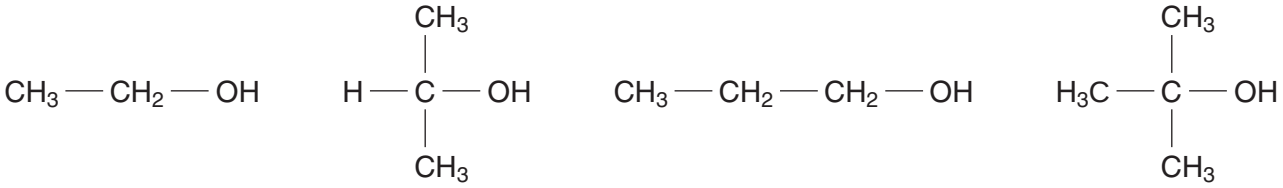
1 Alcohols **A**, **B**, **C** and **D** are shown below.



A **B** **C** **D**

(a) Compound **A** is ethanol, a very useful alcohol.

Identify the two main methods used in the industrial production of ethanol.
Write an equation for each method.

method 1 .....

.....

equation .....

method 2 .....

.....

equation ..... **[4]**

(b) A student heated each alcohol, **A**–**D**, with acidified potassium dichromate(VI) as the oxidising agent. With alcohols **A**, **B** and **C**, the colour turned from orange to green.

(i) Identify the organic product and write a balanced equation for the reaction of alcohol **B** with acidified potassium dichromate(VI).

Use [O] to represent the oxidising agent, acidified potassium dichromate(VI).

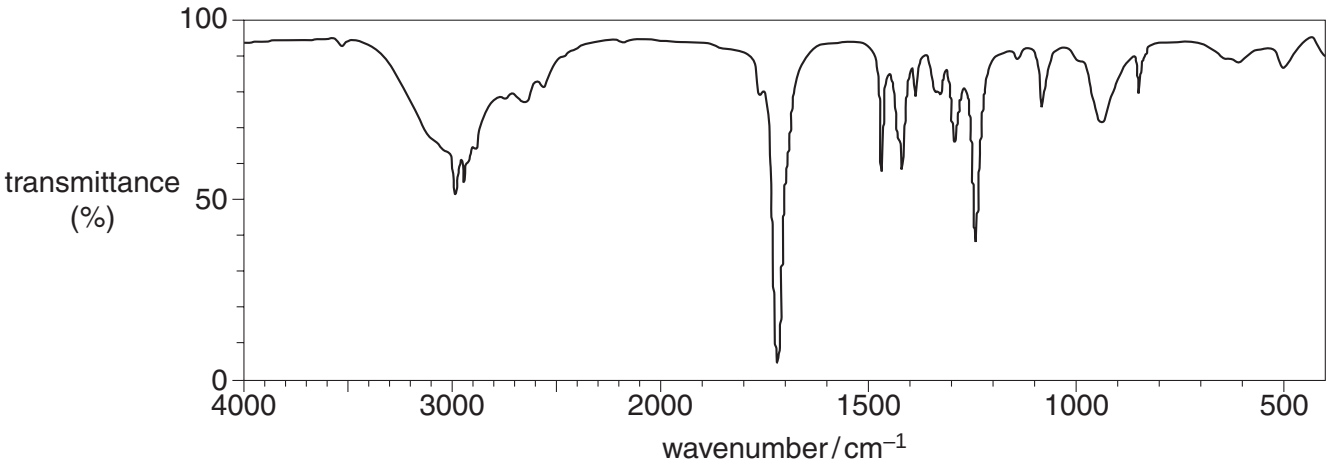
organic product:

balanced equation:

[2]

(ii) The organic product obtained from **C** was analysed by infrared (IR) spectroscopy.

The IR spectrum of the product is shown below.



Use your *Data Sheet* to identify the organic product. Explain your reasoning.

organic product:

reasoning .....

.....

..... **[3]**

(c) The student heated alcohol **D** with ethanoic acid in the presence of an acid catalyst. An organic product **E** was formed with a fruity smell.

(i) Name alcohol **D**.

..... **[1]**

(ii) Name the functional group in the organic product **E**.

..... **[1]**

(iii) Draw the structure of the organic product **E**.

[2]

[Total: 13]

2 In this question, you are asked to suggest structures for several organic compounds2

(a) Compounds **F**, **G** and **H** are **unbranched** alkenes that are isomers, each with a relative molecular mass of 70.0.

Compounds **F** and **G** are *E*/*Z* stereoisomers.

Compound **H** is a structural isomer of compounds **F** and **G**.

- Explain what is meant by the terms *structural isomer* and *stereoisomer*.
- Explain why some alkenes have *E*/*Z* isomerism.
- Analyse this information to suggest possible structures for compounds **F**, **G** and **H**.

In your answer you should make clear how each structure fits with the information given above.

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..... **[11]**

(b) An analytical chemist was provided with a compound **J** which has an unbranched carbon skeleton. After analysis, the chemist obtained the following results.

type of analysis	**evidence**
infrared spectroscopy	broad absorption at 3350 cm^{-1}
percentage composition by mass	C, 70.59%; H, 13.72%; O, 15.69%
mass spectrometry	molecular ion peak at m/z = 102.0

Use this information to suggest all the possible structures for the **unbranched** compound **J**.

In your answer you should make clear how your explanation is linked to the evidence.

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..... **[8]**

[Total: 19]

3 Ethanoic acid, CH_3COOH, is used to make esters.

Some information about two of the processes used to make ethanoic acid is given below.

Process 1

This is a one-step process that involves the reaction of methanol with carbon monoxide.

$$CH_3OH + CO \rightarrow CH_3COOH$$

The conditions used are 180 °C and 30 atmospheres pressure. A rhodium/iodine catalyst is used.

The percentage yield for this process is 99%.

Process 2

This involves the oxidation of naphtha, a fraction obtained from crude oil.

Liquid naphtha is oxidised using air at a temperature of 180 °C and 50 atmospheres pressure. No catalyst is needed.

A large variety of other products are also formed in this oxidation.

(a) Suggest **three** advantages of making ethanoic acid using **Process 1** rather than **Process 2**.

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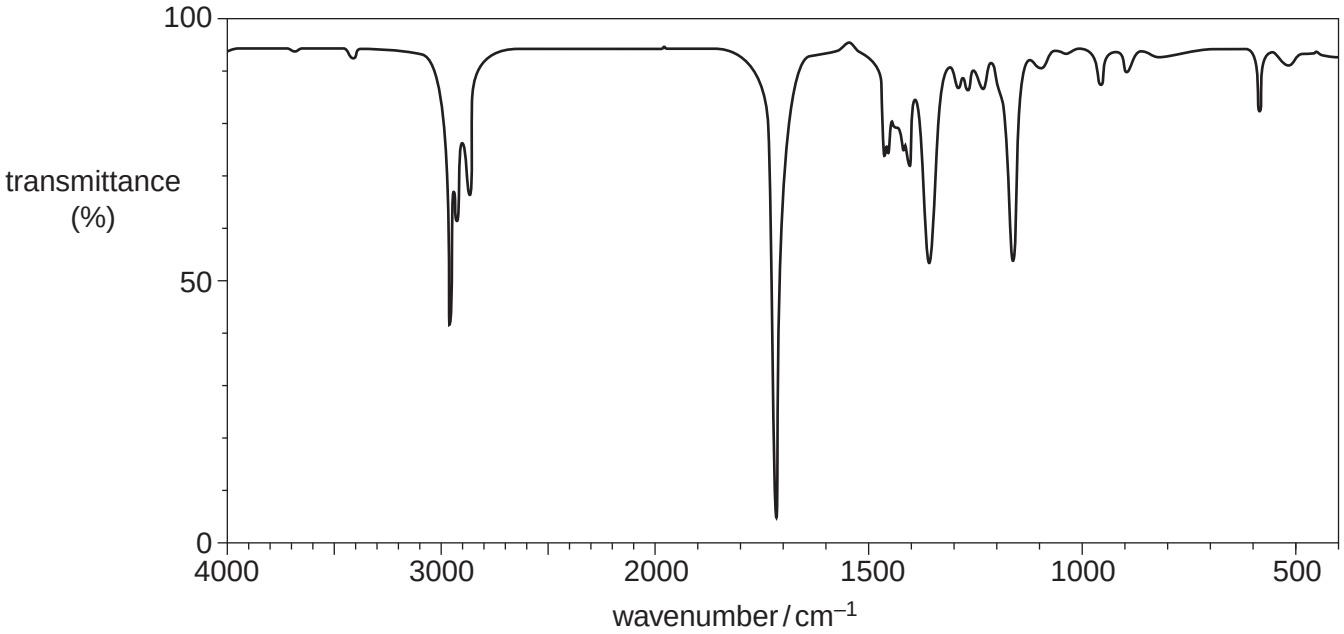
..... **[3]**

(b) The other products formed in **Process 2** are carboxylic acids, aldehydes and ketones.

A research chemist investigates some of these other products of **Process 2**.

(i) The research chemist isolates product, **J**.

The infrared spectrum of **J** is shown below.



The chemist also finds that 0.172 g of a pure sample of **J** contains 2.00×10^{-3} mol of **J**.

Suggest, with reasons, **one** possible structure for **J**.

In your answer you should link the evidence with your explanation.

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..... **[5]**

(ii) The chemist isolates another product, the carboxylic acid, **K**.

K has the molecular formula $C_4H_8O_2$.

Suggest a possible structure and name for **K**.

structure

name ..... **[2]**

(c) Ethanoic acid is used in the manufacture of the ester, propyl ethanoate.

Describe how ethanoic acid is converted into propyl ethanoate.
Include an equation in your answer.

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..... **[4]**

[Total: 14]

4 Chlorofluorocarbons, CFCs, were once used as propellants in aerosols. CFCs contribute to ozone depletion in the upper atmosphere.

(a) A CFC has the formula CF_2Cl_2.

State the three-dimensional shape of a CF_2Cl_2 molecule and the F–C–Cl bond angle.

shape .....

bond angle ..... **[2]**

(b) Two reasons that CF_2Cl_2 was used as an aerosol propellant are that it has low reactivity and will not hydrolyse in water.

(i) State **one** other reason why CF_2Cl_2 was developed for use as an aerosol.

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..... **[1]**

(ii) Suggest why CF_2Cl_2 does **not** hydrolyse in water.

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..... **[1]**

(c) Explain, with the aid of equations, how the presence of CFCs in the upper atmosphere leads to ozone depletion.

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..... **[3]**

(d) Why are scientists concerned about ozone depletion?

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..... **[1]**

(e) International agreements have reduced the use of CFCs. However the concentration of atmospheric CFCs has hardly changed.

Suggest **two** reasons why.

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..... **[2]**

[Total: 10]

5 This question is about the six alcohols below.

butan-2-ol	**ethane-1,2-diol**
2-methylpentan-3-ol	**2-methylpropan-2-ol**
propan-1-ol	**propan-2-ol**

(a) Which alcohol is an example of a tertiary alcohol?

..... **[1]**

(b) Draw the skeletal formula for 2-methylpentan-3-ol.

[1]

(c) Butan-2-ol and 2-methylpropan-2-ol are structural isomers.

(i) What is meant by the term *structural isomer*?

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.....

..... **[1]**

(ii) Draw another structural isomer of these two alcohols.

[1]

(d) Ethane-1,2-diol can be dissolved in water to act as an anti-freeze in car radiators.

Explain why ethane-1,2-diol is very soluble in water.

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..... **[2]**

(e) Ethane-1,2-diol is heated under reflux with ethanoic acid and a small amount of H_2SO_4 catalyst. Compound **A** is formed with molecular formula $C_6H_{10}O_4$.

Draw the structure of compound **A**.

[2]

(f) Butan-2-ol is heated with H_2SO_4 catalyst.

- A mixture of **three** alkenes forms, **B**, **C** and **D**.
- The alkenes **B** and **C** are stereoisomers.

(i) Draw the structures of the two stereoisomers **B** and **C**.

[2]

(ii) What type of stereoisomerism is shown by **B** and **C**?

..... **[1]**

(iii) Draw the structure of the other alkene, **D**, that is formed in this reaction.

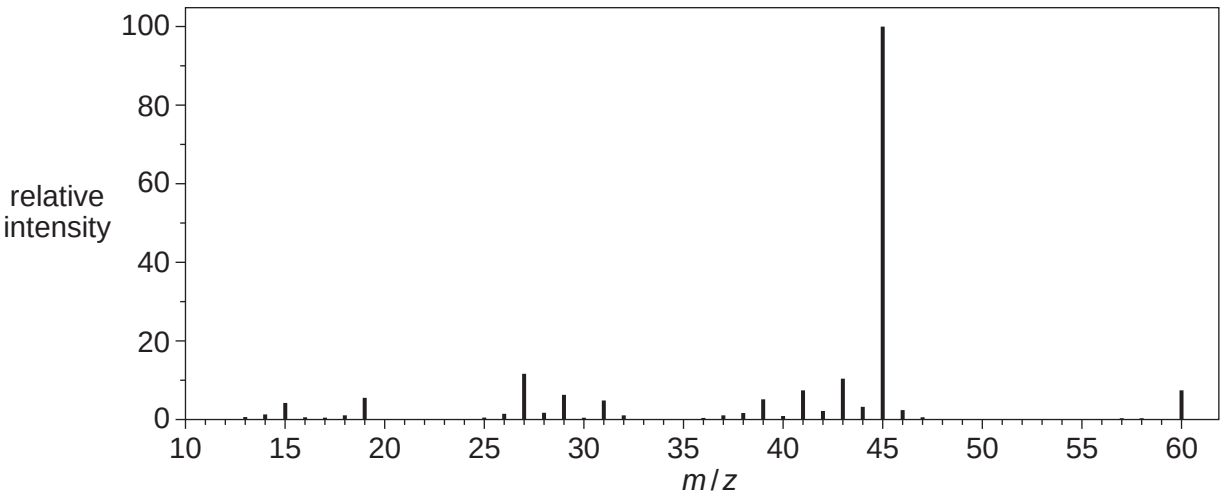
[1]

(g) Alcohol **E** is one of the following alcohols.

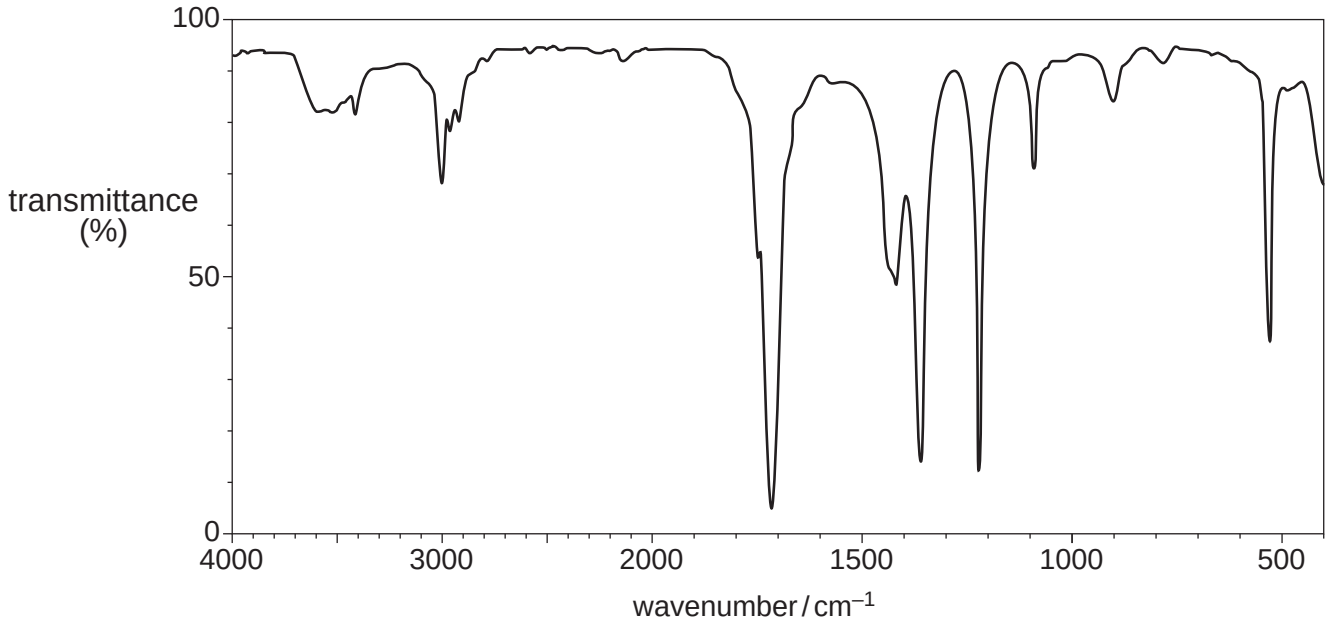
butan-2-ol	**ethane-1,2-diol**
2-methylpentan-3-ol	**2-methylpropan-2-ol**
propan-1-ol	**propan-2-ol**

A student oxidises alcohol **E** by heating under reflux with excess acidified potassium dichromate(VI). An organic product **F** is isolated.

The mass spectrum of the alcohol **E** is shown below.



The infrared spectrum of the organic product **F** is shown below.



- Name **or** draw the structures of the alcohol **E** and the organic product **F**.
- Write an equation for the reaction of alcohol **E** with acidified potassium dichromate(VI).

Use [O] to represent the oxidising agent, acidified potassium dichromate(VI).

In your answer, you should make clear how each structure fits with the information given above.

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..... **[7]**

[Total: 19]