Oxford Cambridge and RSA

Thursday 23 May 2019 – Morning

AS Level Chemistry A

H032/02 Depth in chemistry

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry A (sent with general stationery)

You may use:
- a scientific or graphical calculator

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number						Candidate number				

First name(s) ______________________________

Last name ______________________________

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **20** pages.

Answer **all** the questions.

1 This question is about the properties and reactions of the Group 2 element strontium.

(a) The relative atomic mass of strontium can be determined using a mass spectrometer.

(i) Explain what is meant by the term **relative atomic mass** of an element.

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.... **[2]**

(ii) A sample of strontium has a relative atomic mass of 87.73.

The sample consists of:
- 82.9% Sr-88
- 6.9% Sr-87
- one other isotope.

Determine the other isotope of strontium in the sample.

isotope of strontium = ... **[2]**

(b) The table below shows two physical properties of the element strontium.

Melting point	high
Electrical conductivity	very good

Explain these physical properties of strontium, in terms of bonding and structure.
Include a labelled diagram in your answer.

Diagram

Explanation ....

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.... **[5]**

(c) A student adds a small amount of strontium to water.

When the reaction has finished, the student measures the pH of the final solution.

(i) Write the equation for the reaction of strontium with water.

.... **[1]**

(ii) Describe **two** observations which would be different if the student had used calcium in place of strontium.

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[2]

(d) When hydrated strontium chloride is heated, the water of crystallisation is removed, leaving a residue of anhydrous strontium chloride.

A student carries out an experiment to find the value of **x** in the formula of hydrated strontium chloride, $SrCl_2 \cdot \mathbf{x}H_2O$.

The student's method is outlined below.

Step 1
Weigh an empty crucible.
Add $SrCl_2 \cdot \mathbf{x}H_2O$ to the crucible and reweigh.

Step 2
Heat the crucible and contents for 10 minutes.
Allow to cool and reweigh.

Step 3
Heat the crucible and residue for another 5 minutes.
Allow to cool and weigh the crucible and residue.

Repeat step 3 a further two times.

The student's results are shown below:

Mass of empty crucible / g	15.96
Mass of crucible + $SrCl_2 \cdot \mathbf{x}H_2O$ / g	18.65
First mass of crucible + residue / g	17.66
Second mass of crucible + residue / g	17.61
Third mass of crucible + residue / g	17.58
Fourth mass of crucible + residue / g	17.58

(i) Calculate the value of **x** in $SrCl_2 \cdot \mathbf{x}H_2O$.

Give your answer to **2** significant figures.

x = ... **[3]**

(ii) Suggest why the student takes four readings of the mass of the crucible and residue.

....

.... **[1]**

(iii) Suggest **two** modifications to the method that would reduce the percentage uncertainty in the mass of the residue.

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2 ....

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[2]

2 Magnesium nitrate is used in fertilisers as a source of nitrogen.

(a)* A student plans to prepare 250.0 cm^3 of a 0.4000 mol dm^{-3} solution of magnesium nitrate, starting from magnesium nitrate crystals, $Mg(NO_3)_2{\bullet}6H_2O$.

Describe how the student would prepare the solution, giving full details of quantities, apparatus and method. **[6]**

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Additional answer space if required

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(b) A solution of magnesium nitrate can be prepared by reacting magnesium carbonate, $MgCO_3$, with nitric acid, $HNO_3(aq)$.

The equation is shown below.

$$MgCO_3(s) + 2HNO_3(aq) \longrightarrow Mg(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

Calculate the minimum volume, in cm^3, of $1.75\,mol\,dm^{-3}$ HNO_3 that is needed to prepare a solution containing 5.00 g of $Mg(NO_3)_2$.

Give your answer to **3** significant figures.

volume = ... cm^3 **[3]**

(c) Magnesium nitrate decomposes when heated, as shown in the equation.

$$2Mg(NO_3)_2(s) \longrightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$

Using oxidation numbers, show which element has been oxidised and which has been reduced when magnesium nitrate decomposes.

State the changes in oxidation numbers, including all signs.

Element oxidised ....

Oxidation number change: from .... to ....

Element reduced ....

Oxidation number change: from .... to ....

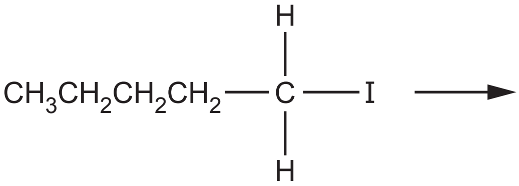
[2]

3 This question is about 1-iodopentane, $CH_3CH_2CH_2CH_2CH_2I$.

(a) 1-Iodopentane can be hydrolysed by aqueous sodium hydroxide.

(i) Outline the mechanism for this reaction.

Include curly arrows, relevant dipoles and the final product(s).



$$CH_3CH_2CH_2CH_2-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-I \longrightarrow$$

[3]

(ii) 1-Iodopentane can also be hydrolysed by water using aqueous silver nitrate, with ethanol as the solvent.

A student uses this method to compare the rates of hydrolysis of 1-iodopentane and 1-bromopentane.

What measurement and observation would allow the student to compare the rates of hydrolysis?

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.... **[1]**

(iii) 1-Iodopentane was found to react faster than 1-bromopentane.

Explain why.

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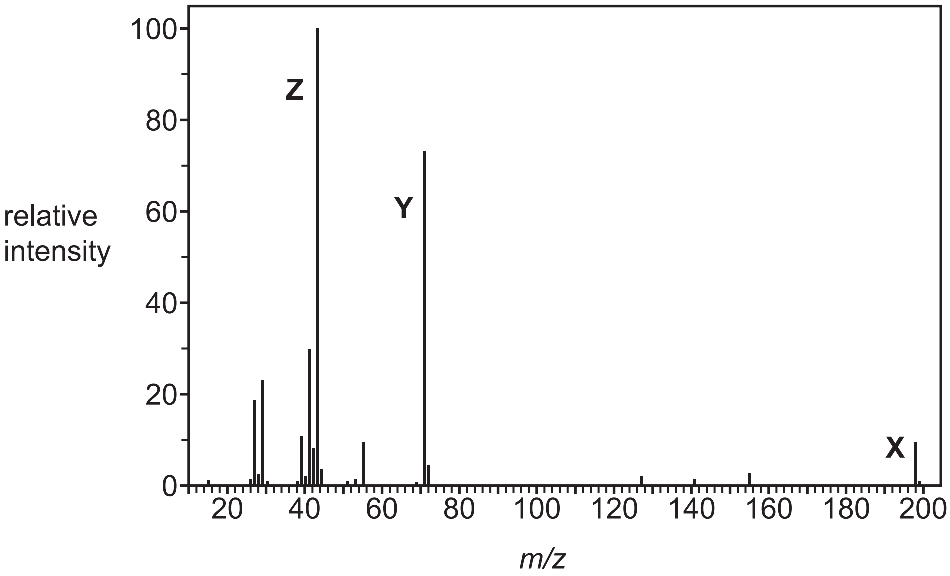
.... **[2]**

(b) The mass spectrum of 1-iodopentane is shown below.



(i) What information is given by the peak labelled **X** (m/z = 198)?

.... **[1]**

(ii) Write the structural formulae of the ions responsible for the peaks labelled **Y** and **Z**.

Y (m/z = 71) ....

Z (m/z = 43) .... **[2]**

(c) 2-Iodo-2-methylbutane is an isomer of 1-iodopentane.

(i) Draw the structure of 2-iodo-2-methylbutane.

[1]

(ii) Suggest **one** similarity and **one** difference between the mass spectra of 1-iodopentane and 2-iodo-2-methylbutane.

Similarity ....

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Difference ....

.... **[2]**

4 Zinc reacts with hydrochloric acid, $HCl(aq)$, as shown in the following equation.

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

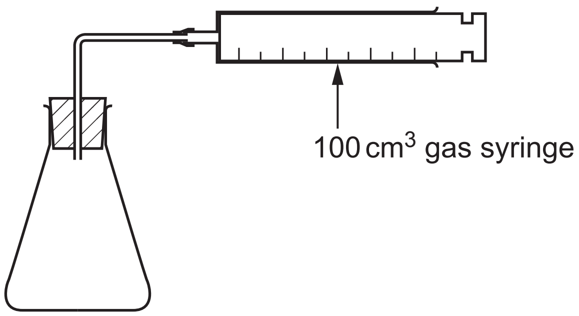
A student investigates the rate of this reaction.

(a) The student plans to react 50.0 cm^3 of 0.100 mol dm^{-3} HCl with 0.200 g of zinc (an excess).

Calculate the volume, in cm^3, of hydrogen that should be produced at RTP.

volume = ... cm^3 **[3]**

(b) The student uses the apparatus in the diagram.



The student's method is outlined below:

- Pour 50.0 cm^3 of 0.100 mol dm^{-3} HCl into the conical flask.
- Add 0.200 g of zinc (an excess), and quickly attach the delivery tube and gas syringe.
- Measure the volume of gas collected every 20 seconds until the reaction stops.

The student obtains the results shown in **Table 4.1**.

Time / s	0	20	40	60	80	100	120	160	200
Volume of gas / cm^3	0	16	27	37	39	50	53	58	58

Table 4.1

(i) On the graph paper in **Fig. 4.1**, label the x axis **and** plot the results in **Table 4.1**. **[1]**

(ii) Circle any anomalous results present in the graph you have drawn in **Fig. 4.1**. **[1]**

(iii) Draw a best-fit smooth curve on the graph you have drawn in **Fig. 4.1**. **[1]**

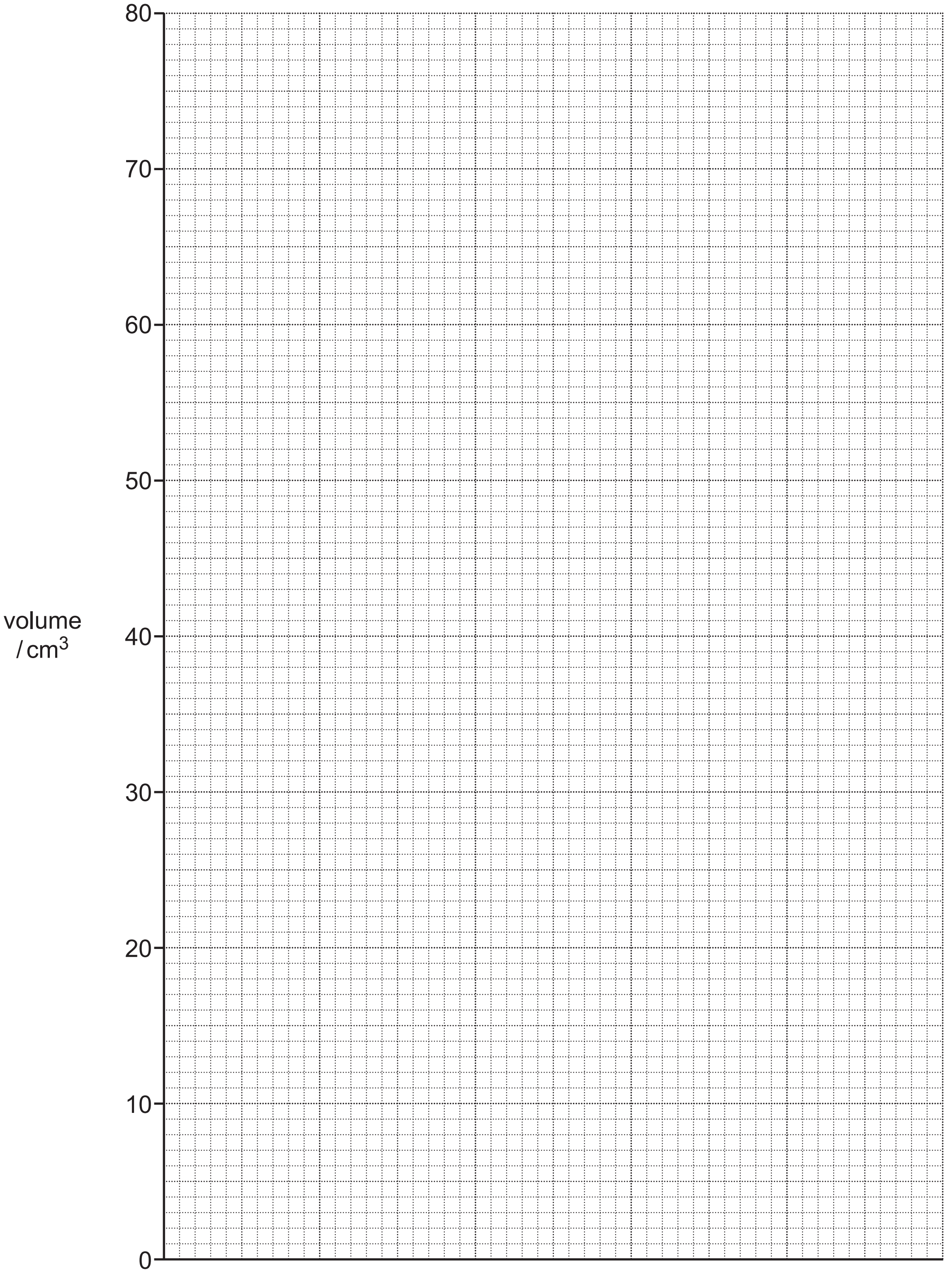


Fig. 4.1

(c) The student repeats the experiment using:

- zinc with the same mass (0.200 g) and same surface area
- the same temperature and pressure
- 40.0 cm^3 of 0.125 $mol\,dm^{-3}$ HCl, instead of 50.0 cm^3 of 0.100 $mol\,dm^{-3}$ HCl.

On your graph in **Fig. 4.1** sketch the curve you would expect in this experiment. **[2]**

(d) The graph shows that rate of reaction decreases over time.

Explain why, in terms of collision theory.

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.... **[2]**

(e) **(i)** The rate of the reaction between zinc and hydrochloric acid can be increased using a solution of copper(II) sulfate as a catalyst.

Explain how a catalyst increases the rate of reaction.

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.... **[2]**

(ii) Why is it difficult to classify the solution of copper(II) sulfate as a homogeneous or heterogeneous catalyst in this reaction?

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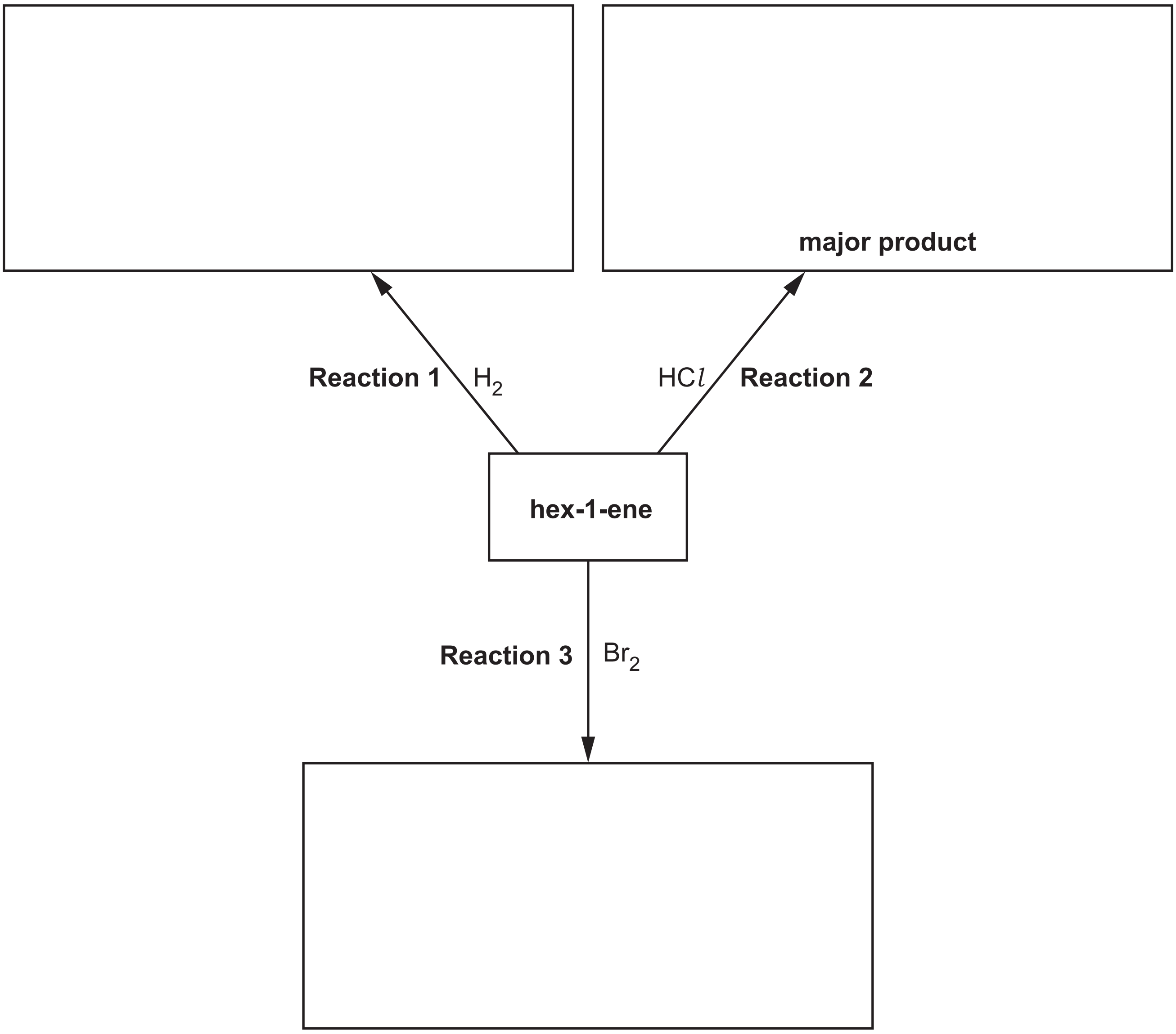
.... **[1]**

5 This question is about hex-1-ene, $CH_3CH_2CH_2CH_2CH{=}CH_2$.

(a) Hex-1-ene is reacted with H_2, HCl and Br_2 as shown in the flowchart below.

(i) Complete the flowchart to show the structures of the organic products of these reactions.



[3]

(ii) State the catalyst needed in **reaction 1**.

.... **[1]**

(iii) What would you observe in **reaction 3**?

....

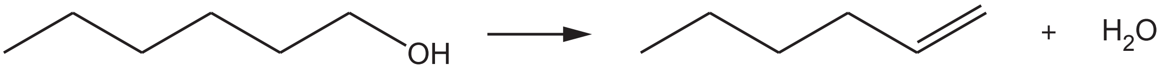
.... **[1]**

(b) Hex-1-ene is a liquid with a boiling point of 63 °C and a density of 0.67 g cm^{-3}.

Hex-1-ene can be prepared by refluxing hexan-1-ol (boiling point 157 °C) with an acid catalyst.

Hexan-1-ol is a liquid with a boiling point of 157 °C and a density of 0.82 g cm^{-3}.

The equation is shown below.



After reflux, the resulting mixture contains unreacted hexan-1-ol, hex-1-ene and water.
The mixture is then purified.

The expected percentage yield of hex-1-ene from hexan-1-ol is 62.5%.

(i)* A student plans to prepare 4.20 g of hex-1-ene by this method.

Calculate the mass of hexan-1-ol that the student should use and explain how you could obtain pure hex-1-ene from the mixture obtained after reflux. **[6]**

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Additional answer space if required

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(ii) Another student suggested that hex-1-ene could be prepared from hexan-2-ol by the same method.

Would you expect the percentage yield of hex-1-ene to be greater than, less than or about the same as when using hexan-1-ol?

Explain your answer.

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.... **[2]**

(c) Hex-1-ene can also be polymerised to form poly(hex-1-ene).

(i) Draw a section of poly(hex-1-ene) containing **two** repeat units.

[1]

(ii) Waste poly(hex-1-ene) can be disposed of usefully by recycling.

State **two** other methods of disposing of polymers that can be beneficial to the environment.

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[2]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).