OCR
Oxford Cambridge and RSA

Tuesday 21 May 2024 – 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

You can use:
- a scientific or graphical calculator
- an HB pencil

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 can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

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

ADVICE
- Read each question carefully before you start your answer.

1 This question is about water, H_2O, and ammonia, NH_3.

(a) Hydrogen and oxygen have different electronegativities.

What is meant by the term **electronegativity**?

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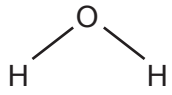
..... **[2]**

(b) H_2O is a polar molecule that has hydrogen bonding.

(i) Complete the diagram below to show hydrogen bonding between the H_2O molecule shown and another H_2O molecule.

Include relevant dipoles and lone pairs.

Label the hydrogen bond.



[2]

(ii) Explain why molecules of H_2O are polar.

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

(iii) One unusual property of H_2O is that ice floats on water.

Explain why ice has a lower density than water.

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

(c) Solid ammonia, NH_3, also contains hydrogen bonds.

(i) Suggest why solid ammonia has a lower melting point than ice.

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

(ii) When ammonia dissolves in water, ammonium ions, NH_4^+, are formed.

Draw a 'dot-and-cross' diagram to show the bonding in an NH_4^+ ion.

Show outer electrons only.

[2]

(iii) Outline how you would test for the presence of NH_4^+ ions in a solution.

Your answer should include observations.

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

(d) A student heats 11.50 g of hydrated zinc sulfate, $ZnSO_4 \cdot 7H_2O$, to remove all the water of crystallisation.

Calculate the mass of anhydrous zinc sulfate that should be obtained.

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

2 This question is about periodicity and the reaction of some Group 2 metals.

(a) Periodicity is the repeating trend in properties of elements across different periods in the periodic table.

(i) Complete the table below with the electron configurations and blocks.

	Group 2	**Group 17 (7)**
Period 2	Be $1s^2$	F $1s^2$ .....
Period 3	Mg $1s^2$	C*l* $1s^2$ .....
Block	.....	.....

[3]

(ii) Use your answers to **(a)(i)** to explain why electron configuration is an example of a periodic trend.

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

(iii) Mg forms 2+ ions but C*l* usually forms 1– ions in their reactions. Explain why.

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

(iv) Magnesium reacts with oxygen in the air.

Write the equation for this reaction.

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

(b) The reaction between calcium and hydrochloric acid is a redox reaction.

$Ca(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2(g)$ **Equation 2.1**

(i) Explain, in terms of electron transfer, why the reaction shown in **equation 2.1** is a redox reaction.

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

(ii) A student plans to add 0.0100 mol of Ca to 120 cm^3 of 0.100 mol dm^{-3} $HCl(aq)$.

When the student carries out this reaction, they are surprised that all the calcium reacts, despite being in excess of the $HCl(aq)$.

- Show by calculation that calcium is in excess of the $HCl(aq)$.
- Suggest a reason for this unexpected result.

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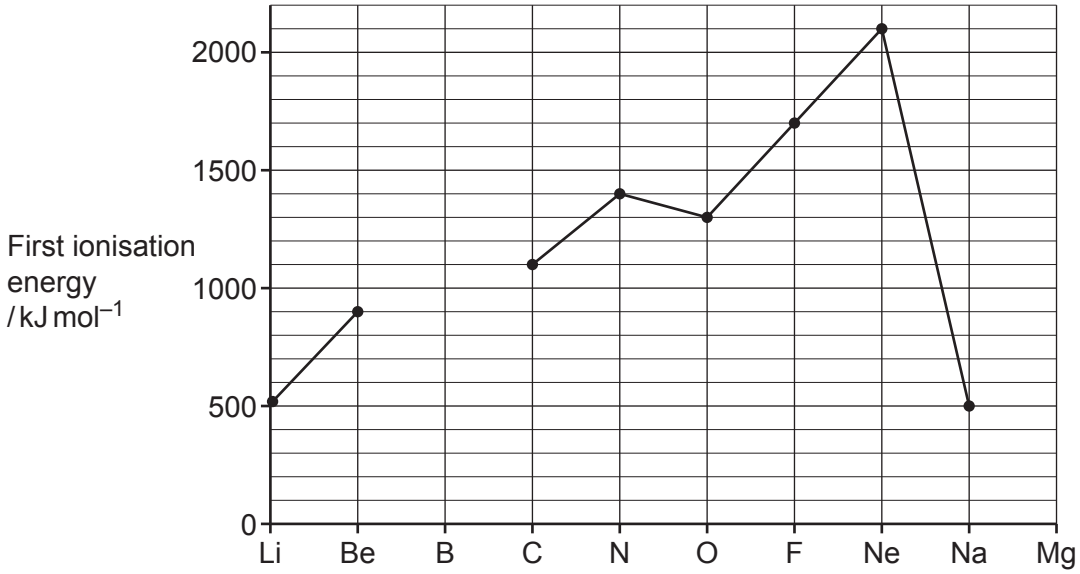
(c) The graph shows the first ionisation energies for the elements Li to Be and for C to Na.



(i) Complete the graph by adding points for the missing values of B and Mg. **[2]**

(ii) Write an equation, including state symbols, to represent the **second** ionisation energy of B.

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

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Turn over for the next question

3 Enthalpy changes of reaction can be determined by experiment.

(a) What is meant by the term **enthalpy change of reaction**?

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

(b)* A student carries out an experiment to determine the enthalpy change for the reaction between zinc and copper(II) nitrate solution.

$Zn(s) + Cu(NO_3)_2(aq) \rightarrow Zn(NO_3)_2(aq) + Cu(s)$ $\Delta_r H$ **Equation 3.1**

The student follows the method outlined below.

- Add 100 cm^3 of 0.500 mol dm^{-3} $Cu(NO_3)_2(aq)$ to a beaker.
- Measure the temperature of the solution.
- Add excess zinc to the beaker.
- Stir the mixture and record the maximum temperature.

The temperature of the solution changes from 19.5 °C to 38.1 °C.

Calculate $\Delta_r H$, in kJ mol^{-1}, for **equation 3.1**.

State any assumptions you have made in your calculation.

Suggest improvements for obtaining a more accurate value for $\Delta_r H$. **[6]**

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(c) The student modifies the experiment using 50 cm^3 instead of 100 cm^3 of 0.500 mol dm^{-3} copper(II) nitrate solution.

The value of $\Delta_r H$ for this modified experiment is the same as in **equation 3.1**.

Explain why.

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

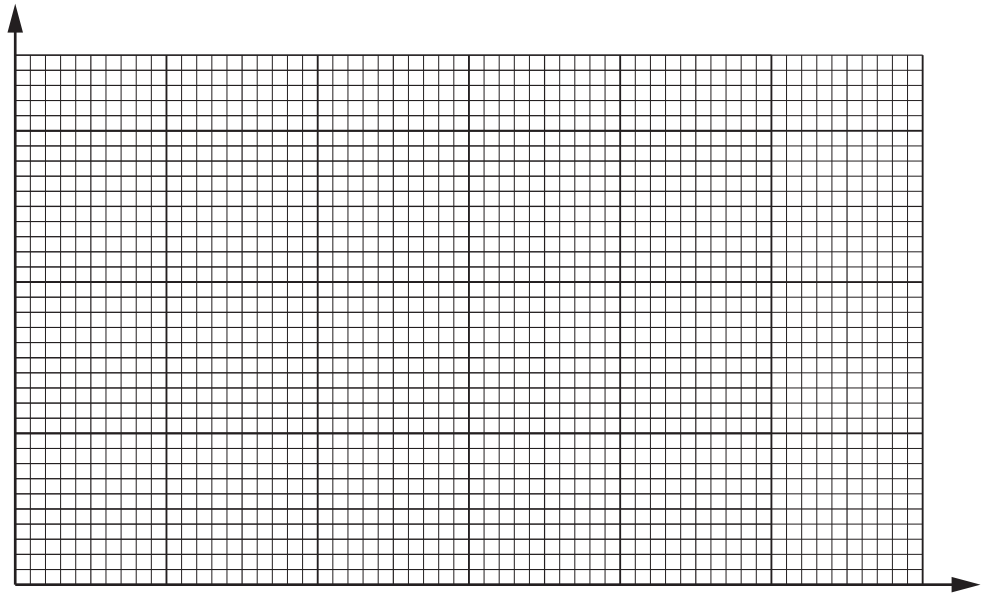
4 Aqueous hydrogen peroxide, $H_2O_2(aq)$, gradually decomposes to produce water and oxygen.

$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$ $\Delta H = -196\,kJ\,mol^{-1}$ **Equation 4.1**

The rate of decomposition of H_2O_2 can be increased by adding a small amount of manganese(IV) oxide, MnO_2, which acts as a catalyst.

(a) Explain, using a Boltzmann distribution model, why the rate of a reaction increases in the presence of a catalyst.

You are provided with the axes below, which you should label.



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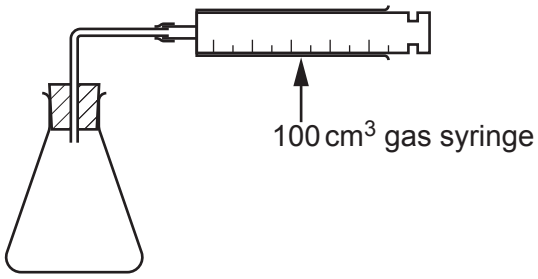
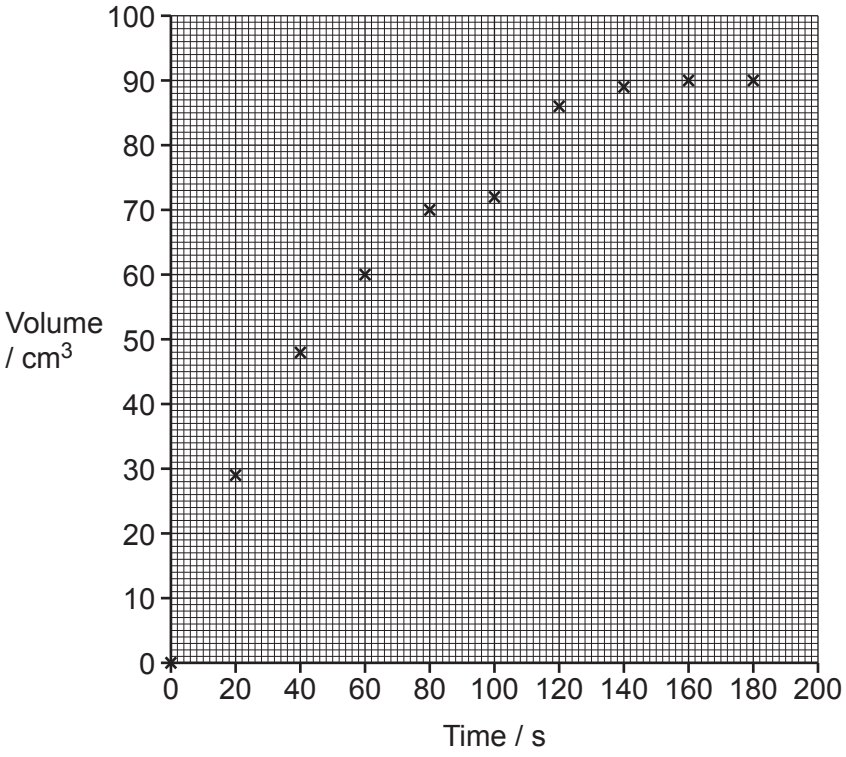
..... **[4]**

(b) A student investigates the rate of decomposition of H_2O_2, on addition of MnO_2 catalyst, using a gas syringe.



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

Graph 4.1



(i) On **graph 4.1**, draw a best-fit smooth curve of the results **and** circle the anomalous result. **[2]**

(ii) Use your graph to determine the rate of reaction, in $cm^3 s^{-1}$, at 50 s.

Show your working below and on the graph.

rate = ... $cm^3 s^{-1}$ **[2]**

(iii) The student uses 50.0 cm^3 of H_2O_2 in the experiment. **Equation 4.1** shows the reaction that takes place.

$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$ **Equation 4.1**

Calculate the concentration of H_2O_2, in mol dm^{-3}, required to produce 90 cm^3 of $O_2(g)$ at RTP.

concentration = ... mol dm^{-3} **[3]**

(c) A student plans to compare the rate of decomposition of H_2O_2 using different metal oxides as the catalyst.

Suggest **two** variables which should be kept constant.

1 .....

2 .....

[2]

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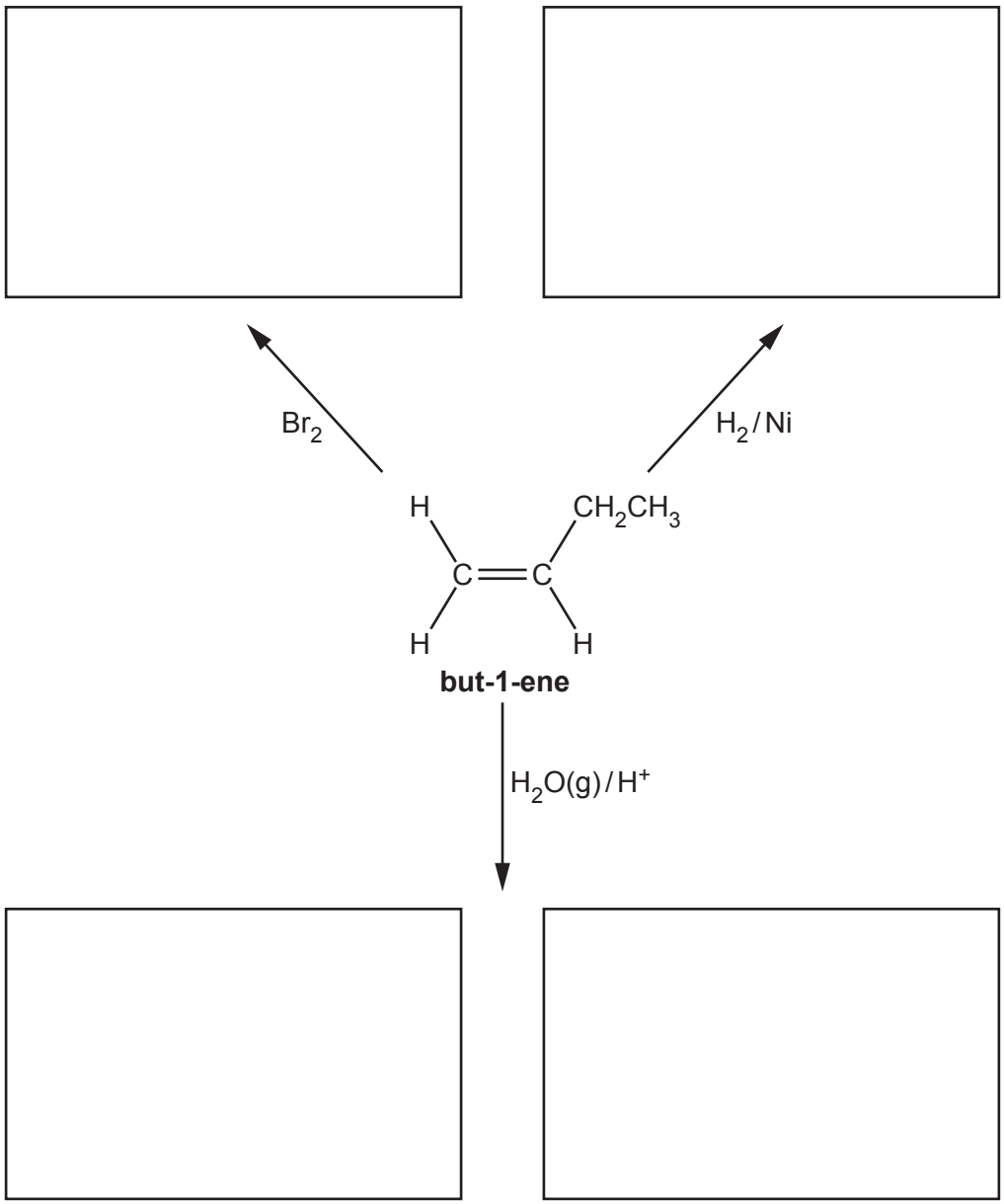
5 This question is about some reactions of alkenes.

(a) Complete the flowchart for the reactions of but-1-ene, by adding the structures of the organic products in each box.

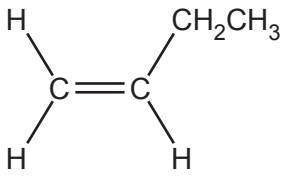


[4]

(b) HBr reacts readily with alkenes.

(i) Outline the mechanism for the reaction of but-1-ene with HBr to form **2-bromobutane**.

Include curly arrows, relevant dipoles and the structure of the product.



[4]

(ii) During this reaction, a small amount of **1-bromobutane** is also produced.

Explain why **2-bromobutane** is the major product.

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

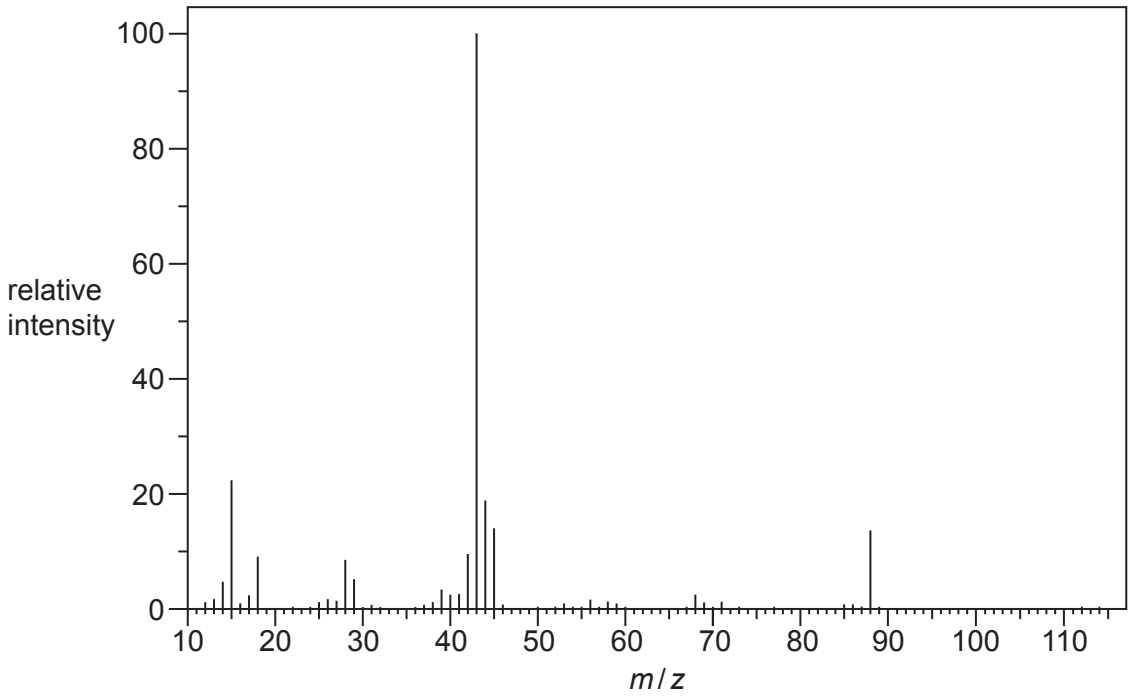
6* Compound **X** is an organic compound with **two** functional groups.

Compound **X** has the percentage composition by mass:
C, 40.91%; H, 4.54%; O, 54.55%.

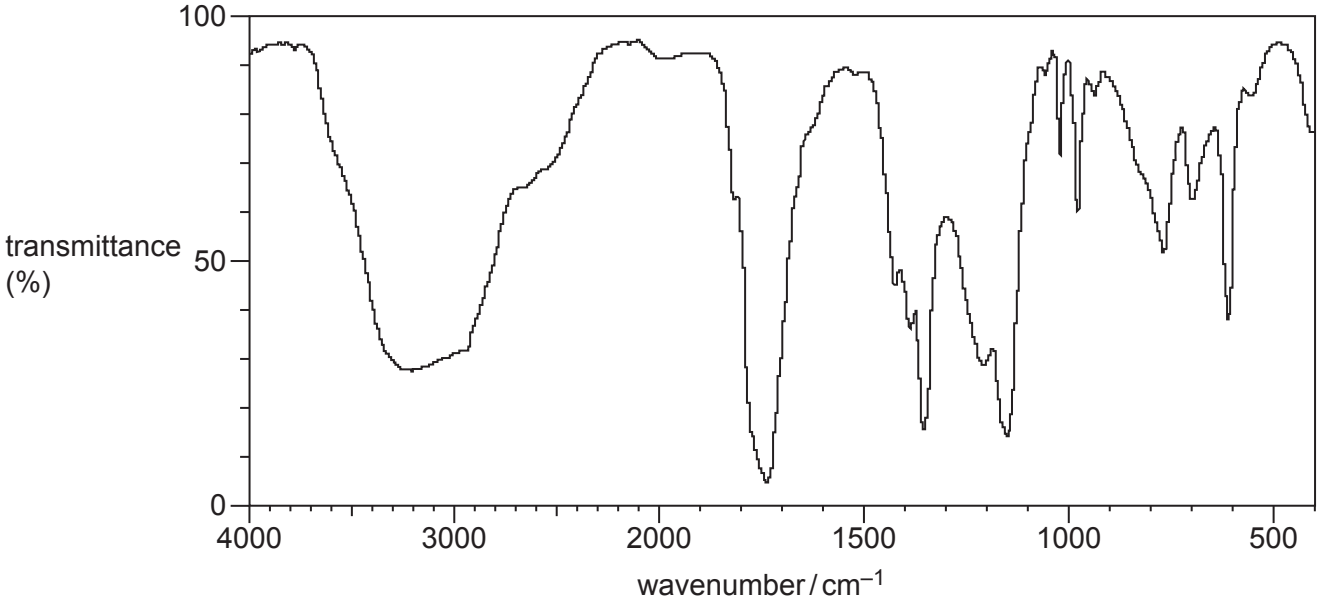
Compound **X** does **not** decolourise bromine water.

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

Mass spectrum of X



IR spectrum of X



Use all the information to determine a possible structure of compound **X**.

In your answer, make it clear how your conclusions are linked to the evidence. **[6]**

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Extra answer space if required

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END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.