OCR
Oxford Cambridge and RSA

AS Level Chemistry A

H032/01 Breadth in chemistry

Tuesday 22 May 2018 – Morning

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry A (sent with general stationery)

You may use:
- a scientific or graphical calculator

First name										
Last name										
Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- 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
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **24** pages.

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 The electron configuration of element **X** is: $1s^2 2s^2 2p^6 3s^2 3p^4$

What is the formula of a compound formed when sodium reacts with element **X**?

A Na**X**

B Na$\mathbf{X}_2$

C $\mathrm{Na}_2\mathbf{X}$

D $\mathrm{Na}_2\mathbf{X}_3$

Your answer ☐ **[1]**

2 What is the number of oxygen atoms in 88.0 g of CO_2?

A 3.01×10^{23}

B 1.20×10^{24}

C 2.41×10^{24}

D 4.82×10^{24}

Your answer ☐ **[1]**

3 A compound has the composition by mass:

H, 5.00%; N, 35.00%; O, 60.00%.

Which compound has this composition?

A HNO_3

B NH_4NO_3

C HNO_2

D NH_2OH

Your answer ☐ **[1]**

4 Sodium reacts with water as shown below.

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

Which mass of sodium reacts with water to produce 960 cm^3 of hydrogen gas at RTP?

A 0.46 g

B 0.92 g

C 1.84 g

D 3.68 g

Your answer ☐ **[1]**

5 Which equation does **not** represent a neutralisation reaction?

A $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

B $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

C $Na_2CO_3 + 2CH_3COOH \rightarrow 2CH_3COONa + CO_2 + H_2O$

D $CuO + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$

Your answer ☐ **[1]**

6 What is the oxidation number of Fe in K_2FeO_4?

A +4

B +5

C +6

D +7

Your answer ☐ **[1]**

7 Which reaction shows oxidation of sulfur?

A $2HBr + H_2SO_4 \rightarrow SO_2 + 2H_2O + Br_2$

B $SO_2 + 2NaOH \rightarrow Na_2SO_3 + H_2O$

C $8HI + H_2SO_4 \rightarrow 4I_2 + H_2S + 4H_2O$

D $H_2S + Cl_2 \rightarrow 2HCl + S$

Your answer ☐ **[1]**

8 What determines the order of elements in the Periodic Table?

A first ionisation energy

B number of electrons in the outer shell

C number of protons in the nucleus

D relative atomic mass

Your answer ☐ **[1]**

9 The first five successive ionisation energies of an element **Y** are shown below.

1st	2nd	3rd	4th	5th
496	4563	6913	9544	13352

What is the formula of a chloride of **Y**?

A **Y**Cl

B **Y**Cl_2

C **Y**Cl_3

D **Y**Cl_4

Your answer ☐ **[1]**

10 Which element has induced dipole–dipole interactions (London forces) in its solid lattice?

A boron

B magnesium

C silicon

D sulfur

Your answer ☐ **[1]**

11 The equation for the reaction of aluminium sulfide, Al_2S_3, with oxygen is shown below.

$$2Al_2S_3(s) + 9O_2(g) \rightarrow 2Al_2O_3(s) + 6SO_2(g)$$

The table shows standard enthalpy changes of formation, $\Delta_f H^{\ominus}$.

Substance	$Al_2S_3(s)$	$O_2(g)$	$Al_2O_3(s)$	$SO_2(g)$
$\Delta_f H^{\ominus}$ **/ kJ mol^{-1}**	−723.8	0	−1675.7	−296.8

What is the standard enthalpy change of combustion of $Al_2S_3(s)$, in kJ mol^{-1}?

A −3684.6

B −1842.3

C +1842.3

D +3684.6

Your answer ☐ **[1]**

12 A student carried out an experiment to measure the enthalpy change of combustion of methanol.

The energy from the combustion of methanol was used to heat a beaker containing water.

The student's calculated enthalpy change of combustion was **more** exothermic than the value in data books.

Which error could have caused this difference?

A Some methanol had evaporated from the wick before the final weighing.

B In the calculation, the student used the molar mass of ethanol instead of methanol.

C There was incomplete combustion.

D The water boiled for 5 minutes before the final temperature was taken.

Your answer ☐ **[1]**

13 The reversible reaction below is at equilibrium.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -197\,kJ\,mol^{-1}$$

Which changes in pressure and temperature would shift the equilibrium position towards the products?

	Pressure	**Temperature**
A	Decrease	Decrease
B	Decrease	Increase
C	Increase	Decrease
D	Increase	Increase

Your answer ☐ **[1]**

14 The reversible reaction below is at equilibrium.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

What is the expression for K_c?

A $\dfrac{[N_2(g)]\,[H_2(g)]^3}{[NH_3(g)]^2}$

B $\dfrac{[NH_3(g)]^2}{[N_2(g)]\,[H_2(g)]^3}$

C $\dfrac{[N_2(g)] + 3[H_2(g)]}{2[NH_3(g)]}$

D $\dfrac{2[NH_3(g)]}{[N_2(g)] + 3[H_2(g)]}$

Your answer ☐ **[1]**

15 1 mol of a compound reacts with 8 mol O_2 for complete combustion.

What is the formula of the compound?

A C_4H_8

B C_4H_9OH

C $C_5H_{11}OH$

D C_5H_{12}

Your answer ☐ **[1]**

16 How many structural isomers of $C_6H_{14}O$ are tertiary alcohols?

A 1

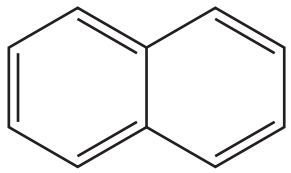
B 2

C 3

D 4

Your answer ☐ **[1]**

17 The structure of naphthalene is shown below.



What is the molecular formula of naphthalene?

A $C_{10}H_8$

B $C_{10}H_{10}$

C $C_{12}H_{10}$

D $C_{12}H_{12}$

Your answer ☐ **[1]**

18 A student reacts pent-2-ene with bromine in the laboratory.

Which compound is formed?

A 1,1-dibromopentane

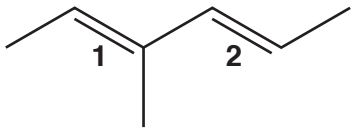
B 1,2-dibromopentane

C 2,2-dibromopentane

D 2,3-dibromopentane

Your answer ☐ **[1]**

19 The molecule below has two double bonds, labelled **1** and **2**.



The arrangement around each double bond can be identified as *E* or *Z*.

Which row in the table is correct for double bond **1** and double bond **2**?

	Double bond 1	**Double bond 2**
A	*E*	*Z*
B	*Z*	*E*
C	*E*	*E*
D	*Z*	*Z*

Your answer ☐ **[1]**

20 Which alcohol is likely to have a fragment ion at $m/z = 31$ in its mass spectrum?

A $CH_3CH_2CH(OH)CH_3$

B $CH_3CH_2CH_2C(OH)(CH_3)_2$

C $CH_3CH(OH)CH_2CH_2CH_3$

D $(CH_3)_2CHCH_2OH$

Your answer ☐ **[1]**

SECTION B

Answer **all** the questions.

21 This question is about elements from the p-block of the periodic table.

(a) Silicon exists as a mixture of three isotopes, ^{28}Si, ^{29}Si and ^{30}Si.

(i) Complete the table to show the atomic structure of ^{30}Si.

	Protons	**Neutrons**	**Electrons**
^{30}Si	.....	.....	.....

[1]

(ii) A sample of silicon is analysed by mass spectrometry.

The mass spectrum shows peaks with the relative abundances below.

- ^{28}Si 92.23%
- ^{29}Si 4.68%
- ^{30}Si 3.09%

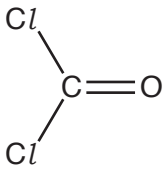
Calculate the relative atomic mass of silicon in the sample.

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

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

(b) Phosgene, $COCl_2$, exists as simple molecules.

The displayed formula of a phosgene molecule is shown below.



(i) Draw a '*dot-and-cross*' diagram of a phosgene molecule.

Show outer electrons only.

[1]

(ii) Name the shape of a phosgene molecule and explain why it has this shape.

Name of shape .....

Explanation .....

.....

.....

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

(c) Why are silicon, carbon, oxygen and chlorine all classified as p-block elements?

.....

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

22 This question is about compounds of magnesium and phosphorus.

(a) A student plans to prepare magnesium phosphate using the redox reaction of magnesium with phosphoric acid, H_3PO_4.

$$3Mg(s) + 2H_3PO_4(aq) \rightarrow Mg_3(PO_4)_2(s) + 3H_2(g)$$

(i) In terms of the number of electrons transferred, explain whether magnesium is being oxidised or reduced.

.....

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

(ii) The student plans to add magnesium to 50.0 cm^3 of 1.24 $mol\,dm^{-3}$ H_3PO_4.

Calculate the mass of magnesium that the student should add to react exactly with the phosphoric acid.

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

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

(iii) How could the student obtain a sample of magnesium phosphate after reacting magnesium with phosphoric acid?

.....

.....

.....

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

(iv) Magnesium phosphate can also be prepared by reacting phosphoric acid with a compound of magnesium.

Choose a suitable magnesium compound for this preparation and write the equation for the reaction.

Formula of compound .....

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

(b) Phosphine, PH_3, is a gas formed by heating phosphorous acid, H_3PO_3, in the absence of air.

$$4H_3PO_3(s) \rightarrow PH_3(g) + 3H_3PO_4(s)$$

(i) 3.20×10^{-2} mol of H_3PO_3 is completely decomposed by this reaction.

Calculate the volume of phosphine gas formed, in cm^3, at 100 kPa pressure and 200 °C.

volume of PH_3 = ... cm^3 **[4]**

(ii) When exposed to air, phosphine spontaneously ignites, forming P_4O_{10} and water.

Construct an equation for this reaction.

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

23 This question is about energy changes and rate of reaction.

(a) Magnesium reacts with aqueous silver nitrate, $AgNO_3(aq)$, as in **equation 23.1**.

$$Mg(s) + 2AgNO_3(aq) \rightarrow 2Ag(s) + Mg(NO_3)_2(aq) \qquad \textbf{Equation 23.1}$$

A student carries out an experiment to determine the enthalpy change of this reaction, $\Delta_r H$.

- The student adds 25.0 cm^3 of 0.512 mol dm^{-3} $AgNO_3$ to a polystyrene cup.
- The student measures the temperature of the solution.
- The student adds a small spatula measure of magnesium powder, stirs the mixture and records the maximum temperature.

Temperature readings

Initial temperature	= 19.5 °C
Maximum temperature	= 47.5 °C

(i) Calculate $\Delta_r H$, in kJ mol^{-1}, for the reaction shown in **equation 23.1**.

Give your answer to an **appropriate** number of significant figures.

Assume that the density and specific heat capacity, *c*, of the solution are the same as for water and that all the aqueous silver nitrate has reacted.

$\Delta_r H$ = ... kJ mol^{-1} **[4]**

(ii) At the end of the experiment, the student adds a few drops of aqueous sodium chloride to the reaction mixture in the polystyrene cup to test whether all the aqueous silver nitrate has reacted.

Explain how the results would show whether all the aqueous silver nitrate has reacted. Include an equation with state symbols in your answer.

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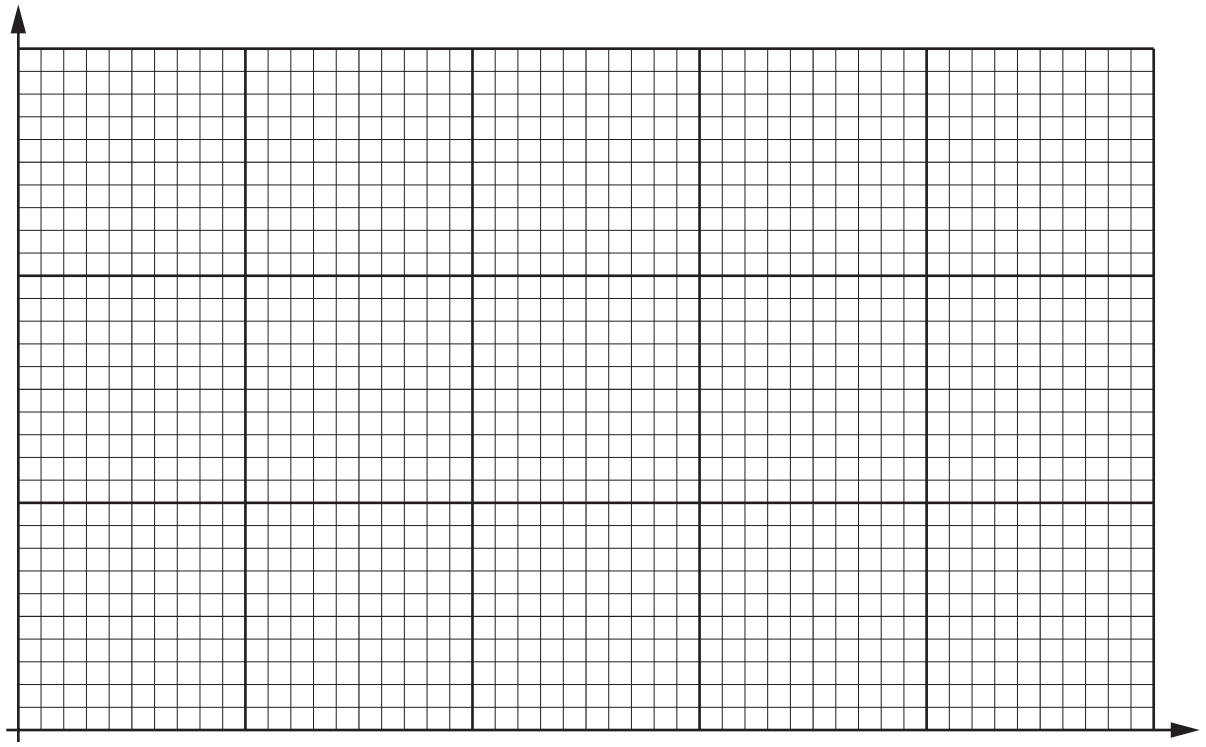
..... **[2]**

(b) Using the Boltzmann distribution model, explain how the rate of a reaction is affected by temperature.

You are provided with the axes below, which should be labelled.



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

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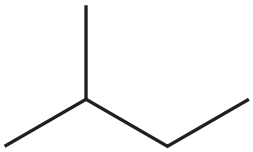
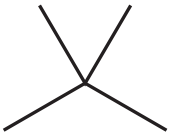
24 This question is about saturated hydrocarbons.

(a) Compounds **A**, **B** and **C** are saturated hydrocarbons.
The structures and boiling points of **A**, **B** and **C** are shown below.

	Isomer	Boiling point / °C
A		36
B		28
C		9

- Use the structures to explain what is meant by the term structural isomer.
- Explain the trend in boiling points shown by **A**, **B** and **C** in the table.

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

(b) Compounds **A**, **B** and **C** all react with chlorine in the presence of ultraviolet radiation to form organic compounds with the formula $C_5H_{11}Cl$.

(i) Name the mechanism for this reaction.

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

(ii) Complete the table to show the number of structural isomers of $C_5H_{11}Cl$ that could be formed from the reaction of chlorine with **A** and **B**.

	A	**B**
Number of structural isomers	.....	.....

[2]

(iii) The reaction of compound **A** with excess chlorine forms a compound **D**, which has a molar mass of $175.5\,g\,mol^{-1}$.

Draw a possible structure for compound **D** and write the equation for its formation from compound **A**. Use molecular formulae in the equation.

Compound D

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

25 This question is about reactions involving alcohols.

(a) Three reactions of an alcohol **E** are shown in **Fig. 25.1**.

(i) Complete **Fig. 25.1** to show the structures of the organic products formed in the reactions.

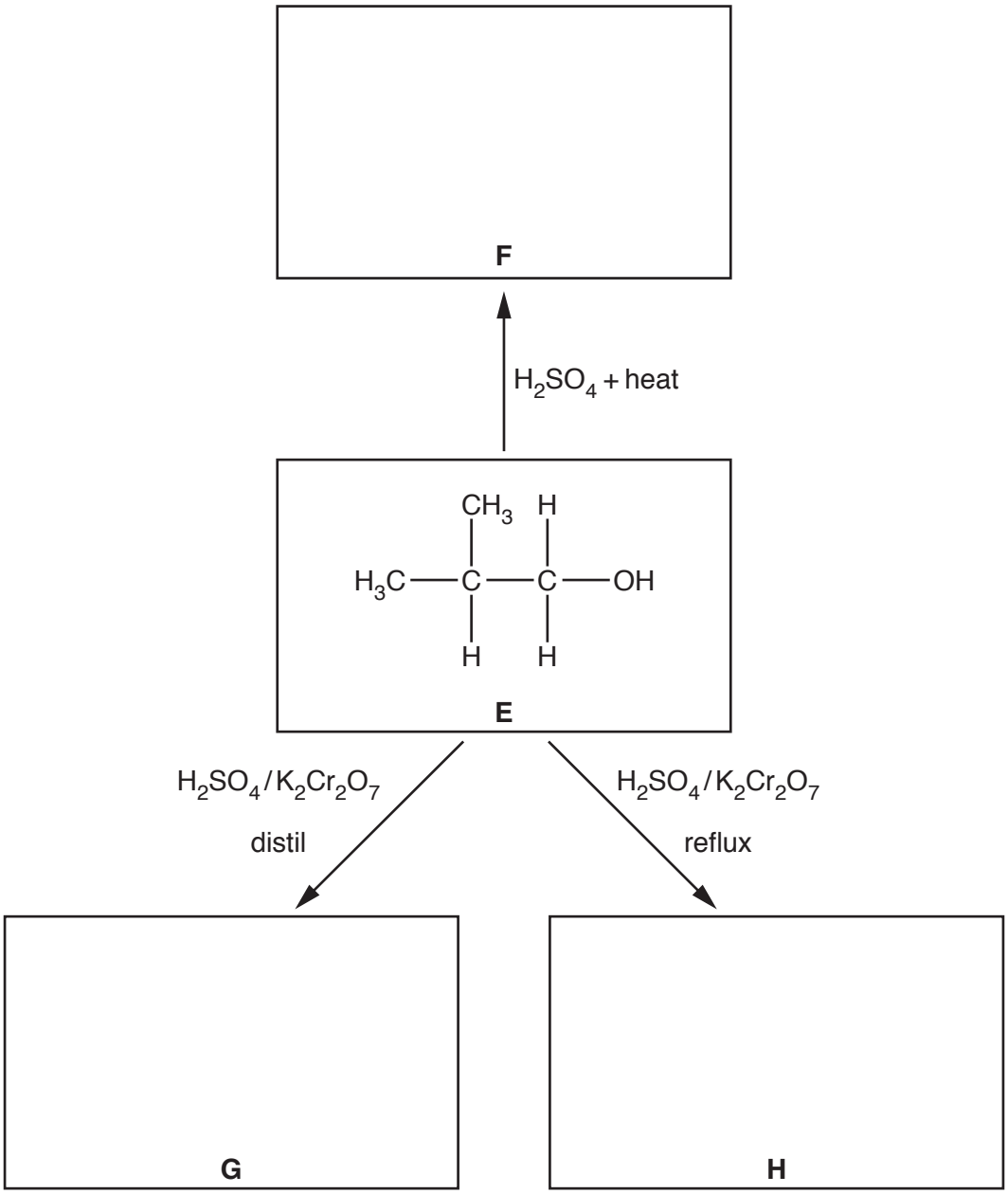

Fig. 25.1

[3]

(ii) What is the systematic name of alcohol **E**?

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

(b) An alcohol can be prepared by hydrolysing the haloalkane $C_2H_5CHBrCH_3$ with aqueous sodium hydroxide.

(i) Outline the mechanism for this reaction.

Show curly arrows and relevant dipoles.

[3]

(ii) The infrared (IR) spectrum for $C_2H_5CHBrCH_3$ is shown in **Fig. 25.2**.
The C–Br bond absorption is labelled.

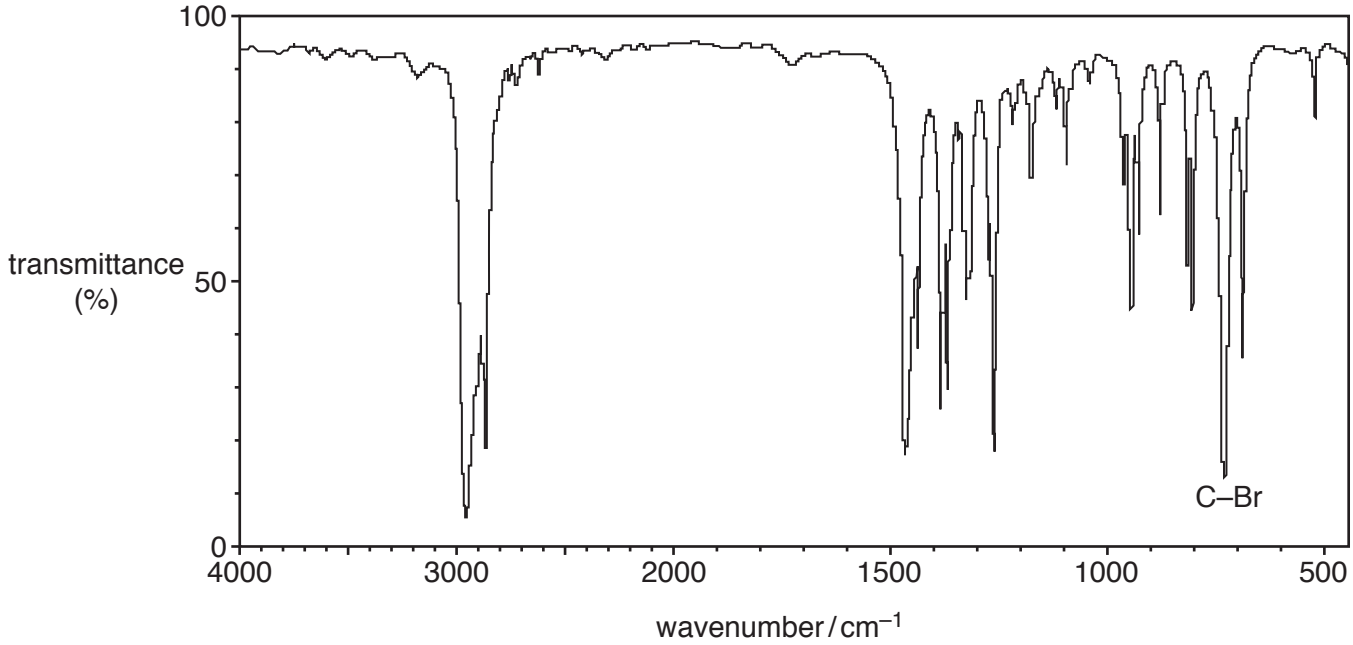

Fig. 25.2

Outline how IR spectroscopy could be used to show that the bromoalkane functional group has reacted and that the alcohol functional group has formed.

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.....

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

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).

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