

1 Compound **G** was extracted from the leaves of a plant. A sample of **G** was analysed by a research chemist. A summary of the chemist's results is shown in the table.

type of analysis	evidence
infrared spectroscopy	absorptions at 1080, 1720 and a very broad absorption at $2900\text{ cm}^{-1}$
percentage composition by mass	C, 26.7%; H, 2.22%; O, 71.1%
volumetric analysis	0.00105 mol of <b>G</b> has a mass of 0.0945 g

Use this information to suggest a possible structure for compound **G**.



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

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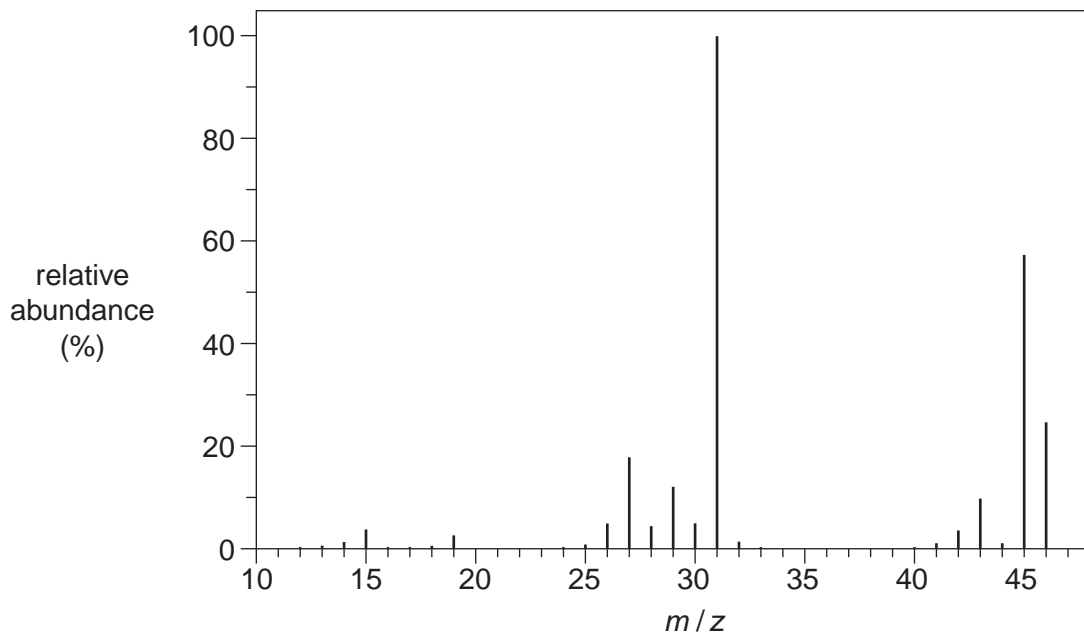
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**[Total: 8]**

2 Mass spectrometry is used in analysis.

(a) Compound **O** contains carbon, hydrogen and oxygen.

The mass spectrum of compound **O** is shown below.



(i) Identify the  $m/z$  value that corresponds to the molecular ion.

..... [1]

(ii) Write the formula of the ion that gives rise to the peak at  $m/z = 31$ .

..... [1]

(iii) Suggest the molecular formula for **O**.

..... [1]

metal the sample contains.

The mass spectrum of the sample shows  $m/z$  peaks as shown in the table.

$m/z$ value	percentage abundance (%)
63	72.2
65	27.8

Positive ions,  $X^+$ , of the metal were responsible for the two  $m/z$  peaks.

Identify the metal **X** by calculating its relative atomic mass to **one decimal place**.

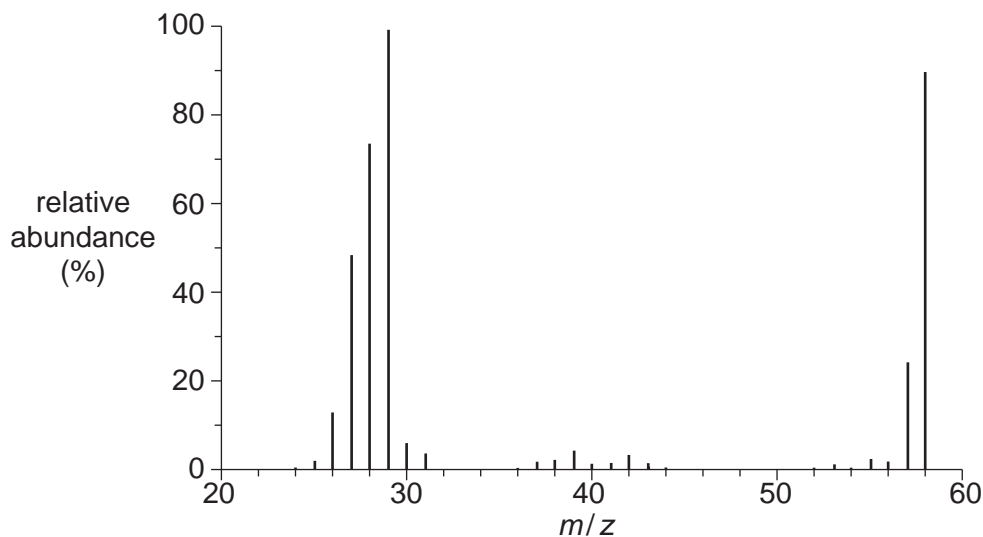
relative atomic mass of **X** = .....

metal **X** = ..... [3]

[Total: 6]

3 Mass spectrometry and infrared spectroscopy are used in analysis.

(a) The mass spectrum of compound **Z** is shown below.



Compound **Z** has the molecular formula  $C_3H_6O_x$ .

(i) Using the mass spectrum, deduce the value of  $x$  in  $C_3H_6O_x$ .

Explain your answer.

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..... [2]

(ii) Suggest a possible structure for **Z**.

[1]

(iii) Suggest the formula of an ion that gives rise to the peak at  $m/z = 29$  in this spectrum.

..... [1]

(b) A space probe has detected the presence of the element iron on the surface of the planet Mars.

Outline how a mass spectrum would show the presence of iron.

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..... [1]

(c) The space probe also detected different isotopes of sulfur on Mars.

(i) Outline how the mass spectrum would show how many different isotopes of sulfur were present on Mars.

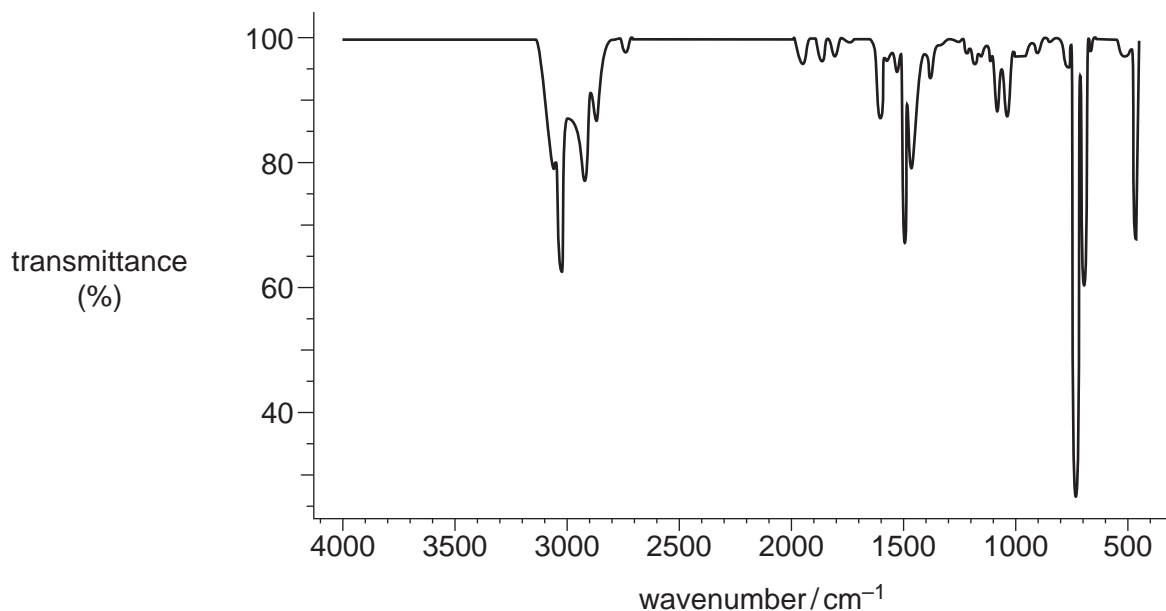
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(ii) The relative atomic mass of the sulfur found by the space probe was different from the relative atomic mass of sulfur on Earth.

Suggest why.

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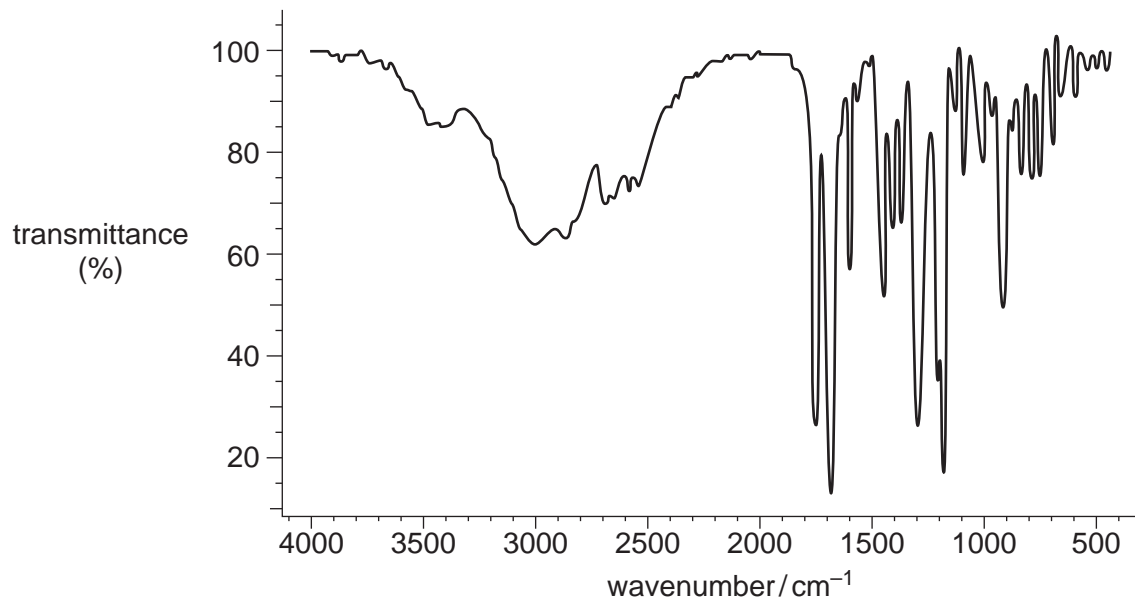
(d) An environmental chemist used infrared spectroscopy to monitor air pollution outside a petrol station. The infrared spectrum below was obtained from one of these pollutants.



What evidence is there in the spectrum that the pollutant may be a hydrocarbon rather than an alcohol or a carbonyl compound?

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..... [1]

(e) The infrared spectrum of a drug is shown below.



Suggest, with reasons, possible functional group(s) present in the drug.

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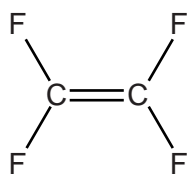
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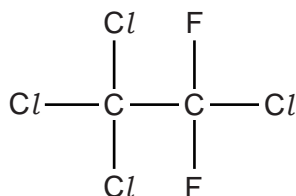
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[Total: 10]

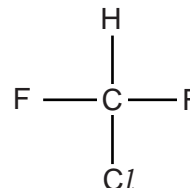
4 This question is about the compounds shown below.



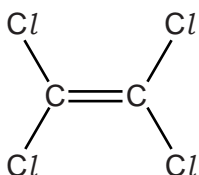
**B**



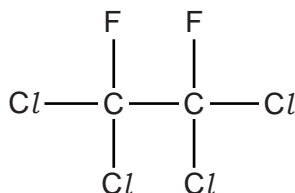
**C**



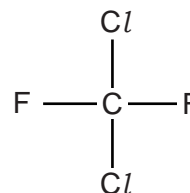
**D**



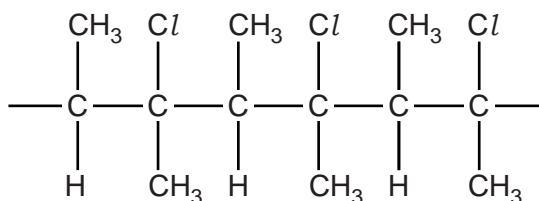
**E**



**F**



**G**



**H**

(a) Which compound, **B** to **H**, could be used to make the polymer PTFE?

..... [1]

(b) Polymer **H** can be disposed of by combustion. One environmental problem is the production of toxic gases, such as CO.

(i) Draw the structure of the monomer needed to produce polymer **H**.

[1]

(ii) Give the formula of an acidic toxic gas that could form during combustion of polymer **H**.

..... [1]



(c) Compound **G** was once used as a propellant in aerosols. Compound **G** has been linked with depletion of the ozone layer in the stratosphere.

(i) State **two** properties that made compound **G** suitable for use as an aerosol.

- 1 .....
- 2 .....

[1]

(ii) Explain the following statements, using equations where appropriate.

- Life on Earth benefits from the presence of an ozone layer.
- The concentration of ozone is maintained in the ozone layer.
- Compound **G** produces radicals which catalyse the breakdown of ozone.

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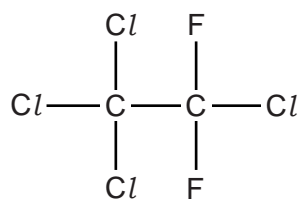
(iii) Alternative ‘ozone-friendly’ compounds are now used as propellants instead of compound **G**.

Which compound, **B** to **H**, might be suitable as an ‘ozone-friendly’ propellant?

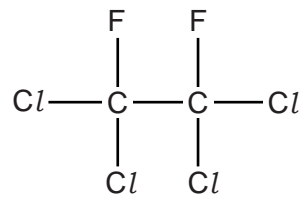
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[1]

(d) Compounds **C** and **F** can be analysed to obtain infrared and mass spectra.



**C**



**F**

(i) What happens to molecules when infrared radiation is absorbed?

..... [1]

(ii) Suggest the molecular formulae of **two** ions responsible for peaks in the mass spectrum of **C** that are **not** in the mass spectrum of **F**.

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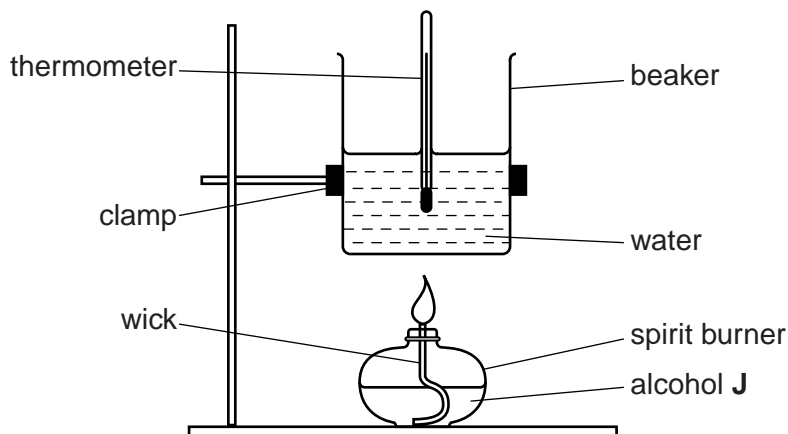
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[Total: 13]

5 A branched-chain alcohol **J** is a liquid and has the molecular formula  $C_5H_{12}O$ .

(a) A student does an experiment to measure the enthalpy change of combustion,  $\Delta H_c$ , of alcohol **J**.

(i) The student burns alcohol **J** using the apparatus below.



The student found that combustion of 1.54 g of alcohol **J** changes the temperature of 180 g of water from 22.8 °C to 75.3 °C.

The specific heat capacity of water is  $4.18 \text{ J g}^{-1} \text{ K}^{-1}$ .

- Calculate the amount, in mol, of alcohol **J** that burns.
- Calculate the enthalpy change of combustion,  $\Delta H_c$ , of alcohol **J**, in  $\text{kJ mol}^{-1}$ .

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

$\Delta H_c = \dots\dots\dots \text{kJ mol}^{-1}$  [4]

- (ii) The calculated value of  $\Delta H_c$  from this experiment is different from the value obtained from data books.

Apart from heat loss, suggest **two** reasons for the difference.

Assume that the calculation has been carried out correctly.

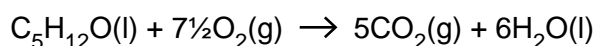
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- (b) The enthalpy change of combustion for alcohol **J** can also be determined indirectly from standard enthalpy changes of formation.

- (i) Write an equation, including state symbols, for the chemical change that represents the standard enthalpy change of formation of the liquid alcohol **J**,  $C_5H_{12}O$ .

..... [1]

- (ii) The equation for the complete combustion of alcohol **J** is shown below.



Enthalpy changes of formation,  $\Delta H_f$ , are shown in the table.

Substance	$C_5H_{12}O(l)$	$CO_2(g)$	$H_2O(l)$
$\Delta H_f / kJ mol^{-1}$	-366	-394	-286

Calculate the enthalpy change of combustion,  $\Delta H_c$ , of alcohol **J** from the information given above.

$$\Delta H_c = \dots\dots\dots kJ mol^{-1} \quad [3]$$



**(d)** The alcohol **J** is soluble in water.

Explain why alcohol **J** is soluble in water.

Use a labelled diagram to support your answer.

Include relevant dipoles and lone pairs.

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..... [1]

**[Total: 17]**

6 A student carries out an investigation on some halogenoalkanes.

(a) She decided to hydrolyse 1-bromopentane and 1-chloropentane using aqueous sodium hydroxide.

State and explain the difference in the rates of hydrolysis of 1-bromopentane and 1-chloropentane.

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(b) A student wants to determine the structure of an unknown iodoalkane **B**.

She knows that the molecular formula of **B** is  $C_4H_9I$ .

The student heats **B** with aqueous sodium hydroxide. A reaction mixture forms containing the organic compound **C** and  $I^-(aq)$ .

(i) Draw all of the possible structural isomers for **B**.

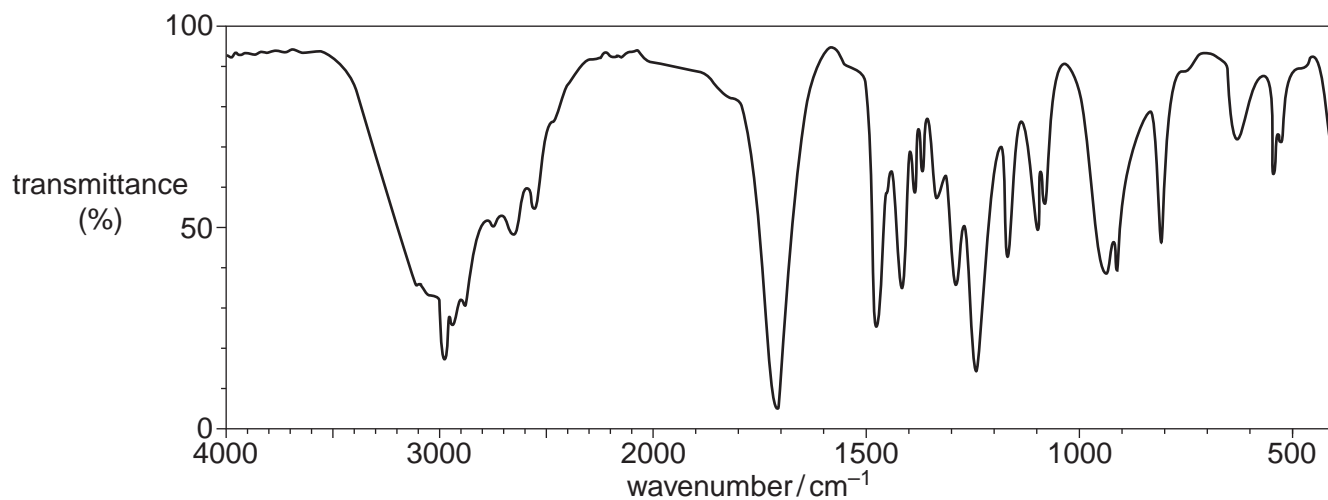
[4]

(ii) What is the molecular formula for compound **C**?

..... [1]

(iii) The student purifies compound **C** and splits it into two portions.

- She heats one portion of **C** with concentrated sulfuric acid. The product of this reaction is methylpropene.
- To the other portion of **C**, she adds acidified potassium dichromate(VI) and heats the mixture under reflux. The product of this reaction is compound **D**.
- The infrared spectrum for compound **D** is shown at the top of page 19.



Use this evidence to suggest structures for **B**, **C** and **D**.



*In your answer you should make clear how your explanations are linked to the evidence.*

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