OCR
Oxford Cambridge and RSA

Tuesday 5 October 2021 – Afternoon

AS Level Chemistry A

H032/01 Breadth 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

8937833255

H032/01

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 **[ ]**.
- This document has **24** pages.

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

SECTION A

You should spend a maximum of 25 minutes on this section.

Answer **all** the questions.

Write your answer to each question in the box provided.

1 Which compound has the highest boiling point?

A ethanol

B heptane

C sodium chloride

D water

Your answer ☐ **[1]**

2 Pauling electronegativity values for the halogens F to I and some elements in period 2 of the periodic table are shown below.

B 2.04	C 2.55	N 3.04	O 3.44	F 3.98
				Cl 3.16
				Br 2.96
				I 2.66

Which bond has the correct polarity?

A	B	C	D
$^{\delta-}$N—I$^{\delta+}$	$^{\delta-}$C—F$^{\delta+}$	$^{\delta-}$B—Cl$^{\delta+}$	$^{\delta-}$Br—Cl$^{\delta+}$

Your answer ☐ **[1]**

3 Which compound releases hydroxide ions when it dissolves in water?

A CH_3COOH

B HNO_3

C H_2SO_4

D NH_3

Your answer ☐ **[1]**

4 Which alkane is 82.8% carbon by mass?

A CH_4

B C_2H_6

C C_4H_{10}

D C_8H_{18}

Your answer ☐ **[1]**

5 Which gas sample has the greatest mass at RTP?

A 50 cm^3 of Ar(g)

B 100 cm^3 of O_2(g)

C 150 cm^3 of N_2(g)

D 200 cm^3 of Ne(g)

Your answer ☐ **[1]**

6 A student mixes 250.0 cm^3 of 0.100 mol dm^{-3} KOH with 750.0 cm^3 of 0.100 mol dm^{-3} $Ca(OH)_2$. What is the OH^- concentration, in mol dm^{-3}, in the resulting mixture?

A 0.0250

B 0.100

C 0.150

D 0.175

Your answer ☐ **[1]**

7 After delivering a solution from a pipette, a droplet remains in the tip of the pipette.

How should a student ensure that the pipette delivers the volume of solution stated on the pipette?

A Fill the pipette just above the graduation line to compensate for the volume of the droplet that remains in the tip.

B Leave the droplet in the tip.

C Shake the pipette to force out the droplet left in the tip.

D Use a pipette filler to force the droplet out of the tip.

Your answer ☐ **[1]**

8 Which sequence has elements in order of increasing first ionisation energy?

A Na < Mg < A*l*

B Mg < A*l* < Si

C A*l* < Si < P

D Si < P < S

Your answer ☐ **[1]**

9 Which element has atoms with the largest number of unpaired p-electrons?

A aluminium

B oxygen

C chlorine

D phosphorus

Your answer ☐ **[1]**

10 The equation for the complete combustion of propene, C_3H_6, is shown below.

$C_3H_6(g) + 4½O_2(g) \rightarrow 3CO_2(g) + 3H_2O(l)$

Standard enthalpy changes of formation, $\Delta_f H^\ominus$, are shown in the table.

Compound	$\Delta_f H^\ominus$ / kJ mol^{-1}
$C_3H_6(g)$	+20
$O_2(g)$	0
$CO_2(g)$	–394
$H_2O(l)$	–286

What is the standard enthalpy change of combustion of $C_3H_6(g)$, in kJ mol^{-1}?

A –2060

B –700

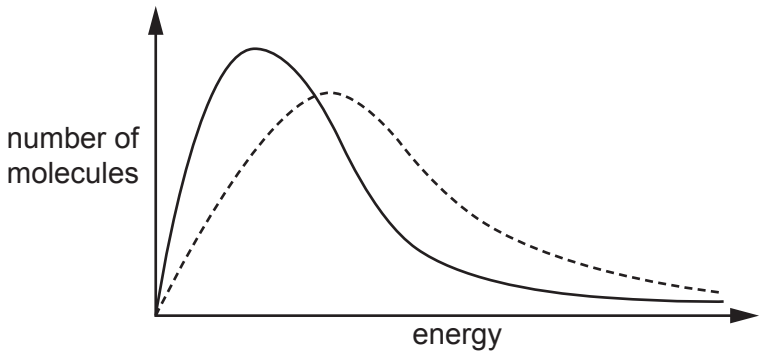
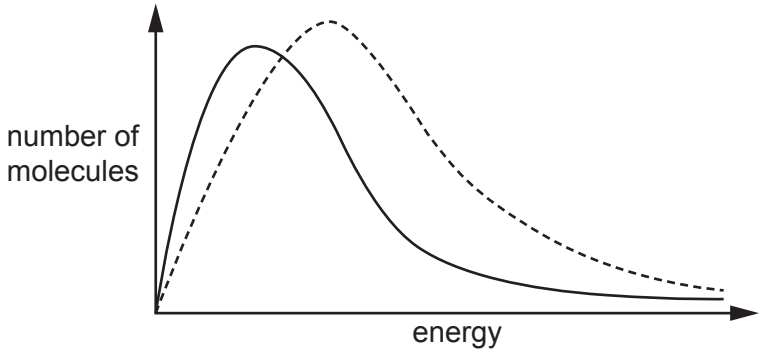
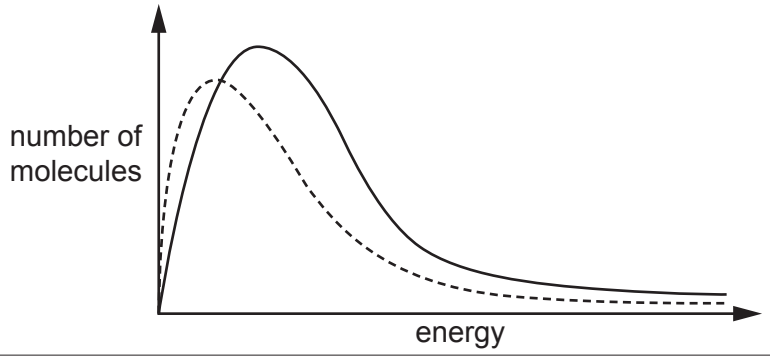
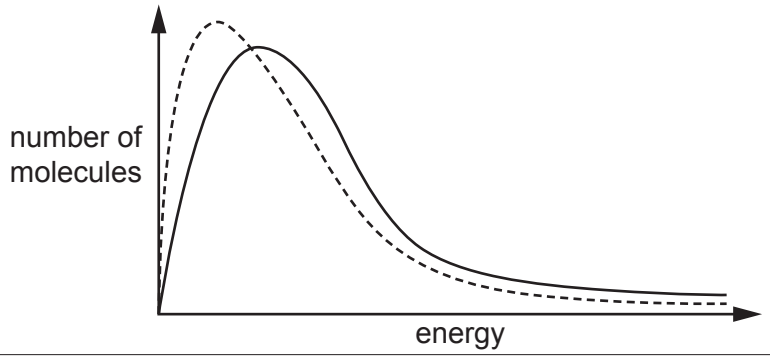
C +700

D +2060

Your answer ☐ **[1]**

11 The Boltzmann distributions below show a gas at two different temperatures.

Which Boltzmann distribution shows the dotted curve at a higher temperature?

A	
B	
C	
D	

Your answer ☐ **[1]**

12 Which statement about dynamic equilibrium is **not** correct?

A A catalyst increases the rate of both forward and reverse reactions by the same amount.

B Dynamic equilibrium exists only in a closed system.

C The concentrations of the reactants and products are equal.

D The rate of the forward reaction is equal to the rate of the reverse reaction.

Your answer ☐ **[1]**

13 What is the number of unsaturated isomers (structural and stereoisomers) that have the molecular formula C_4H_8?

A 3

B 4

C 5

D 6

Your answer ☐ **[1]**

14 What do curly arrows **always** show in reaction mechanisms?

A Movement of one electron.

B Movement of a pair of electrons.

C Movement of a lone pair of electrons.

D Movement of the electrons in a covalent bond.

Your answer ☐ **[1]**

15 Which structural isomer of C_7H_{16} has the weakest induced dipole–dipole interactions (London forces)?

A 2,3-dimethylpentane

B 3-ethylpentane

C 2-methylhexane

D 2,2,3-trimethylbutane

Your answer ☐ **[1]**

16 Which compound contains the smallest bond angle?

A bromoethane

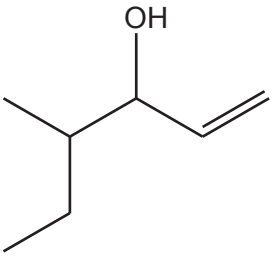
B ethanol

C ethane

D ethene

Your answer ☐ **[1]**

17 What is the systematic name of the compound below?



A 3-methylhex-5-en-4-ol

B 4-methylhex-1-en-3-ol

C 2-ethylpent-4-en-3-ol

D 4-ethylpent-1-en-3-ol

Your answer ☐ **[1]**

18 The 'dienes' are a homologous series of non-cyclic compounds with two double bonds.

The simplest diene is shown below.

What is the general formula of the dienes homologous series?

A C_nH_{2n+2}

B C_nH_{2n}

C C_nH_{2n-2}

D C_nH_{2n-4}

Your answer ☐ **[1]**

19 Which statement about absorption of radiation is correct?

A Absorption of IR radiation can break covalent bonds, forming radicals.

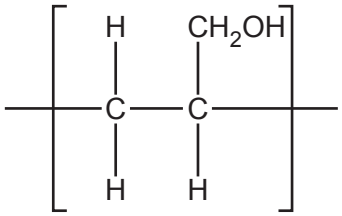
B Absorption of IR radiation causes covalent bonds to vibrate more.

C Absorption of UV radiation is a major cause of global warming and climate change.

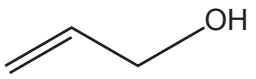
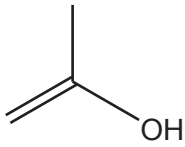
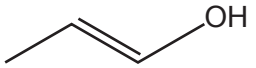
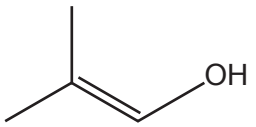
D Absorption of UV radiation is used in modern breathalysers to measure ethanol in the breath.

Your answer ☐ **[1]**

20 The repeat unit of an addition polymer is shown below.



What is the monomer?

A	
B	
C	
D	

Your answer ☐ **[1]**

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SECTION B

Answer **all** the questions.

21 This question is about atomic structure.

(a) Complete the table to show the maximum number of electrons that can occupy each shell and sub-shell. Some boxes may need to be left blank.

Shell	Total number of electrons	Sub-shell		
		s	p	d
1st				
2nd				
3rd				

[2]

(b) Selenium, Se, has the atomic number 34.

^{76}Se and ^{82}Se are two isotopes of selenium.

Complete the table to show the numbers of protons, neutrons and electrons in these two isotopes.

	Protons	Neutrons	Electrons
^{76}Se	.....	.....	.....
^{82}Se	.....	.....	.....

[1]

(c) The relative atomic mass of an element can be determined from its mass spectrum.

The table shows the results of a mass spectrum of a sample of sulfur, S.

Isotope	Abundance (%)
^{32}S	94.93
^{33}S	0.78
^{34}S	4.29

Calculate the relative atomic mass of the sample of sulfur.

Give your answer to **3** decimal places.

relative atomic mass = ... **[2]**

(d) Halothane, $C_2HBrClF_3$, (M_r = 197.4) is used as a general anaesthetic in medicine.

(i) The systematic name for halothane is 2-bromo-2-chloro-1,1,1-trifluoroethane.

Draw the structure of a halothane molecule.

[1]

(ii) What is the number of fluorine **atoms** in 7.896 g of halothane, $C_2HBrClF_3$?

number of fluorine atoms = ... **[2]**

22 This question is about enthalpy changes.

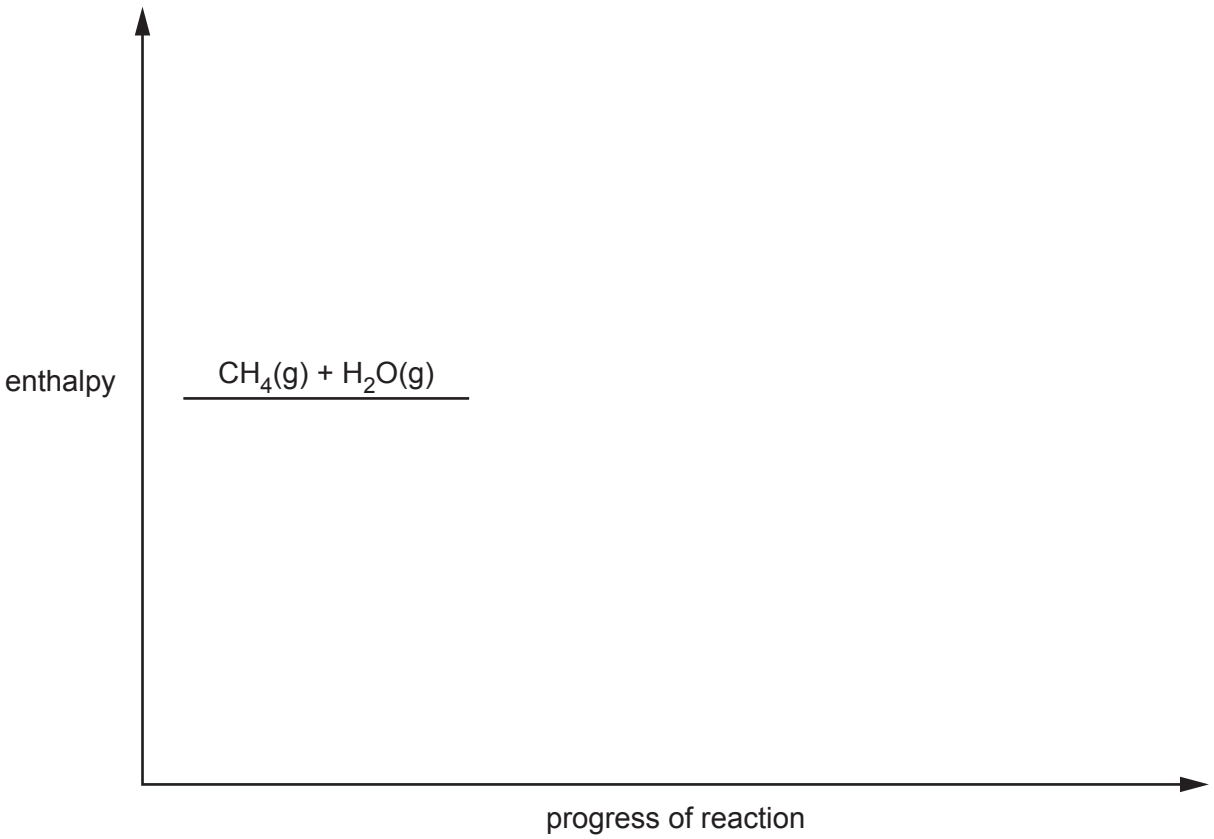
Hydrogen, H_2, can be manufactured by the reaction of methane and steam.
This is a reversible reaction, as shown in **Equilibrium 22.1** below.

Equilibrium 22.1 $CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$ $\Delta H = +206\,kJ\,mol^{-1}$

(a) The rate of this reaction increases when a catalyst is present.

Complete the enthalpy profile diagram below.

On your diagram:
- label the activation energies, $\boldsymbol{E_a}$ (without catalyst) and $\boldsymbol{E_c}$ (with catalyst)
- label the enthalpy change of reaction, $\boldsymbol{\Delta H}$.



[3]

(b) Explain how le Chatelier's principle can be used to predict the conditions of pressure and temperature for a maximum **equilibrium** yield of hydrogen in **Equilibrium 22.1**.

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

(c) The reaction for the production of hydrogen is repeated below.

$CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$ $\Delta H = +206\,kJ\,mol^{-1}$

Average bond enthalpies are shown in the table.

Bond	Average bond enthalpy / kJ mol^{-1}
C–H	413
O–H	464
C≡O	1077

Calculate the bond enthalpy of the H–H bond.

bond enthalpy = ... kJ mol^{-1} **[3]**

23 This question is about halogens.

(a) Chlorine is used to kill bacteria in drinking water.

State **one** risk in using chlorine in drinking water.

.....

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

(b) Chlorine can be prepared by reacting concentrated hydrochloric acid with manganese(IV) oxide, MnO_2.

$4HCl(aq) + MnO_2(s) \rightarrow Cl_2(g) + MnCl_2(aq) + 2H_2O(l)$

Using oxidation numbers, show which element has been oxidised and which has been reduced in this reaction. State the changes in oxidation numbers, including all signs.

Element oxidised .....

Oxidation number change: from ..... to .....

Element reduced .....

Oxidation number change: from ..... to .....

[2]

(c) A mixture of potassium perchlorate, $KClO_4$, and aluminium is used in fireworks.

When the firework ignites, $KClO_4$ reacts with aluminium to form potassium chloride, KCl, and aluminium oxide, Al_2O_3.

Write the balanced equation for this reaction.

State symbols are **not** required.

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

(d) A student investigates the trend in reactivity of the halogens Cl_2, Br_2 and I_2.

The student is supplied with:
- solutions of Cl_2, Br_2 and I_2 in cyclohexane (an organic solvent)
- aqueous solutions of the halides: NaCl, NaBr and NaI.

The colours of the halogen solutions in cyclohexane are shown below.

Halogen	Cl_2	Br_2	I_2
Colour in cyclohexane	Pale green	Orange	Violet

Plan an experiment on a test tube scale that would show the trend in the reactivity of the halogens Cl_2, Br_2 and I_2.

Include **all** the expected observations and an ionic equation for **one** of the reactions.

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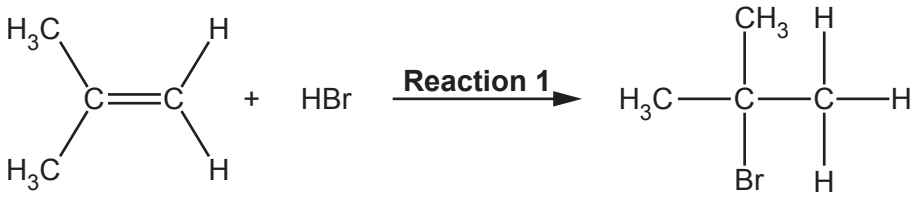
..... **[5]**

24 A student reacts methylpropene with hydrogen bromide, HBr, as shown in **Reaction 1**.



Methylpropene **Compound A**

(a) Outline the reaction mechanism for **Reaction 1**.

The structures of methylpropene and compound **A** have been provided.

Include curly arrows and relevant dipoles.

name of mechanism ..... **[4]**

(b) When reacting methylpropene with HBr, a small amount of compound **B** also forms.

Compound **B** is a structural isomer of compound **A**.

(i) Explain the term **structural isomer**.

.....

.....

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

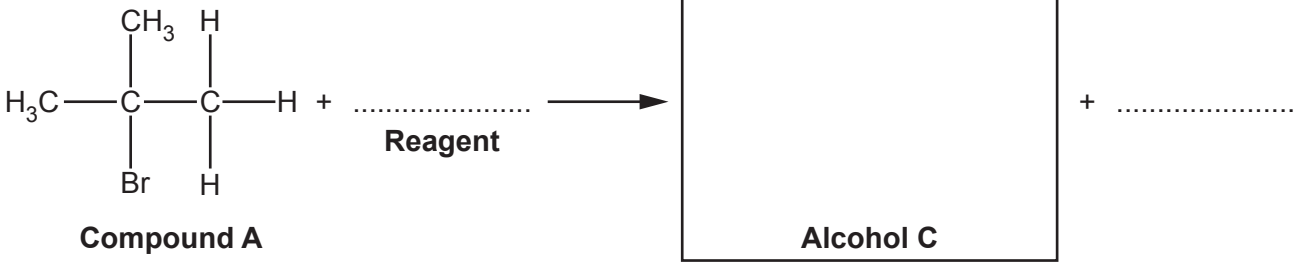
(ii) Show the structure for compound **B**.

[1]

(c) Compound **A** can be refluxed with a reagent to make alcohol **C**.

(i) Choose a reagent for this reaction and complete the equation for this reaction.

Your equation should show the structure of alcohol **C**.



[2]

(ii) Draw a labelled diagram to show how you would set up apparatus for reflux.

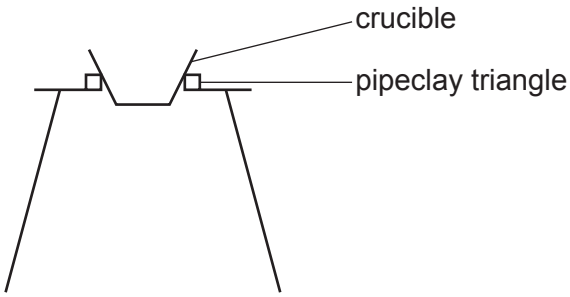
[2]

25 This question is about the analysis of unknown compounds.

(a) Scandium (atomic number 21) reacts with oxygen to form an oxide of scandium.

A student carries out an experiment to determine the empirical formula of the scandium oxide.

A diagram of the apparatus used by the student is shown below.



The student's method is outlined below.

- Weigh an empty crucible.
- Add scandium to the crucible and reweigh.
- Heat the crucible and contents for 10 minutes.
- Allow to cool and reweigh.

The student's results are shown below.

Mass of crucible / g	12.165
Mass of crucible + scandium / g	12.435
Mass of crucible + scandium oxide / g	12.579

(i) Determine the empirical formula of the scandium oxide.

empirical formula = ... **[2]**

(ii) The student was unsure that all of the scandium had reacted.

Suggest **one** modification that the student could make to their method to be confident that all the scandium had reacted. Explain your reasoning.

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

(b) A gas cylinder has a gas volume of 9.39 dm^3.
The gas cylinder holds 1.69 kg of a gas at a pressure of 1.37×10^7 Pa at 20 °C.

Determine the molar mass and possible identity of the gas.

molar mass = ... $g\,mol^{-1}$

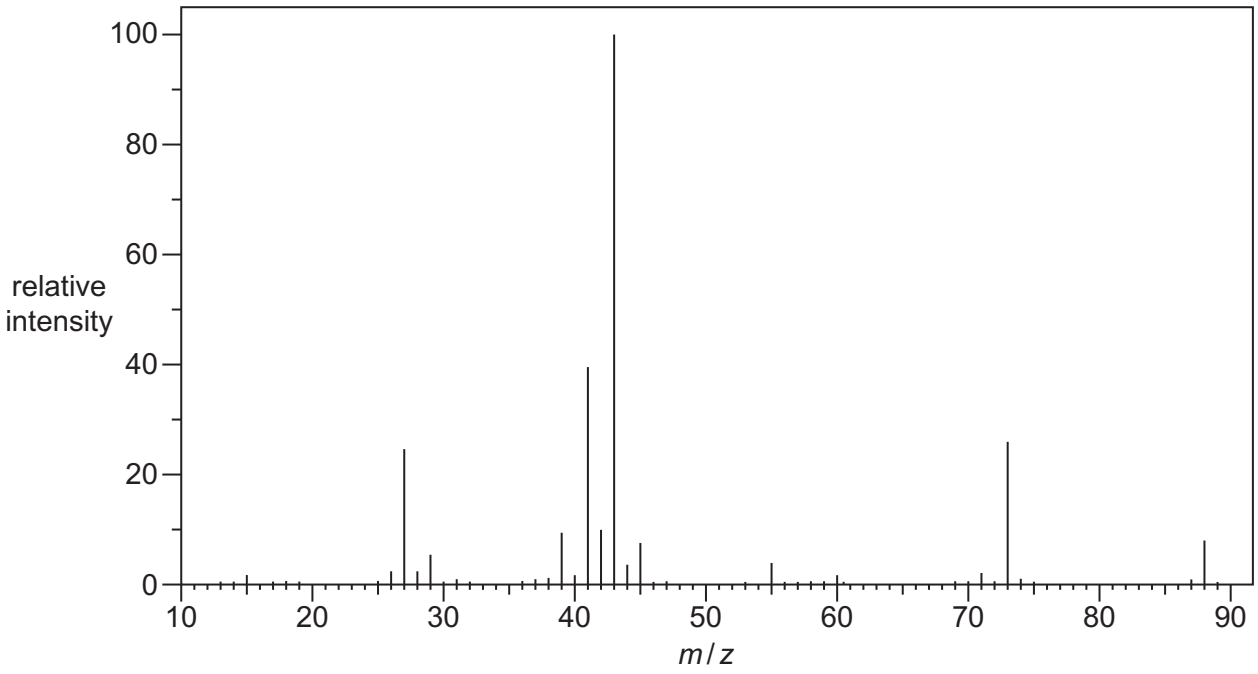
identity of gas = ...

[5]

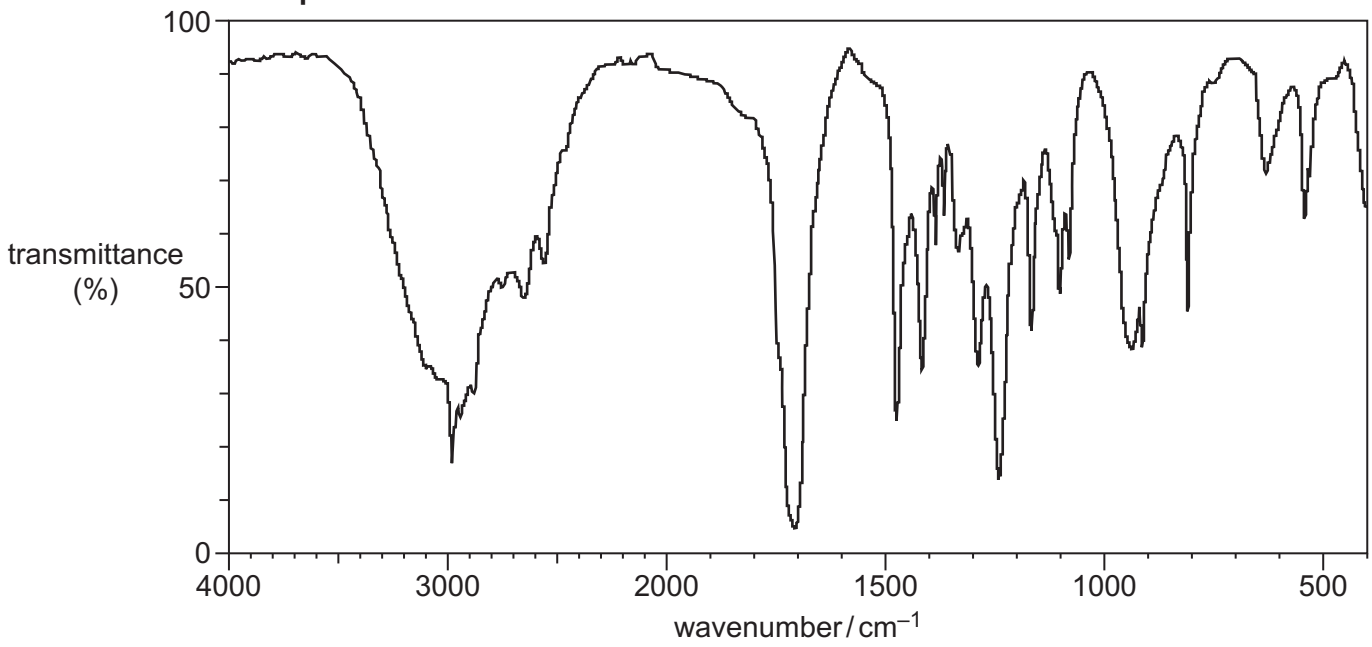
26 An organic compound **E** contains C, H and O only.

The mass and infrared spectra of organic compound **E** are shown below.

Mass spectrum



Infrared spectrum



Analyse this information to suggest **two** different possible structures for compound **E**.

Explain your reasoning.

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Structures	

[5]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).