aq) + NaOH(aq) \longrightarrow Na_2CO_3(aq) + H_2O(l) \qquad \Delta H_{reaction}$$

In this titration, the initial temperature of a 40.0 cm^3 sodium hydrogencarbonate solution before the addition of sodium hydroxide is added is measured and recorded.

5.0 cm^3 portions of 1.50 mol dm^{-3} aqueous sodium hydroxide are added to the polystyrene cup. The temperature of the solution in the cup is measured after each addition. The maximum temperature occurs when complete neutralisation has been achieved.

The results are shown in Fig. 7.1.

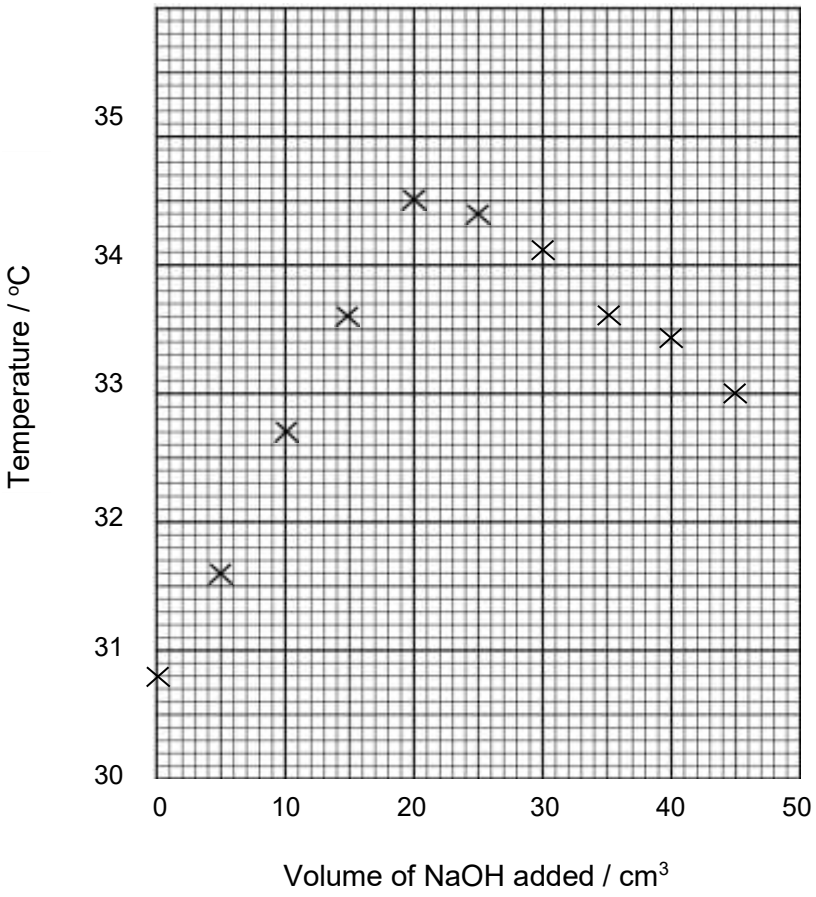


Fig. 7.1

(i) Draw two separate straight lines of best fit.

The first line should take into account the increasing temperatures.

The second line should take into account the decreasing temperatures.

Extend the lines until they intersect (cross).

Use your graph to determine the maximum temperature rise, ΔT_{max}, of the experiment.

Show your working.

[2]

(ii) Use your graph to determine the volume of sodium hydroxide, V_{NaOH}, required to neutralise the acid.

Show on your graph how you determined the value.

[1]

(iii) Using your answers to **(a)(i)** and **(a)(ii)**, calculate the energy, in kJ, evolved during the reaction.

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}.

[1]

(iv) Using your answer to **(a)(iii)**, calculate a value for the enthalpy change of reaction, $\Delta H_{reaction}$, in kJ mol^{-1}.

[3]

(b) State and explain the difference in the radii of each of the pairs of species in **(b)(i)** and **(b)(ii)**.

The radii can be found in the *Data Booklet*.

(i) Atomic radii of a magnesium atom and a phosphorus atom.

……

……

……

……

……[3]

(ii) Ionic radii of a sodium ion and a phosphorus ion.

……

……[1]

(c) The shapes of the covalent molecules CCl_4 and PCl_3 are different.

Using the VSEPR theory, draw and explain the shape and bond angle of

CCl_4 molecule

……

……

……

……

……

PCl_3 molecule

……

……

……

……

[6]

(d) Elements in Group 17 are known as halogens. These elements readily react with Group 1 metals to form important halide salts such as sodium chloride.

The table below shows the results of experiments in which the halogens, Cl_2, Br_2 and I_2 were added to separate aqueous solutions containing Cl^-, Br^- and I^- ions.

	X^- (aq)	Y^- (aq)	Z^- (aq)
X_2	-	no reaction	Z_2 formed
Y_2	X_2 formed	-	Z_2 formed
Z_2	no reaction	no reaction	-

Based on the results in the given table, identify the halogens represented by X_2, Y_2 and Z_2.

X_2 is …….. Y_2 is …… Z_2 is ……..

[1]

(e) Halogens react with hydrogen gas to form hydrogen hydrides. State and explain the trend in thermal stability of these hydrides of Group 17.

Include data from the *Data Booklet* in your answer.

……

……

……

…….[2]

[Total: 20]

8 **(a)** Hydrogen cyanide dissolves in water to form the weak acid hydrocyanic acid, HCN(aq) while sodium cyanide dissolves in water to form a weak alkaline solution.

The following equilibrium illustrates the acid dissociation of hydrogen cyanide in water.

$$HCN(aq) + H_2O(l) \rightleftharpoons CN^-(aq) + H_3O^+(aq)$$

(i) Define the terms acid and base using Brønsted-Lowry theory of acids and bases.

……

……[1]

(ii) Identify one conjugate acid-base pair in the reaction occurring in the equilibrium.

……

……[1]

(iii) Write an equation to explain why sodium cyanide dissolves in water to form a weak alkaline solution.

……[1]

(iv) For hydrocyanic acid, pK_a = 4.79 at 25°C.

Calculate the value of K_a for hydrocyanic acid at 25°C.

[1]

(b) The table below lists the melting points of some compounds.

compound	melting point / °C
HCN	-13.4
H_2O	0
NaCN	564

Explain as fully as you can the differences in their melting points.

Include the bonding and structure of each substance in your answer.

……..

……..

……..

……..

……..

……..

……..

……..

……..[3]

(c) 3-bromopropene can be hydrolysed by aqueous sodium hydroxide to form alcohols.

Three sets of experiments were carried out to investigate the kinetics of this reaction:

Table 8.1

Experiment	$[CH_2=CHCH_2Br]$ / mol dm^{-3}	[NaOH] / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	0.10	0.20	0.01
2	0.20	0.10	0.02
3	0.30	0.20	0.03

(i) Use data from Table 8.1 to determine the order of reaction with respect to $CH_2=CHCH_2Br$ and NaOH and hence deduce the rate equation for this reaction.

[3]

(ii) Using your answer from **(c)(i)**, calculate the value of the rate constant, *k*. include its units.

[2]

(d) When an ester **A**, $C_7H_{14}O_2$, is heated with aqueous HC*l*, two products **B**, $C_3H_6O_2$, and **C**, $C_4H_{10}O$, are formed.

B turns moist blue litmus paper red.

C reacts with concentrated sulfuric acid to form three isomeric compounds that decolourise bromine water.

(i) State the type of reaction ester **A** undergoes.

……..[1]

(ii) Suggest the structure for **B**.

[1]

(iii) Draw the displayed formula of **C**. Explain your answer.

[2]

……..

……..

……..

……..……[1]

(iv) Hence, using your answers in **(d)(ii)** and **(d)(iii)**, draw the structural formula of compound **A**.

[1]

(v) Two of the isomeric products that decolourise bromine water differ only in their arrangement in space.

Draw the skeletal formulae of these two isomers.

[2]

[Total: 20]