Synthesis

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

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.

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--- **[6]**

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.

--- **[2]**

(b). 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]

2. A student hydrolyses a haloalkane, **E**, using the following method.

- 0.0100 mol of haloalkane **E** is refluxed with excess NaOH(aq) to form a reaction mixture containing an organic product **F**.
- The reaction mixture is neutralised with dilute nitric acid.
- Excess $AgNO_3$(aq) is added to the reaction mixture. 1.88 g of a precipitate **G** forms.

Organic product, **F**, has a molar mass of 74.0 g mol^{-1} and has a chiral carbon atom.

i. Draw a **labelled** diagram to show how the student would carry out the hydrolysis of haloalkane **E**.

[2]

ii. Analyse the information to identify **E**, **F** and **G**.

Show your working.

[3]

3. 1-Bromobutane is an organic liquid with a boiling point of 102 °C.

A student prepares 1-bromobutane by reacting butan-1-ol with sulfuric acid and sodium bromide. The student boils the mixture for one hour.

The equation is shown below.

$$CH_3CH_2CH_2CH_2OH + H^+ + Br^- \rightarrow CH_3CH_2CH_2CH_2Br + H_2O$$

The student obtains a reaction mixture containing an organic layer (density = 1.27 g cm^{-3}) and an aqueous layer (density = 1.00 g cm^{-3}).

i. * Draw a labelled diagram to show how you would safely set up apparatus for the preparation. Outline a method to obtain a pure sample of 1-bromobutane from the reaction mixture.

--- **[6]**

ii. The student used 0.150 mol of butan-1-ol. The student obtained a 61.4% percentage yield of 1-bromobutane.

Calculate the mass of 1-bromobutane obtained.

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

mass = ______________________________ g **[2]**

4. Describe the oxidation reactions of butan-1-ol forming an aldehyde and a carboxylic acid.

Explain, using a diagram, how the aldehyde can be produced in the laboratory by controlling the reaction conditions.

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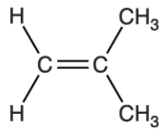
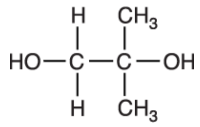
____ **[6]**

5. Compound **B**, shown below, can be used to synthesise organic compounds with different functional groups.



Compound B

The structure of compound **F** is shown below.



Compound F

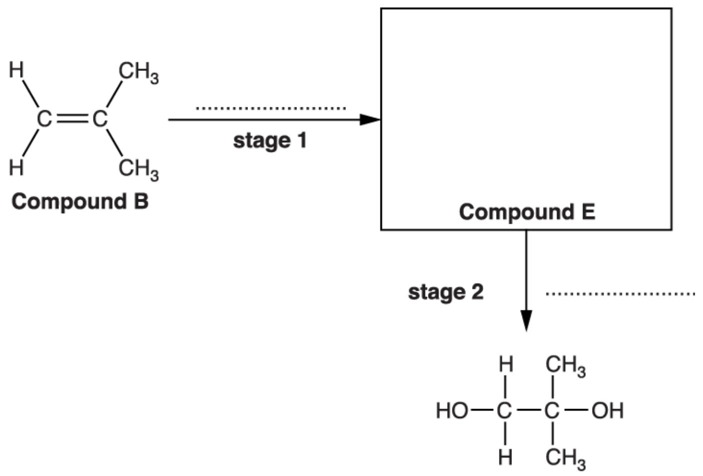
i. What is the empirical formula of compound **F**?

-- **[2]**

ii. A student plans a two-stage synthesis for preparing compound **F** from compound **B.**

The synthesis first prepares compound **E**, as shown in the flowchart.

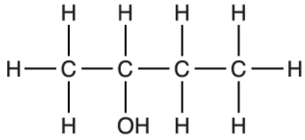
Draw the structure of compound **E** in the box and state the reagents for each stage on the dotted lines.



Compound F

[3]

6. This question is about the properties and reactions of butan-2-ol.



Some properties of butan-2-ol are listed in the table.

Melting point	−115 °C
Boiling point	99.5 °C

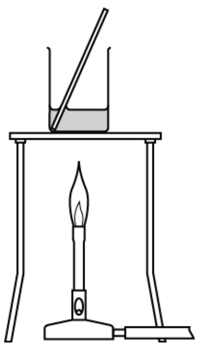
Butan-2-ol can be oxidised by heating with an oxidising agent.

i. Write an equation for the reaction.

Use [O] to represent the oxidising agent and show the structure of the organic product.

[2]

ii. A student plans to carry out this oxidation using the apparatus shown in the diagram.



Give **one** reason why the apparatus is **not** suitable and describe a more suitable way of carrying out this oxidation.

[2]

7(a). Cyclohexanone can be prepared in the laboratory by reacting cyclohexanol with concentrated sulfuric acid and sodium dichromate.

Ethanedioic acid is added to the reaction mixture to react with any excess dichromate.

The mixture is then distilled. The impure distillate is a mixture of cyclohexanone and water.

You will need to refer to some or all of the following data to answer these questions.

	Boiling point / °C	**Density / g cm^{-3}**	M_r
Cyclohexanol	161	0.962	100.0
Cyclohexanone	156	0.948	98.0

* Draw a labelled diagram to show how you would safely set up apparatus for distillation and describe a method to obtain a pure sample of cyclohexanone from the distillate.

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____ **[6]**

(b). Ethanedioic acid removes excess dichromate ions, $Cr_2O_7^{2-}$, as in the equation below.

$$3(COOH)_2 + Cr_2O_7^{2-} + 8H^+ \rightarrow 6CO_2 + 2Cr^{3+} + 7H_2O$$

Suggest how you could tell when the excess dichromate has completely reacted with the ethanedioic acid.

--- **[1]**

(c). A student monitors the course of this reaction using thin-layer chromatography (TLC).

Outline how TLC could be used to monitor the course of the reaction.

--- **[2]**

(d). Plan an experiment that would allow the student to confirm the identity of the pure organic product by means of a chemical test.

--- **[3]**

8. A student carries out the following experiment to investigate the reaction between hexane and chlorine. The chlorine is made by r
aqueous sodium chlorate(I) with dilute hydrochloric acid.

Procedure	**Observations**
1 cm^3 of hexane is mixed with 1 cm^3 dilute aqueous sodium chlorate(I) in a test-tube.	The mixture forms two colourless layers.
1 cm^3 dilute hydrochloric acid is slowly added to the mixture.	The acid mixes with the lower layer, which turns a pale green colour.
The tube is then stoppered and shaken.	The pale green colour moves to the upper layer, leaving the lower layer colourless.
The tube is placed under a bright light and shaken at regular intervals for about 10 minutes. The stopper is loosened regularly to release any pressure.	The pale green colour slowly disappears leaving two colourless layers after about 10 minutes.

i. The reaction between aqueous sodium chlorate(I) and dilute hydrochloric acid produces aqueous sodium chloride as we
chlorine.

Suggest an equation for this reaction.

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ii. Outline a simple practical test that would confirm the presence of chloride ions in the lower layer, and give the expected

test: ....

result: ....

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iii. Name the apparatus that could be used to separate the two liquid layers present at the end of the experiment.

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9. This question is about alkenes.

When alcohol **A** is heated with an acid catalyst, a reaction takes place forming alkene **B**.
The equation for this reaction is shown below as **Equation 16.1**.

$CH_3CH(CH_3)CH_2CHOHCH_3 \rightarrow CH_3CH(CH_3)CHCHCH_3 + H_2O$ **Equation 16.1**

alcohol A **alkene B**

i. State the type of reaction in **Equation 16.1**.

____ **[1]**

ii. Alkene **B** has two stereoisomers.

Explain what is meant by the term *stereoisomers*, and draw the **skeletal** formulae of the two stereoisomers of alkene **B**.

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[3]

iii. The reaction of **A** with an acid catalyst also forms another alkene, **C**.

Alkene **C** is a structural isomer of alkene **B**.

Suggest the structure of alkene **C**.

[1]

iv. * A student carries out the reaction in **Equation 16.1** using 9.26 g of alcohol **A**.

The student obtains a liquid reaction mixture containing a mixture of organic products and the acid catalyst.

The student purifies the reaction mixture to obtain the liquid alkene **B** with a percentage yield of 75.0%.

Describe a method to obtain a pure, dry sample of alkene **B** from the reaction mixture and calculate the mass of alkene **B** that the student produced.

[6]

END OF QUESTION PAPER