OCR
Oxford Cambridge and RSA

# Friday 9 June 2017 – Afternoon

## AS GCE CHEMISTRY A

**F322/01** Chains, Energy and Resources

Candidates answer on the Question Paper.

**OCR supplied materials:**
- *Data Sheet for Chemistry A* (inserted)

**Other materials required:**
- Scientific calculator

**Duration:** 1 hour 45 minutes

* F 3 2 2 0 1 *

* 6 7 6 5 0 1 7 0 6 *

| Candidate forename | | Candidate surname | |
|---|---|---|---|

| Centre number | | | | | | Candidate number | | | | |
|---|---|---|---|---|---|---|---|---|---|---|

**INSTRUCTIONS TO CANDIDATES**

- The insert will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

**INFORMATION FOR CANDIDATES**

- The number of marks is given in brackets **[ ]** at the end of each question or part question.

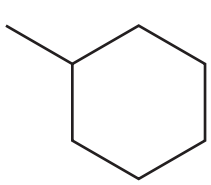
Where you see this icon you will be awarded marks for the quality of written communication in your answer.

This means for example you should:
- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
- organise information clearly and coherently, using specialist vocabulary when appropriate.

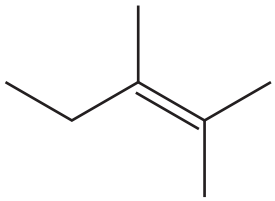
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **100**.
- This document consists of **20** pages. Any blank pages are indicated.

Answer **all** the questions.

**1** This question is about the following hydrocarbons.

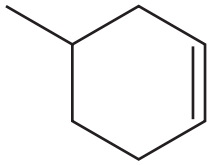


**A**

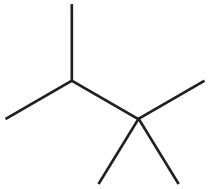


**B**

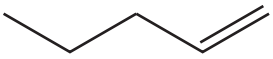
**C**



**D**



**E**



**F**

**(a)** What is the molecular formula of compound **F**?

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

**(b)** Which compounds are saturated hydrocarbons?

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

**(c)** Which compound is an *E* isomer?

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

**(d)** Which compounds are members of the same homologous series?

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

**(e)** Which compounds have the same general formula?

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

**(f)** Which compounds could have been formed from the cracking of a nonane molecule?

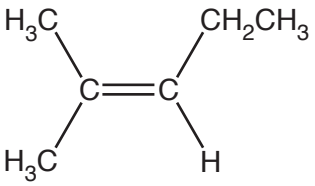
..... **[1]**

**(g)** What is the name of compound **B**?

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

**[Total: 7]**

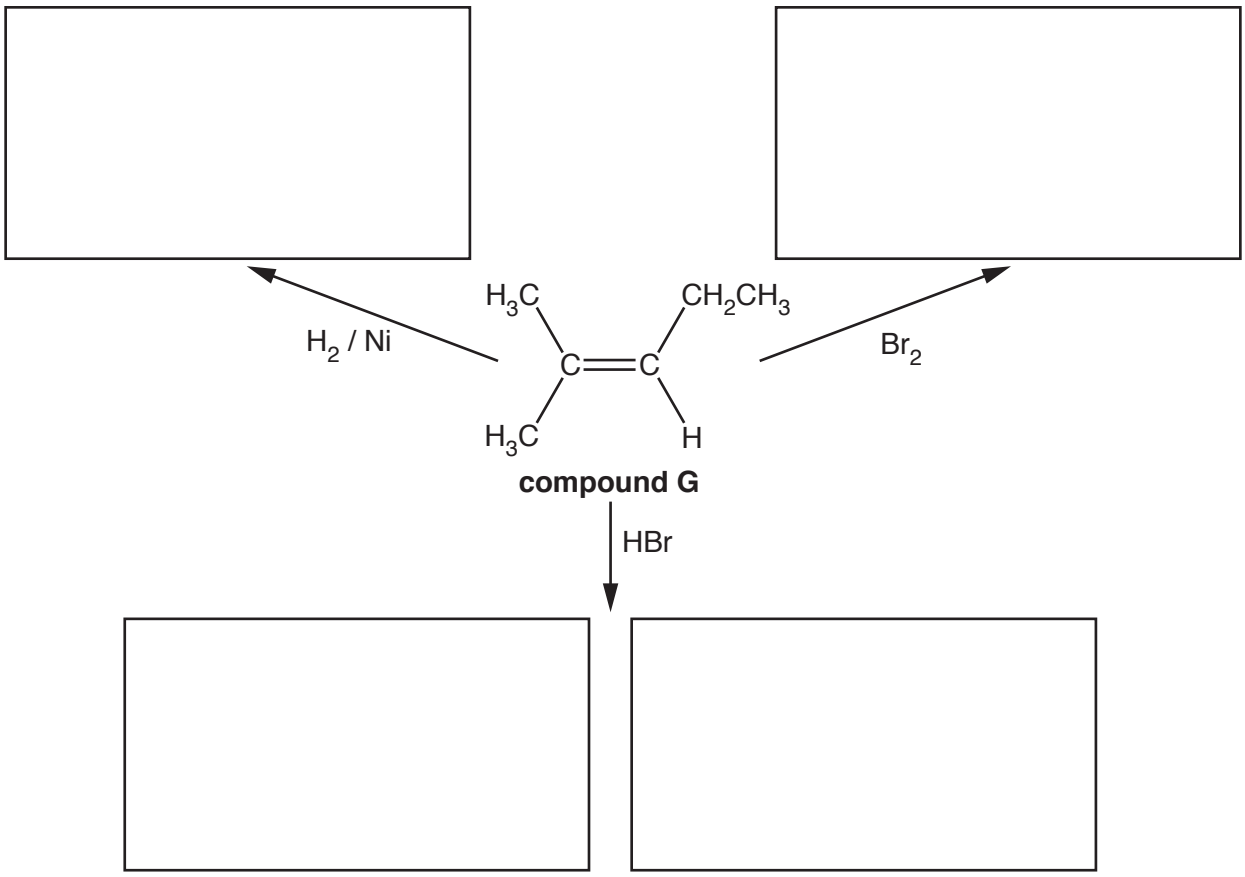
**2** Compound **G** is an alkene that can be used as the starting material for making organic compounds.




**compound G**

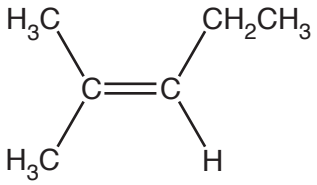
**(a)** The flowchart shows three reactions of compound **G**.

Complete the flowchart to show the organic products formed by the reactions.




**[4]**

**(b)** Compound **G** can be polymerised.




**compound G**

**(i)** Name the type of polymerisation.

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

**(ii)** Write a balanced equation for the polymerisation of **G**.

The equation should include the structure of the repeat unit of the polymer.

**[2]**

**(iii)** After their useful life, waste polymers can be processed rather than being dumped in landfill sites.

One method of processing is recycling.

State **two** other methods that are used to process waste polymers.

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2 .....

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**[2]**

**[Total: 9]**

**3** This question is about 1-bromohexane, $CH_3(CH_2)_5Br$.

**(a)** A student hydrolyses 1-bromohexane with aqueous sodium hydroxide, NaOH(aq).

**(i)** Outline the mechanism of this reaction.

Include curly arrows, relevant dipoles and final product(s).

**[3]**

**(ii)** Name the type of mechanism.

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

**(iii)** Name the type of bond fission that occurs.

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

**(iv)** The student repeats the hydrolysis using 1-chlorohexane and 1-iodohexane instead of 1-bromohexane.

State and explain the different rates of hydrolysis of the three halogenoalkanes.

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

**(b)** A student plans to prepare 1-bromohexane, $CH_3(CH_2)_5Br$ by reacting hexane with bromine. The equation and two relative molecular masses are shown below.

$$CH_3(CH_2)_4CH_3 + Br_2 \rightarrow CH_3(CH_2)_5Br + HBr$$

$M_r$ ($CH_3(CH_2)_4CH_3$) = 86.0 $M_r$ ($CH_3(CH_2)_5Br$) = 164.9

**(i)** Calculate the atom economy of this reaction.

Give your answer to **one** decimal place.

atom economy = ……..% **[1]**

**(ii)** Outline the mechanism of this reaction.

In your mechanism, hexane and 1-bromohexane can be shown as their molecular formulae, $C_6H_{14}$ and $C_6H_{13}Br$.

Include in your answer:
- the names of the three stages in this mechanism
- the essential conditions
- all termination steps
- the type of bond fission.

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

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..... **[6]**

**(iii)** When the student carries out this preparation, the student reacts 12.90 g of hexane but only 2.31 g of 1-bromohexane are obtained.

Calculate the percentage yield of 1-bromohexane from this preparation.

Give your answer to **three** significant figures.

percentage yield of 1-bromohexane = ..... % **[3]**

**(iv)** From this preparation of 1-bromohexane, the two organic impurities, **H** and **I**, are formed.

- Compound **H** has the percentage composition by mass:
  C, 43.66%; H, 7.88%; Br, 48.46%.
- Compound **I** has a relative molecular mass of 243.8.

Suggest possible structures for **H** and **I** and explain how they could have formed.

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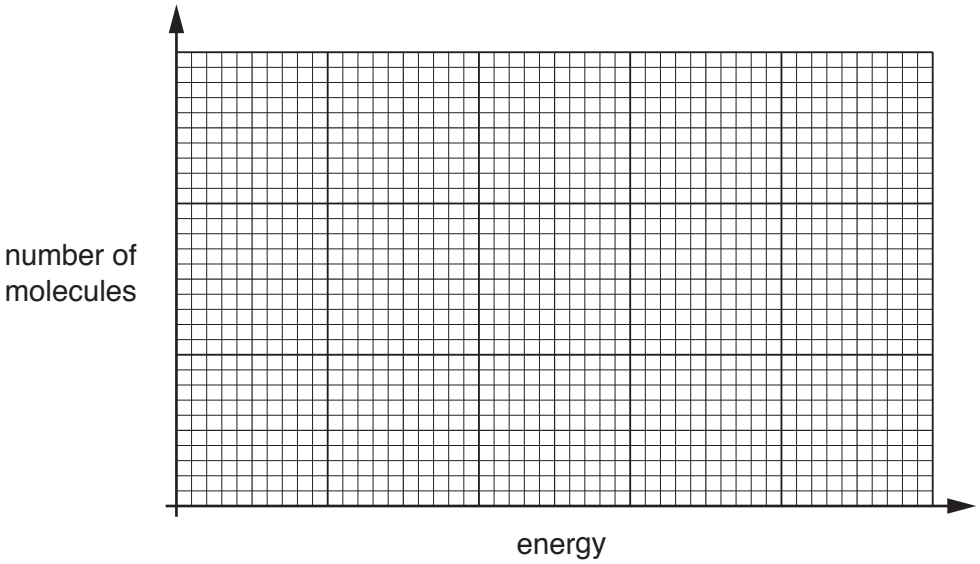
..... **[6]**

**[Total: 23]**

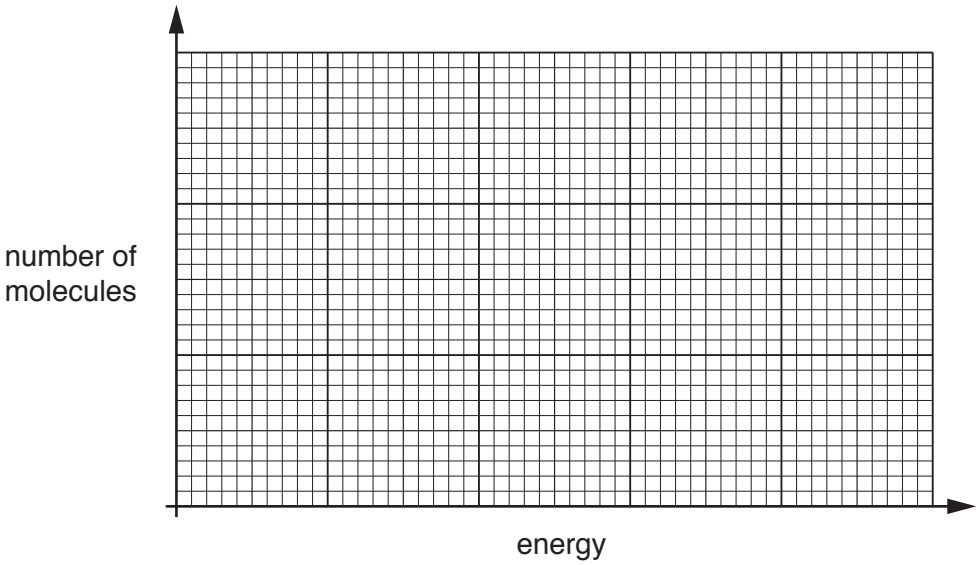
**4** Boltzmann distributions can be used to explain how the rate of a chemical reaction is affected by increasing the temperature or by adding a suitable catalyst.

Explain these changes in reaction rate.
Draw suitable Boltzmann distributions on the axes below to help your explanation.

**Increasing temperature**




**Presence of a catalyst**

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**[Total: 6]**

**5** Ammonia, $NH_3$, is manufactured by the chemical industry in the Haber process.

Nitrogen and hydrogen gases are reacted together in the presence of an iron catalyst.
The equation for this reversible reaction is shown below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ\,mol^{-1}$$

**(a)** Suggest sources for the $N_2$ and $H_2$ used by the chemical industry.

$N_2$: .....

$H_2$: .....
**[1]**

**(b)** Predict the conditions of pressure and temperature that would give the maximum equilibrium yield of $NH_3$.

Explain your reasoning.

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

**(c)** Explain why the actual temperature and pressure used by the chemical industry may be different from those required for a maximum equilibrium yield.

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

**(d)** State **two** ways that the use of an iron catalyst helps the chemical industry to manufacture ammonia more sustainably and with less harm to the environment.

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

**(e)** The combustion of ammonia produces nitrogen gas and steam, as shown below.

$$4NH_3(g) + 3O_2(g) \longrightarrow 2N_2(g) + 6H_2O(g)$$

The enthalpy change of this reaction can be calculated using the average bond enthalpies below.

| Bond | Average bond enthalpy /kJ mol$^{-1}$ |
|---|---|
| N–H | +391 |
| O–H | +464 |
| O=O | +498 |
| N≡N | +945 |

**(i)** What is meant by the term *average bond enthalpy*?

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

**(ii)** Calculate the enthalpy change of this reaction, $\Delta H_r$.

$$4NH_3(g) + 3O_2(g) \longrightarrow 2N_2(g) + 6H_2O(g)$$

$\Delta H_r$ = ..... kJ mol$^{-1}$ **[3]**

**(iii)** The standard enthalpy change of combustion, $\Delta H_c^{\ominus}$, for ammonia is different from the value calculated in **(ii)**.

You are provided with the enthalpy change below.

$$H_2O(l) \longrightarrow H_2O(g) \qquad \Delta H = +44\,kJ\,mol^{-1}$$

Calculate $\Delta H_c^{\ominus}$ for $NH_3(g)$ using this enthalpy change and your answer to **(ii)**.

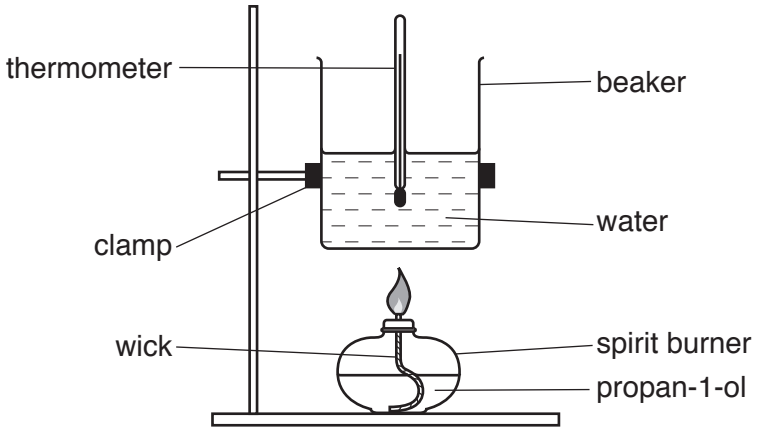
$\Delta H_c^{\ominus}$ = ..... $kJ\,mol^{-1}$ **[2]**

**[Total: 15]**

**6** This question is about some enthalpy changes involving alcohols.

A student carries out an experiment to determine the enthalpy change of combustion of propan-1-ol, $CH_3CH_2CH_2OH$.

The student uses the apparatus below.




The student's measurements and relevant constants are shown below.

**Measurements**

Mass of burner and propan-1-ol before burning = 102.728 g
Mass of burner and propan-1-ol after burning = 100.916 g

Initial temperature = 18.5 °C
Maximum temperature reached = 80.5 °C

Volume of water = 125 $cm^3$

**Constants**

The specific heat capacity of water = 4.18 $J g^{-1} K^{-1}$
Density of water = 1.00 $g cm^{-3}$

**(a)** Calculate the enthalpy change of combustion of propan-1-ol, in $kJ mol^{-1}$.

Give your answer to **three** significant figures.

$\Delta H_c$ = ..... $kJ mol^{-1}$ **[4]**

**(b)** Enthalpy changes of combustion can be determined indirectly from standard enthalpy changes of formation, $\Delta H_f^{\ominus}$.

**(i)** Define the term *standard enthalpy change of formation*, $\Delta H_f^{\ominus}$.
Include the standard conditions.

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

**(ii)** Write an equation, including state symbols, for the chemical change that represents the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, of hexan-1-ol, $CH_3(CH_2)_5OH(l)$.

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

**(iii)** The standard enthalpy change of combustion of hexan-1-ol, $\Delta H_c^{\ominus}$, can be calculated using the information in the table.

| **Substance** | $CO_2(g)$ | $H_2O(l)$ | $CH_3(CH_2)_5OH(l)$ |
|---|---|---|---|
| $\Delta H_f^{\ominus}$ **/ kJ mol$^{-1}$** | –394 | –286 | –378 |

Calculate $\Delta H_c^{\ominus}$ for hexan-1-ol, in kJ mol$^{-1}$.

The equation for the complete combustion of hexan-1-ol is shown below.

$$CH_3(CH_2)_5OH(l) + 9O_2(g) \rightarrow 6CO_2(g) + 7H_2O(l)$$

$\Delta H_c^{\ominus}$ = ..... kJ mol$^{-1}$ **[3]**

**[Total: 11]**

**7** This question is about different alcohols.

**(a)** Ethanol is the most widely used alcohol.

Two main methods are used for the industrial production of ethanol.

For each method, state the reagents and essential conditions, and write an equation.

method 1: .....

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method 2: .....

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**[4]**

**(b)** 3-Methylbutan-2-ol, $(CH_3)_2CHCH(OH)CH_3$ can be converted into two alkenes that are structural isomers of one another. This is an elimination reaction.

**(i)** State a suitable catalyst for this reaction.

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

**(ii)** Which molecule is eliminated in this reaction?

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

**(iii)** Draw skeletal formulae for the two alkenes formed.

**[2]**

**(iv)** Explain how you could monitor the progress of this reaction using infrared spectroscopy so that you would know when all of the 3-methylbutan-2-ol had reacted.

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

**(c)** Alcohols can be converted into organic compounds containing different functional groups.

Describe reactions that would convert:
- pentan-1-ol into a carboxylic acid
- pentan-1-ol into an ester.

Include reagents, conditions and equations for the reactions.
Show structures of the organic products, with functional groups fully displayed.

*Your answer needs to be clear and well organised using the correct terminology, and linking the reactions to the functional groups.*

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**[Total: 16]**

**8** Scientists are concerned about the environmental effects resulting from the presence of some gases in the atmosphere.

**(a)** The presence of chlorine radicals and nitrogen oxide radicals in the upper atmosphere can lead to depletion of the ozone layer.

**(i)** What is meant by the term *radical*?

.....

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

**(ii)** Draw a '*dot-and-cross*' diagram to show that nitrogen monoxide is a radical.
Show outer electron shells only.

**[1]**

**(iii)** Explain how chlorine radicals and nitrogen oxide radicals have come to be present in the upper atmosphere.

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

**(iv)** Write equations to show how chlorine radicals reduce the amount of ozone in the upper atmosphere.

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

**(b)** The presence of nitrogen oxides next to the Earth's surface also leads to environmental concerns.

State **one** of these environmental concerns.

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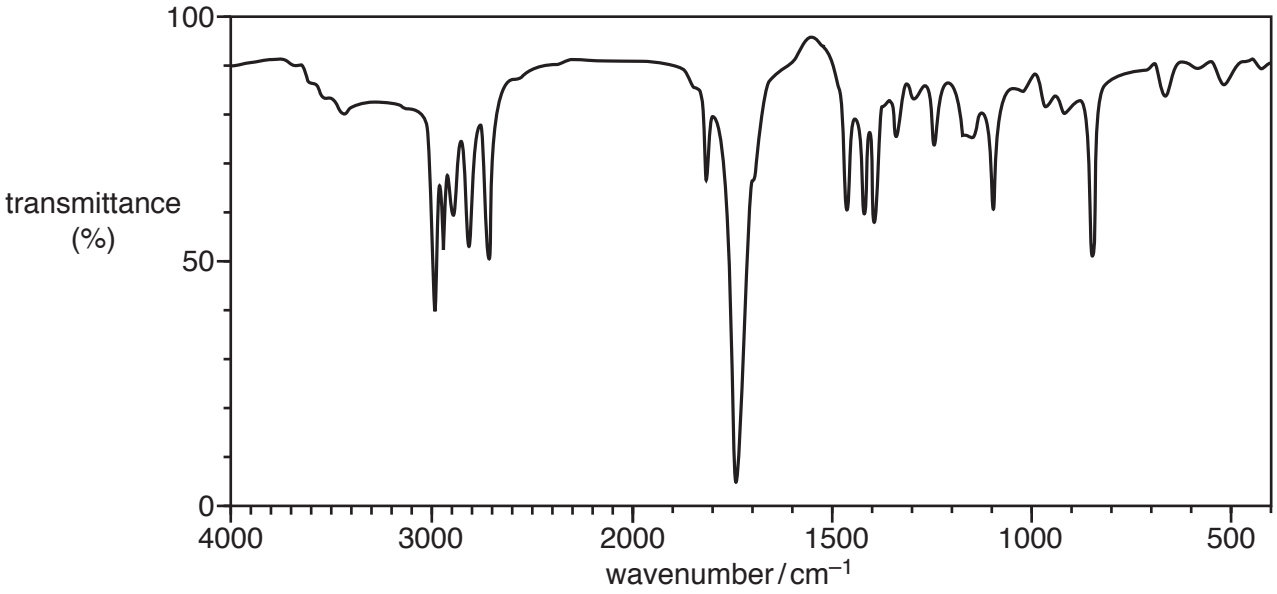
..... **[1]**

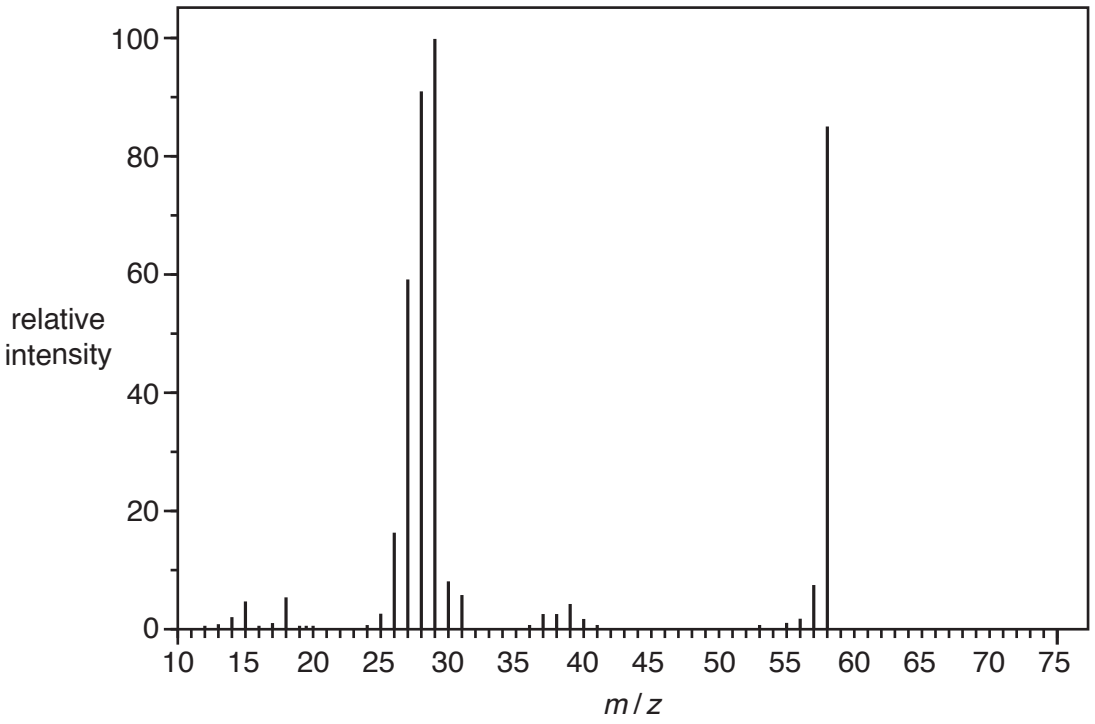
**(c)** Air pollutants can be monitored and identified using infrared spectroscopy and mass spectrometry.

An atmospheric pollutant has the formula $C_xH_yO$.
The pollutant produces the IR spectrum and mass spectrum shown below.

**IR spectrum**




**Mass spectrum**



**(i)** Analyse the spectra and suggest the molecular formula and possible structural formula of the pollutant.

Explain your reasoning using the peaks from the spectra.

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

**(ii)** Explain how the mass spectrum can be used to confirm the identity of the pollutant.

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

**[Total: 13]**

**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).