OCR
Oxford Cambridge and RSA

AS Level Chemistry A

H032/02 Depth in Chemistry

Friday 25 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.
- 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 answer space is required, you should use the lined page(s) at the end of the 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 **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **20** pages.

Answer **all** the questions.

1 A student carries out a titration to determine the molar mass and structure of a weak acid **A**.

The student follows the method below.

- Dissolve a weighed mass of **A** in 100 cm^3 of distilled water and make the solution up to 250 cm^3 in a beaker.
- Add the solution of **A** to a burette.
- Titrate the solution of **A** with a standard solution of sodium hydroxide, NaOH.

(a) What is meant by the term standard solution?

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

(b) Sodium hydroxide is an alkali.

What is meant by the term alkali?

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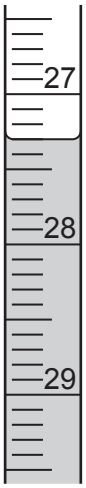
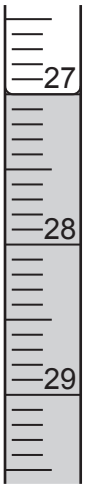
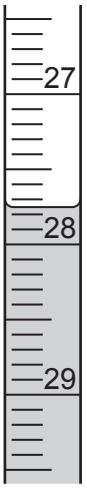
..... **[1]**

(c) The student carries out a trial, followed by three further titrations.
The diagram shows the initial and final burette readings for the three **further** titrations.

The student measures all burette readings to the nearest 0.05 cm^3.

Titration 1		**Titration 2**		**Titration 3**	
Initial reading	Final reading	Initial reading	Final reading	Initial reading	Final reading
					

(i) Record the student's readings and the titres in the table below.

Calculate the mean titre, to the nearest 0.05 cm^3, that the student should use for analysing the results.

	Titration 1	**Titration 2**	**Titration 3**
Final reading/cm^3			
Initial reading/cm^3			
Titre/cm^3			

mean titre = ... cm^3 **[4]**

(ii) The uncertainty in each burette reading is ± 0.05 cm^3.

Calculate the percentage uncertainty for the titre in **Titration 1**.

percentage uncertainty = ... % **[1]**

(iii) The student realised that the solution of **A** had not been prepared correctly.

How should the student have made up the solution?

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

(d) A student repeats the titration to determine the molar mass and structure of **A**.

- The student prepares a 250.0 cm^3 solution from 1.513 g of **A**.
- The solution of **A** is added to the burette and titrated with 25.0 cm^3 volumes of 0.112 mol dm^{-3} NaOH(aq).
- 1 mol of **A** reacts with 2 mol of NaOH.
- The student obtains a mean titre of 27.30 cm^3.

(i) Calculate the molar mass of **A** from these results.

Give your answer to the nearest whole number.

Show your working.

molar mass of **A** = ... g mol^{-1} **[4]**

(ii) **A** is an organic acid, containing C, H and O only.
One molecule of **A** contains two COOH groups.

Suggest the structure of **A**.

[1]

2 Sodium sulfide, Na_2S, is an ionic compound of sodium, Na, and sulfur, S.

(a) Draw a '*dot-and-cross*' diagram to show the bonding in sodium sulfide.

Show outer electrons only.

[2]

(b) The table below compares the properties of sodium sulfide, sodium and sulfur.

Complete the table.

		Sodium sulfide	**Sodium**	**Sulfur**
Melting point / °C		1180	98	113
Type of structure (**giant** or **simple**)				
Electrical conductivity (**good** or **poor**)	solid			
	liquid			

[3]

(c) Selenium is in the same group of the periodic table as sulfur.

(i) Complete the full electron configuration of a selenium atom.

$1s^2$ ..... **[1]**

(ii) Sodium selenide reacts with hydrochloric acid to form a toxic gas, **B**, with a relative molecular mass of 81.0.

Identify gas **B** and write an equation for this reaction.

Gas **B** .....

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

3 This question is about halogens.

(a) Bromine is used to extract iodine from a solution containing iodide ions.

(i) Write an ionic equation for the reaction.

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

(ii) Explain why iodine is less reactive than bromine.

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

(b) Iodine can be used for the small-scale purification of drinking water.

(i) Iodine reacts with water as shown below.

$$I_2 + H_2O \rightleftharpoons HI + HIO$$

Using oxidation numbers, explain why this reaction is a disproportionation.

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

(ii) Chlorine is used to purify water on a large scale.

State **one** disadvantage of using chlorine for the purification of drinking water.

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

(c) Hydrogen reacts with chlorine to form hydrogen chloride, HCl:

$$H_2(g) + Cl_2(g) \longrightarrow 2HCl(g) \qquad \Delta H = -184\,kJ\,mol^{-1}$$

Table 3.1 shows bond enthalpies.

Bond	Bond Enthalpy / kJ mol^{-1}
H–H	+436
Cl–Cl	+243

Table 3.1

Calculate the bond enthalpy for the H–Cl bond from the information above.

bond enthalpy = ... kJ mol^{-1} **[2]**

(d) 'Enthalpy change of vaporisation' is the enthalpy change when one mole of a substance changes from a liquid to a gas at its boiling point.

(i) Write an equation, including state symbols, to represent the enthalpy change of vaporisation of bromine.

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

(ii) Suggest whether the enthalpy change of vaporisation of bromine is exothermic or endothermic.

Explain your answer.

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

4 The reaction of ammonia, NH_3, with oxygen to form nitrogen monoxide, NO, is an important industrial process.

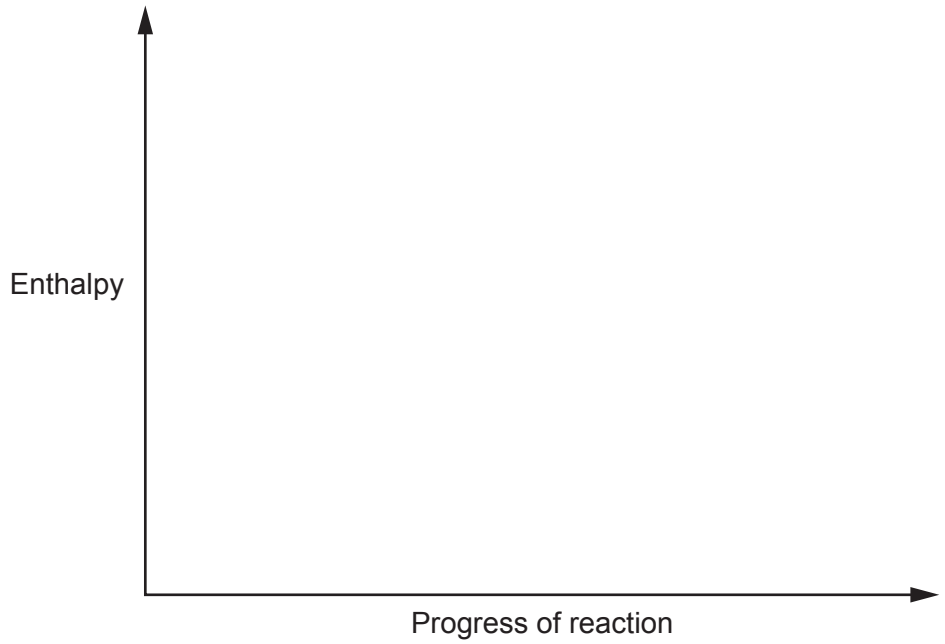
The equation for this reaction is shown in **equilibrium 4.1** below.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -905 \text{ kJ mol}^{-1} \qquad \textbf{Equilibrium 4.1}$$

(a) The forward reaction in **equilibrium 4.1** converts NH_3 into NO.

(i) Complete the enthalpy profile diagram for this reaction.

On your diagram:
- Label the activation energy, E_a
- Label the enthalpy change of reaction, ΔH
- Include the formulae of the reactants and products.



[2]

(ii) 5.10 tonnes of NH_3 are converted into NO.

Calculate the energy released, in kJ, for this conversion.

Give your answer in **standard form** and to an **appropriate** number of significant figures.

energy released = ... kJ **[4]**

(b) Write an expression for the equilibrium constant, K_c, in **equilibrium 4.1**.

[1]

(c) Predict the conditions of temperature and pressure for a maximum equilibrium yield of nitrogen monoxide in **equilibrium 4.1**.

- Explain your prediction in terms of le Chatelier's principle.
- State and explain how these conditions could be changed to achieve a compromise between equilibrium yield, rate and other operational factors.

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

5 **(a)** 1-Bromobutane is an organic liquid with a boiling point of 102 °C.

A student prepares 1-bromobutane by reacting butan-1-ol with sulfuric acid and sodium bromide. The student boils the mixture for one hour.

The equation is shown below.

$$CH_3CH_2CH_2CH_2OH + H^+ + Br^- \rightarrow CH_3CH_2CH_2CH_2Br + H_2O$$

The student obtains a reaction mixture containing an organic layer (density = 1.27 g cm^{-3}) and an aqueous layer (density = 1.00 g cm^{-3}).

(i)* Draw a labelled diagram to show how you would safely set up apparatus for the preparation. Outline a method to obtain a pure sample of 1-bromobutane from the reaction mixture.

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

(ii) The student used 0.150 mol of butan-1-ol. The student obtained a 61.4% percentage yield of 1-bromobutane.

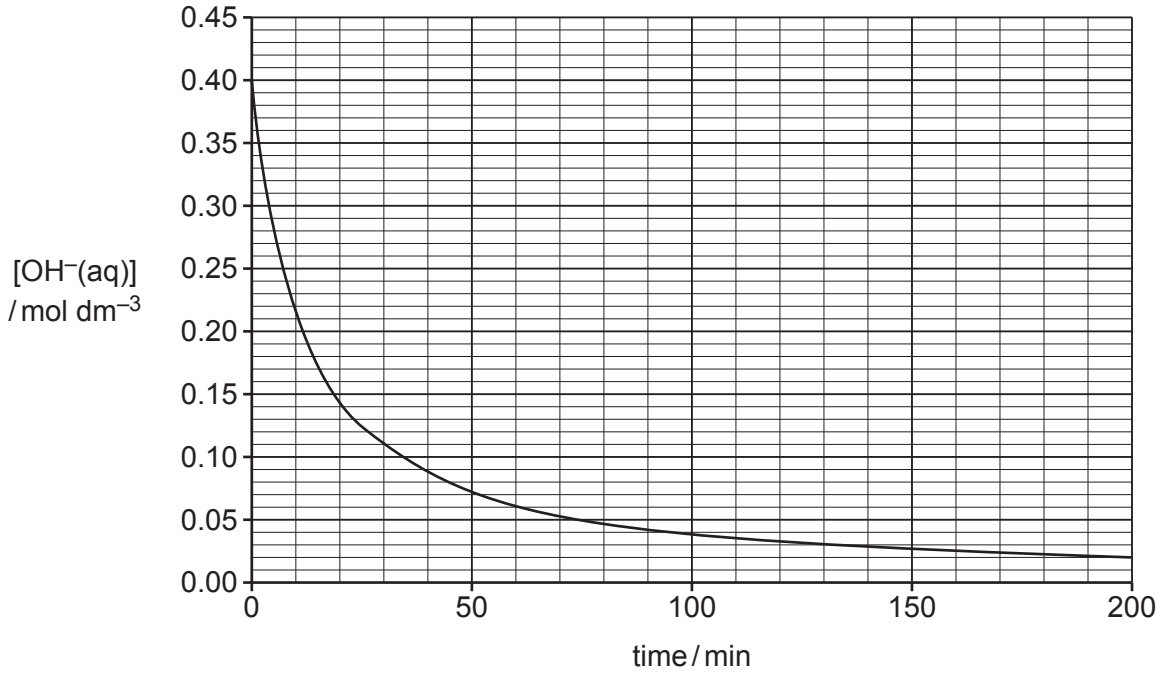
Calculate the mass of 1-bromobutane obtained.

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

mass = ... g **[2]**

(b) A student investigates the rate of reaction of 1-bromobutane with aqueous hydroxide ions.

The graph shows how the hydroxide ion concentration, $[OH^-(aq)]$, changes during the reaction.



Using the graph, calculate the rate of reaction, in $mol\,dm^{-3}\,min^{-1}$, at 30 minutes.

Show your working on the graph and in the space below.

rate of reaction = ... $mol\,dm^{-3}\,min^{-1}$ **[2]**

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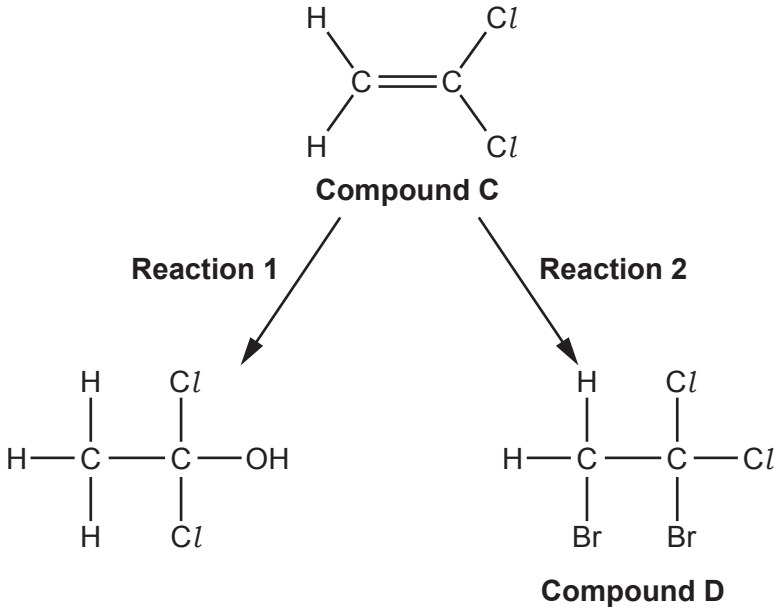
6 Two reactions of compound **C** are shown in the flowchart below.



(a) State the reagents and conditions for **reaction 1**.

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

(b) In **reaction 2**, compound **C** reacts with bromine to form compound **D**.

(i) Give the systematic name of compound **D**.

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

(ii) Outline the mechanism for **reaction 2**.

Include curly arrows, charges and relevant dipoles.

[3]

(c) Compound **C** forms an addition polymer **E**.

(i) Write a balanced equation for this reaction.

Show displayed formulae.

[2]

(ii) State **one** advantage and **one** disadvantage of using combustion as a method for the disposal of waste polymer **E**.

Advantage .....

.....

Disadvantage .....

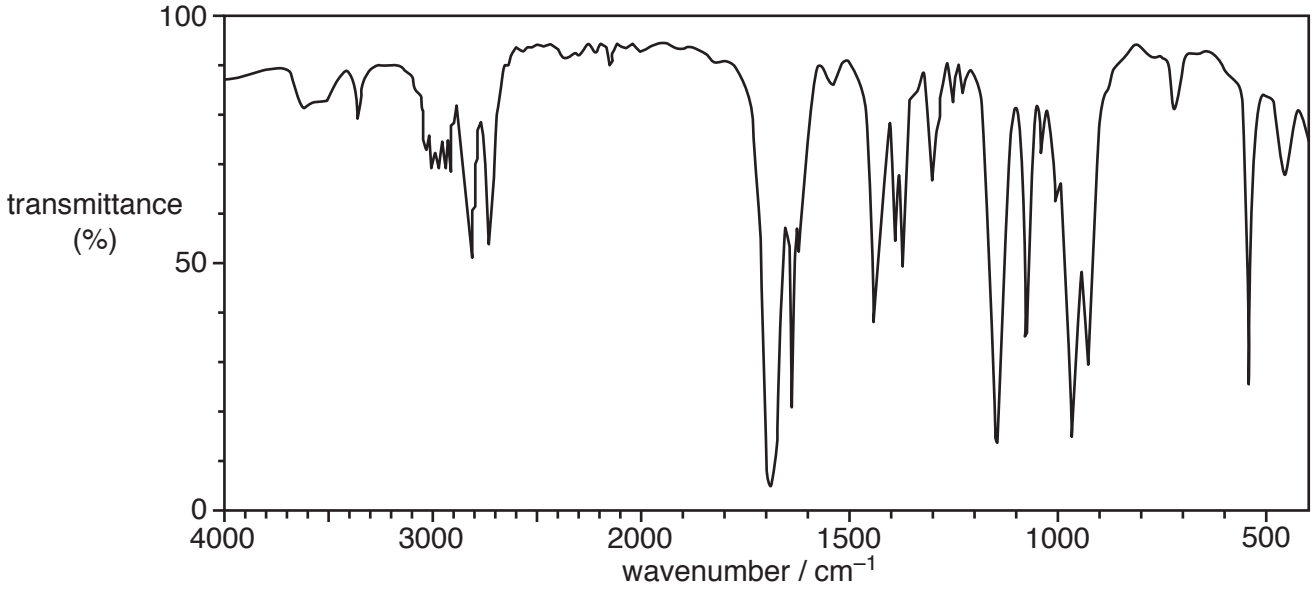
..... **[2]**

7* Compound **F** is a *trans* stereoisomer which is a useful intermediate in organic synthesis.

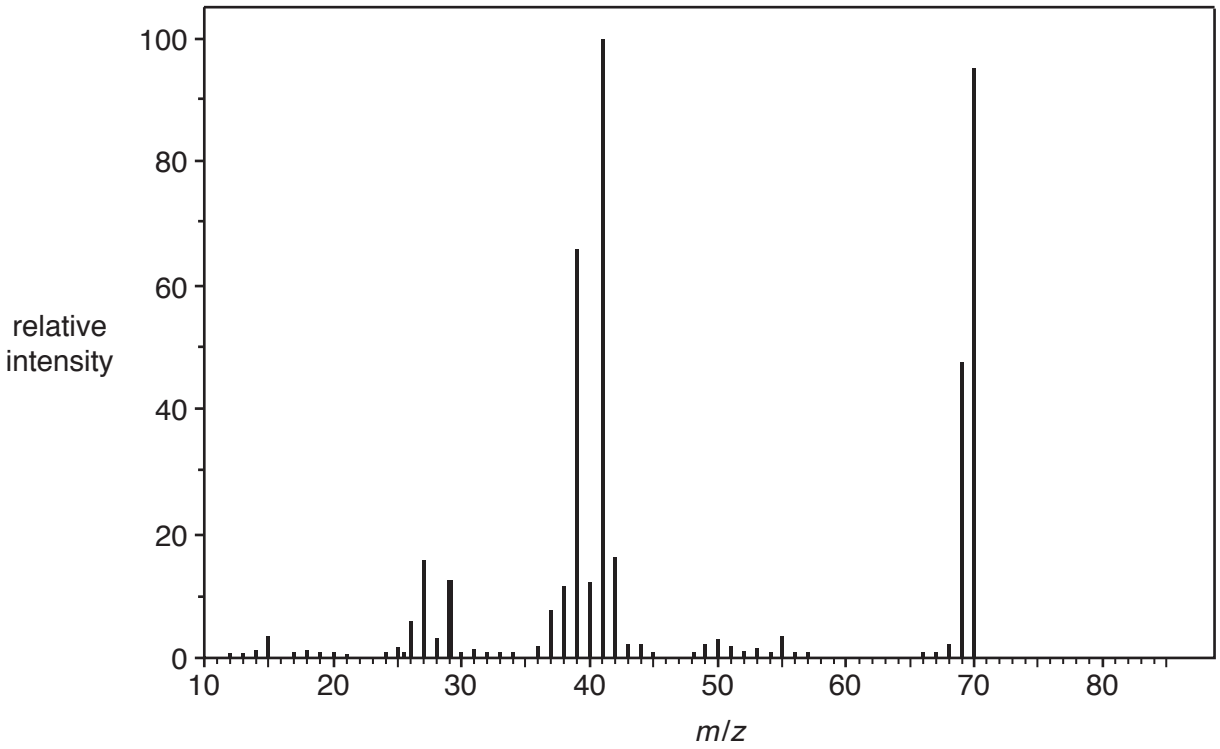
The results of elemental and spectral analysis of compound **F** are shown below.

Percentage composition by mass: C, 68.6 %; H, 8.6 %; O, 22.8 %.

Infrared spectrum



Mass spectrum



In the mass spectrum, the peak with the greatest relative intensity is caused by the loss of a functional group from the molecular ion of compound **F**.

Determine the structure of compound **F**.

Explain your reasoning and show your working.

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

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).