Alcohols

1. Alcohols can be used to prepare organic compounds with different functional groups.

$HO(CH_2)_4OH$ can be oxidised to form $HOOC(CH_2)_2COOH$.

i. State the reagents and conditions and write an equation for this oxidation.

In the equation, use [O] for the oxidising agent.

Reagents and conditions:

Equation:

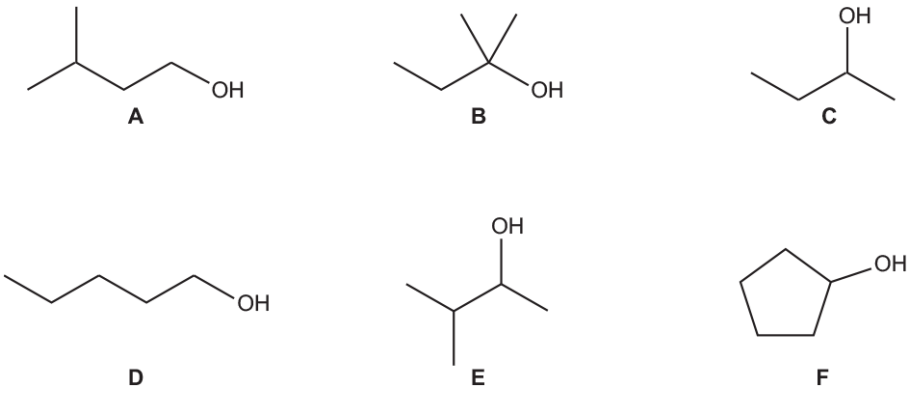
[3]

ii. $HOOC(CH_2)_2COOH$ is soluble in water.

Explain, using a labelled diagram, why $HOOC(CH_2)_2COOH$ is soluble in water.

[2]

2. This question is about the alcohols **A–F** shown below.



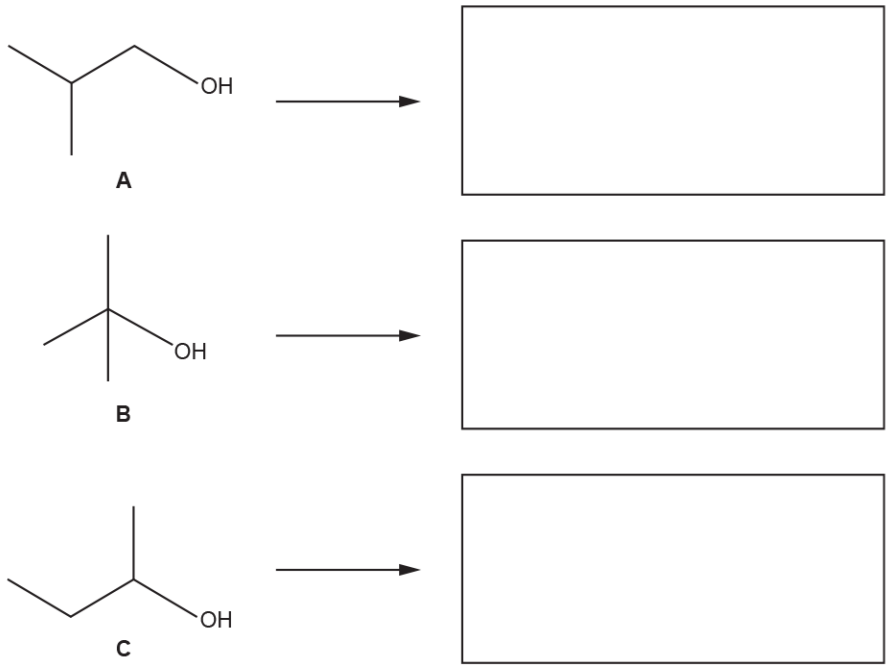
Which of the alcohols **A–F** are secondary alcohols?

_____ **[2]**

3. This question is about alcohols and alkanes.

Three alcohols **A**, **B** and **C** are structural isomers of $C_4H_{10}O$.
Each alcohol is refluxed with acidified dichromate(VI), $H^+/Cr_2O_7^{2-}$.

i. Draw the structures for the organic products.
If there is no reaction, write **'NONE'**.



[3]

ii. Write the systematic name for alcohol **C**.

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[1]

iii. Complete the equation below for the complete combustion of alcohol **A**.

$C_4H_{10}O$ ..... → ..... **[1]**

4. This question is about reactions involving alcohols.

Three reactions of an alcohol **E** are shown in **Fig. 25.1**.

i. Complete **Fig. 25.1** to show the structures of the organic products formed in the reactions.

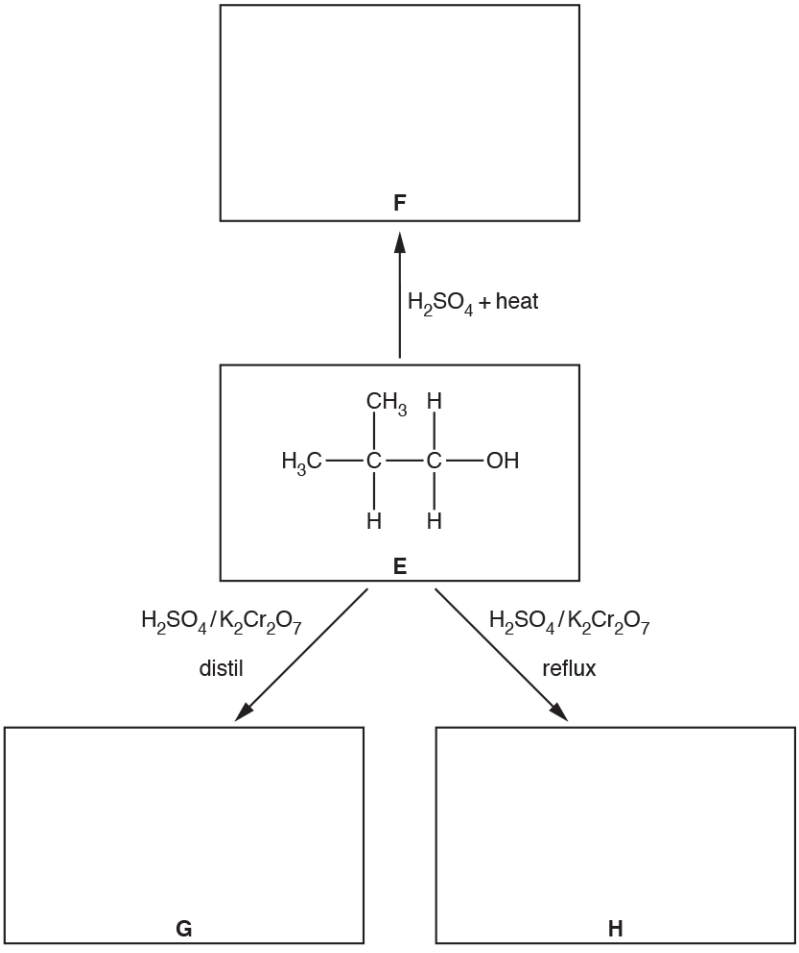

Fig. 25.1

[3]

ii. What is the systematic name of alcohol **E**?

_____ **[1]**

5. The relative molecular masses and boiling points of some fuels are shown in **Table 22.1**.

Fuel	Relative molecular mass	Boiling point / °C
hexane	86	69
pentan-1-ol	88	138
heptane	100	98

Table 22.1

Explain the difference in the boiling points of the fuels in **Table 22.1**.

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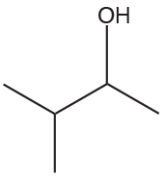
_____ **[4]**

6(a). This question is about reactions of organic compounds containing carbon, hydrogen and oxygen.

A chemist investigates two reactions of alcohol **A**, shown below.



alcohol A

i. What is the systematic name of alcohol **A**?

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[1]

ii. What is the structural formula of alcohol **A**?

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[1]

iii. The chemist heats alcohol **A** with an acid catalyst to form a mixture containing **two** alkenes.

Draw the structures of the **two** alkenes formed in this reaction.

[2]

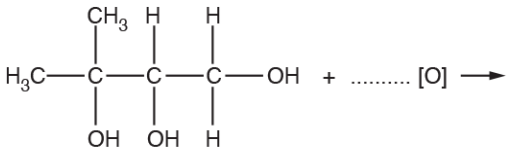
iv. The chemist heats alcohol **A** with sodium chloride and sulfuric acid.

Construct a balanced equation for this reaction.
Show structures for the organic compounds in your equation.

[2]

(b). Compound **B**, shown below, is refluxed with excess acidified potassium dichromate(VI) to form a single organic product.

Complete the equation for this reaction.



compound B

[2]

7.

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]**

8. * Alcohols can be converted into alkenes in an elimination reaction.

The elimination of H_2O from pentan-2-ol forms a mixture of organic products.

Give the names and structures of all the organic products in the mixture.

Your answer should explain how the reaction leads to the different isomers.

---**[6]**

9(a). The hydroxyl group, –OH, is responsible for many properties of alcohols.

Methanol, CH_3OH, is soluble in water because it has polar bonds.

Pauling electronegativity values for carbon, oxygen and hydrogen are shown below.

Element	Electronegativity
Carbon	2.5
Oxygen	3.5
Hydrogen	2.1

Use a labelled diagram to explain why methanol is soluble in water.

- Use displayed formulae showing one molecule of methanol and one molecule of water.
- Add partial charges δ+ and δ – to show the **two** most polar bonds in a methanol molecule and the polar bonds in a water molecule.
- Show all lone pairs.
- Label the most important intermolecular bond between the molecules.

[2]

(b). 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.

---

[6]

10(a). This question is about alcohols.

Construct an equation for the complete combustion of an unsaturated alcohol with 5 carbon atoms.

---

[1]

(b). Many alcohols, including ethanol, are soluble in water.

i. Explain, with the aid of a diagram, why ethanol is soluble in water.
Include relevant dipoles and lone pairs.

---

[2]

ii. The solubility of hexan-1-ol and hexane-1,6-diol in water is shown below in **Table 19.1**.

Alcohol	**Solubility in water / g dm^{-3}**
hexan-1-ol	5.9
hexane-1,6-diol	500

Table 19.1

Explain the difference in solubility of hexan-1-ol and hexane-1,6-diol.

---

[1]

(c). Butan-1-ol can be oxidised to form two different organic products, depending on the reaction conditions used.

Describe both oxidation reactions of butan-1-ol.

For each reaction include

- the structure of the organic product
- a balanced equation
- the essential reaction conditions.

In your equations you may use [O] to represent the oxidising agent.

---

[5]

11(a). At room temperature and pressure, the first four members of the alkanes are all gases but the first four alcohols are all liquids.

Explain this difference in terms of intermolecular forces.

---**[2]**

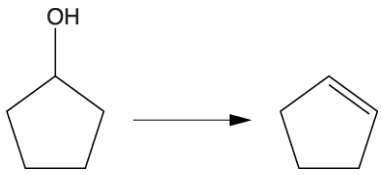
(b). The boiling points of 2-methylpropan-1-ol and butan-1-ol are shown below.

Alcohol	Boiling point / °C
2-methylpropan-1-ol	108
butan-1-ol	117

Explain why the boiling points are different.

---**[2]**

(c). Alkenes can be prepared from alcohols. Cyclopentene can be prepared from cyclopentanol as shown in the equation below.



A student plans to prepare 5.00 g of cyclopentene from cyclopentanol. The percentage yield of this reaction is 45.0%.

i. What is the name of this type of reaction?

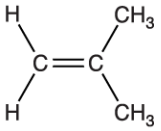
---**[1]**

ii. Calculate the mass of cyclopentanol that the student should use.

Show your working.

mass of cyclopentanol = ... g **[3]**

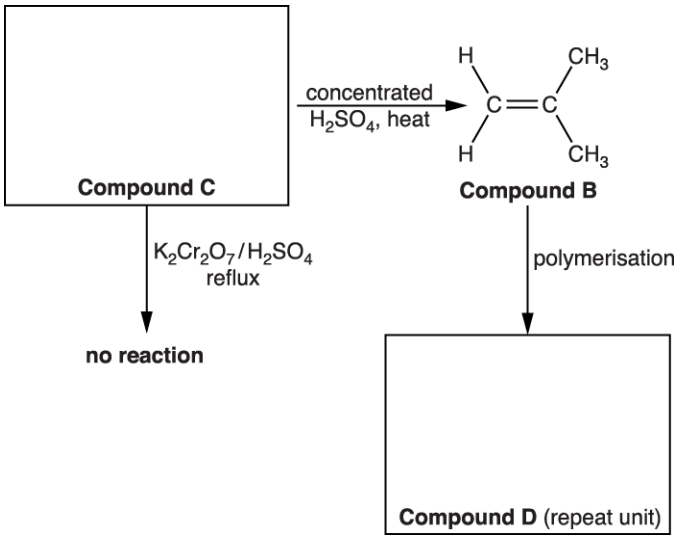
12. Compound **B**, shown below, can be used to synthesise organic compounds with different functional groups.



Compound B

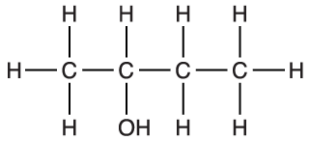
Some reactions involving compound **B** are shown in the flowchart below.

Complete the flowchart, showing the structures of organic compounds **C** and **D**.



[2]

13(a). 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

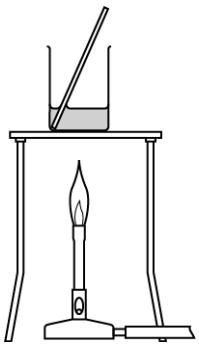
Butan-2-ol can be oxidised by heating with an oxidising agent.

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]**

(b). Why is butan-2-ol classified as a secondary alcohol?

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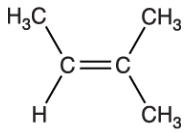
[1]

14. Compound **A** is an alkene.



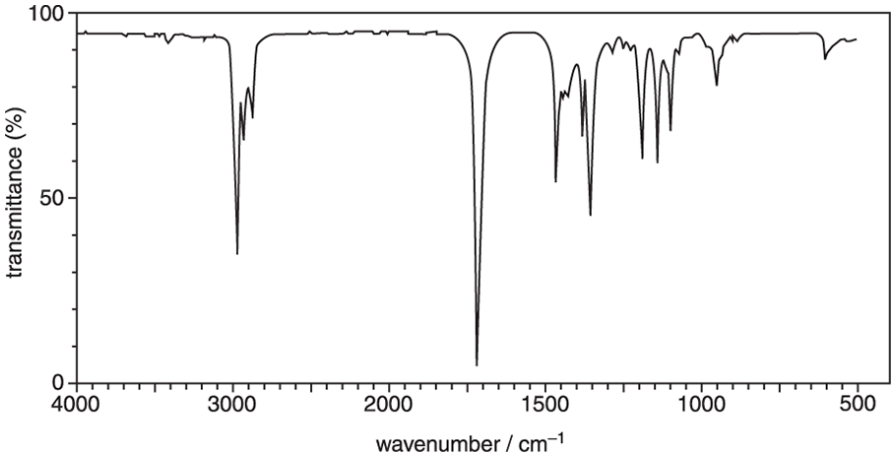
compound **A**

Compound **A** can be made from alcohol **B** by heating with an acid catalyst.

Suggest **two** possible structures for alcohol **B** .

[2]

15(a). The branched-chain alcohol **J**, $C_5H_{12}O$, was heated under reflux with excess H_2SO_4 / $K_2Cr_2O_7$ to form an organic compound **K** with the infrared spectrum below.



- Determine the structures for the branched-chain alcohol **J** and compound **K**.
  Your answer should explain all your reasoning using the evidence given.
- Write an equation for the reaction of **J** when heated under reflux with excess H_2SO_4 / $K_2Cr_2O_7$ to form **K**.
  Use [O] to represent the oxidising agent.

Your answer needs to be clear and well organised using the correct terminology.

[6]

(b). The alcohol **J** is soluble in water.

Explain why alcohol **J** is soluble in water.

Use a labelled diagram to support your answer.

Include relevant dipoles and lone pairs.

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[1]

16. Compound **B**, C_xH_yO, can be oxidised to form a ketone **C**.

0.035 mol of **B** has a mass of 2.59 g.

Compound **B** reacts with compound **D**, $C_3H_6O_2$, in the presence of an acid catalyst to form two compounds **E** and **F**.

- Calculate the molar mass of compound **B**.
- Give the structures of compounds **B**, **C**, **D**, **E** and **F**.

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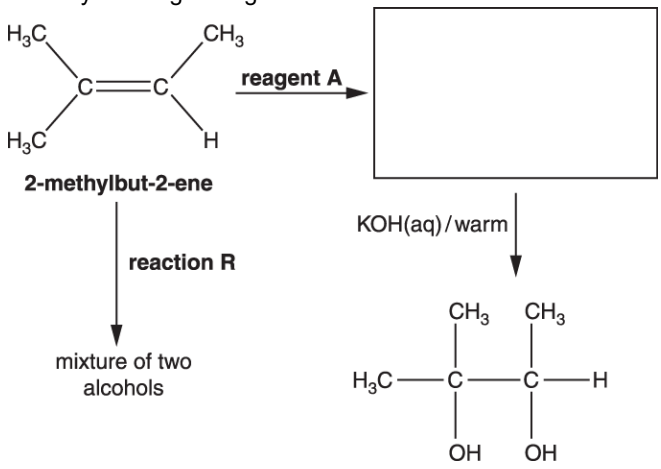
[6]

17(a). The flowchart shows how 2-methylbut-2-ene can be converted into a number of organic products.

Complete the flowchart by drawing an organic structure in the box below.



[1]

(b). Identify reagent **A**.

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[1]

(c). In the flowchart, **reaction R** forms a mixture of two alcohols that are structural isomers of $C_5H_{12}O$.

i. State the reagents and conditions needed for **reaction R**.

---

[1]

ii. What is meant by the term *structural isomers*?

---

[1]

iii. Draw the two structural isomers of $C_5H_{12}O$ formed in **reaction R**.

[2]

iv. Suggest why 2-methylbut-2-ene is less soluble in water than either of the structural isomers formed.

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[2]

(d). Describe the oxidation reactions of propan-1-ol when using a suitable oxidising agent.
Indicate how the use of different reaction conditions can control which organic product forms.
Include reagents, observations and equations in your answer.
In your equations, use structural formulae and use [O] to represent the oxidising agent.

---

[6]

18(a). Compound **F** has the molecular formula C_4H_8.

Compound **F** is reacted with steam in the presence of an acid catalyst, to form a mixture of three alcohols, **G**, **H** and **I**.

Compound **G** is oxidised with acidified potassium dichromate(VI) to form compound **J**.

Compound **J** reacts with Tollens' reagent to form compound **K**.

Compounds **H** and **I** are optical isomers.

Draw the structures of the compounds **F**, **G**, **H**, **I**, **J** and **K**.

[6]

(b). Explain, with reference to a suitable chemical test, how compound **J** could be identified.

Your answer should **not** include spectroscopy.

---**[3]**

19. 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**.

---

[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.

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_____ **[6]**

20. * You are provided with three alcohols that are structural isomers: $CH_3CH_2CH_2CH_2OH$, $CH_3CH_2CHOHCH_3$ and $(CH_3)_3COH$. You do not know which is which.
You have access to normal laboratory apparatus and chemicals, Quickfit apparatus, and an infrared spectrometer.
Describe a plan that would allow you to identify the three alcohols using the same experimental set up and method.

You should provide

- equations using structural formulae for any reactions
- a description of how you will identify the three alcohols from any observations and results.

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_____ **[6]**

END OF QUESTION PAPER