2 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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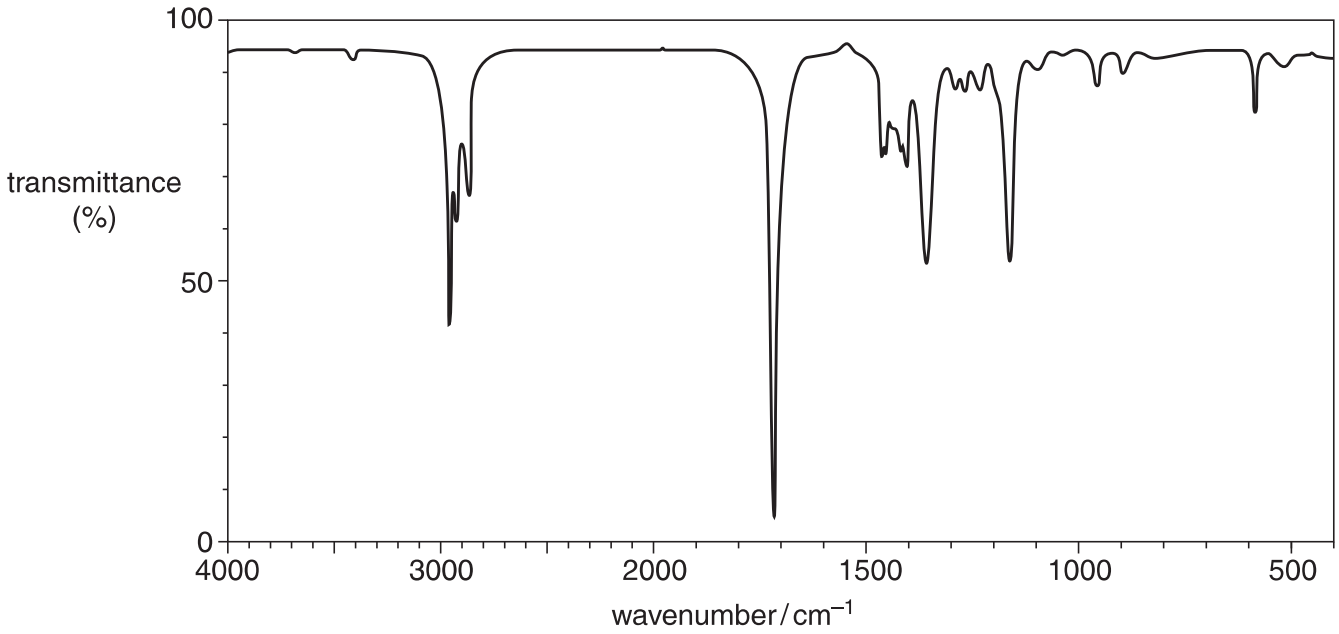
..... **[3]**

(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]

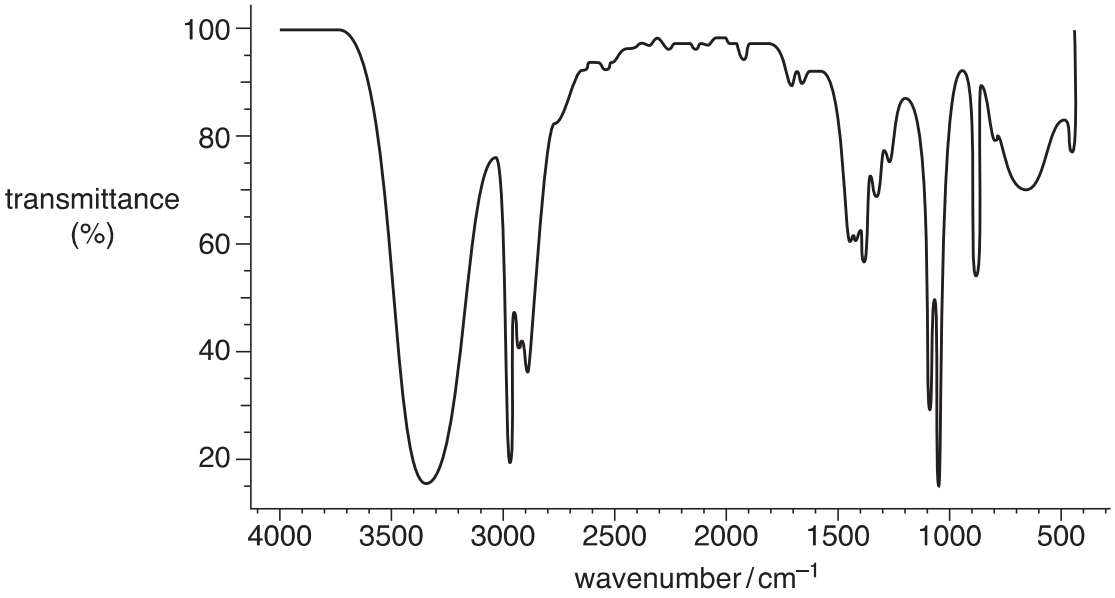
7 Compound **X** and compound **Y** react together to make an ester **Z.** Samples of **X** and **Y** were analysed by a research chemist. A summary of the chemist's results are shown below.

Analysis of compound X

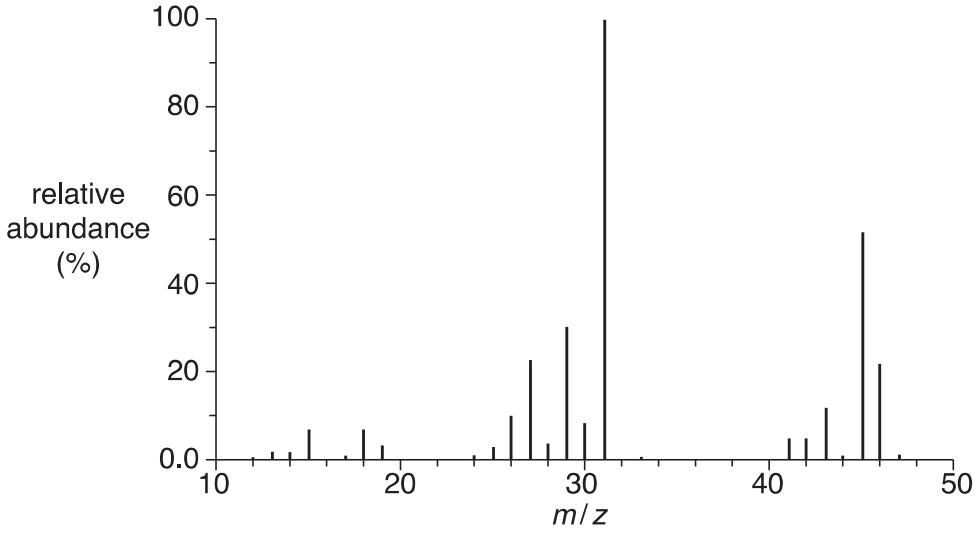
type of analysis	evidence
infrared spectroscopy	absorption at 1720 cm^{-1} and a very broad absorption between 2500 and 3300 cm^{-1}
percentage composition by mass	C, 48.65%; H, 8.11%; O, 43.24%
mass spectrometry	molecular ion peak at $m/z = 74.0$

Analysis of compound Y

infrared spectrum of **Y**



mass spectrum of **Y**



Use this information to suggest the identity of compound **X**, compound **Y** and ester **Z.**

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

..... **[10]**

[Total:10]

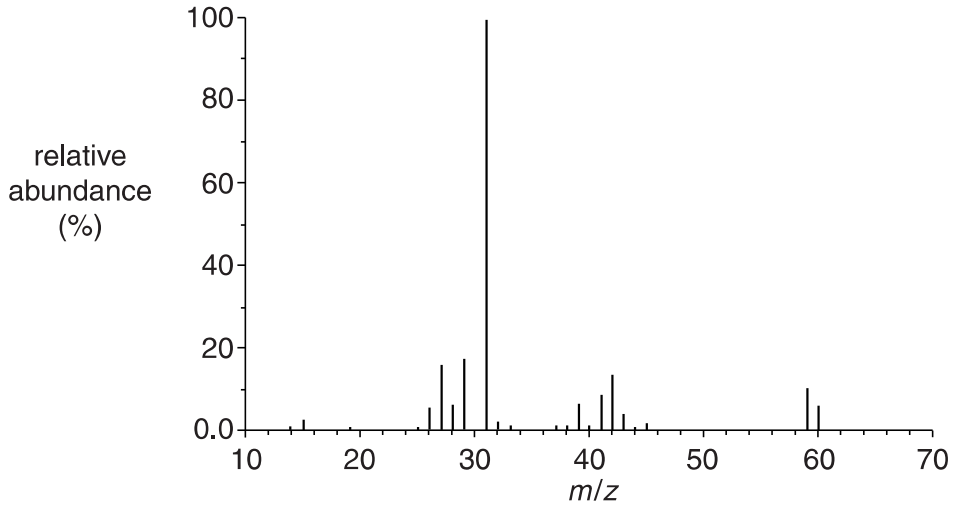
END OF QUESTION PAPER

8 Compound **X** is a saturated compound that contains carbon, hydrogen and oxygen only.

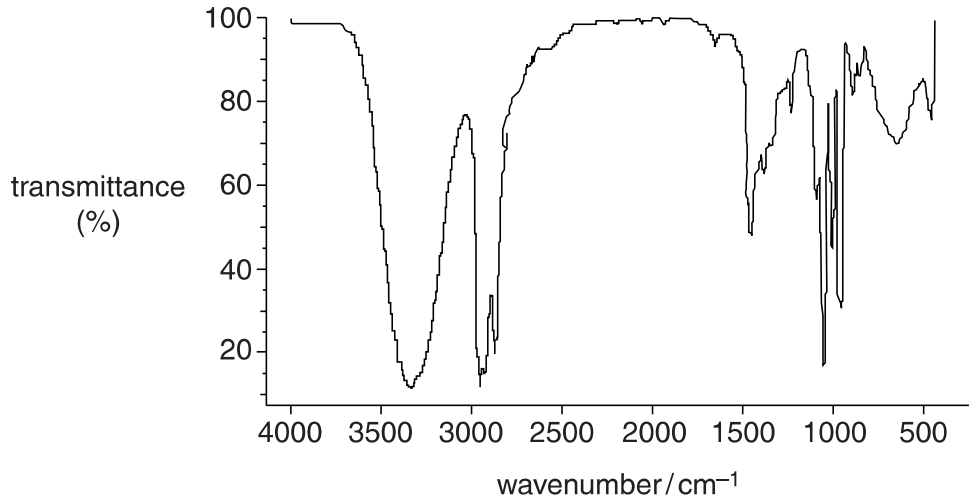
A scientist analyses a 1.00 g sample of compound **X** and finds it contains 0.133 g of hydrogen and 0.600 g of carbon.

The scientist also analyses compound **X** using mass spectrometry and infrared spectroscopy.

mass spectrum of X



IR spectrum of X



The scientist finds that compound **X** reacts with ethanoic acid in the presence of a concentrated sulfuric acid catalyst to make compound **Y.**

Compound **Y** has the molecular formula $C_5H_{10}O_2$.

Using all the information, show the structures of compounds **X** and **Y.**
Include an equation for the reaction of compound **X** with ethanoic acid to make compound **Y.**

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

.... [10]

[Total: 10]

END OF QUESTION PAPER