



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  $100\text{cm}^3$  of distilled water and make the solution up to  $250\text{cm}^3$  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?

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


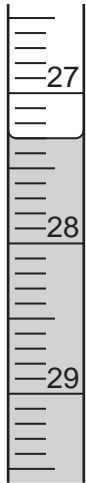

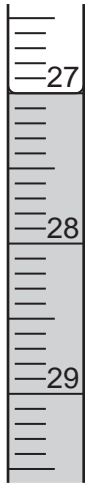

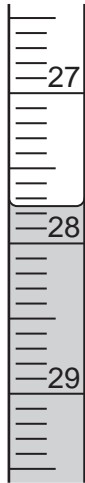
- (b) Sodium hydroxide is an alkali.

What is meant by the term alkali?

.....  
 ..... [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  $0.05\text{cm}^3$ .

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

3

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

Calculate the mean titre, to the nearest  $0.05\text{ cm}^3$ , that the student should use for analysing the results.

	Titration 1	Titration 2	Titration 3
Final reading/ $\text{cm}^3$			
Initial reading/ $\text{cm}^3$			
Titre/ $\text{cm}^3$			

mean titre = .....  $\text{cm}^3$  [4]

- (ii) The uncertainty in each burette reading is  $\pm 0.05\text{ cm}^3$ .

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?

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

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

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

(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** = .....  $\text{g mol}^{-1}$  [4]

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

Suggest the structure of **A**.

[1]

2 Sodium sulfide,  $\text{Na}_2\text{S}$ , 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/ $^{\circ}\text{C}$		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.

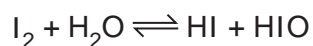
..... [1]

(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.



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

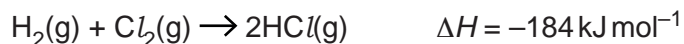
.....  
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.....  
..... [3]

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

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

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

- (c) Hydrogen reacts with chlorine to form hydrogen chloride,  $\text{HCl}$ :



**Table 3.1** shows bond enthalpies.

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

**Table 3.1**

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

bond enthalpy = .....  $\text{kJ mol}^{-1}$  [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.

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

- 4 The reaction of ammonia,  $\text{NH}_3$ , with oxygen to form nitrogen monoxide,  $\text{NO}$ , is an important industrial process.

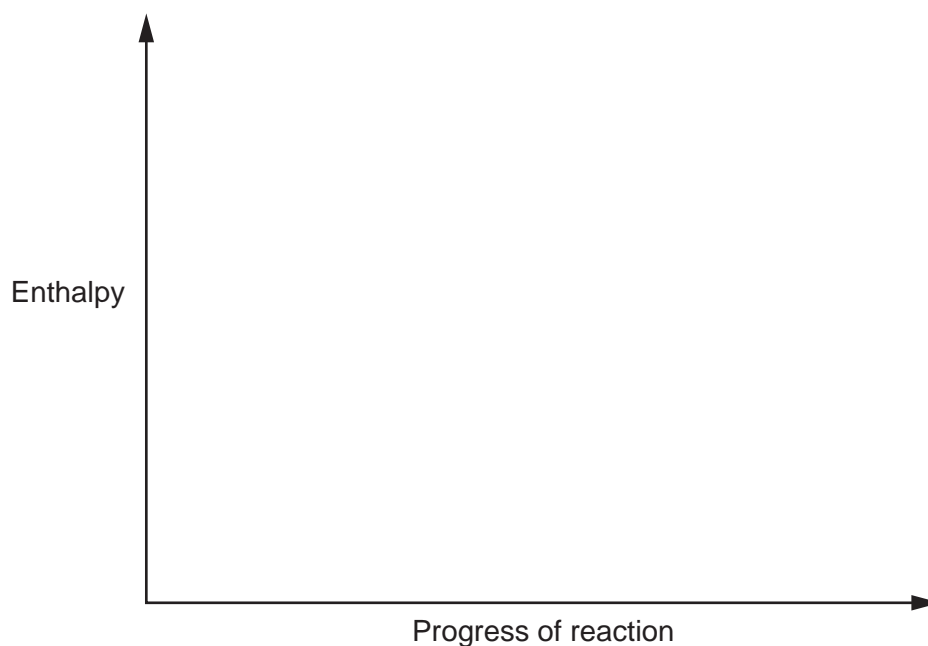
The equation for this reaction is shown in **equilibrium 4.1** below.



- (a) The forward reaction in **equilibrium 4.1** converts  $\text{NH}_3$  into  $\text{NO}$ .
- (i) Complete the enthalpy profile diagram for this reaction.

On your diagram:

- Label the activation energy,  $E_a$
- Label the enthalpy change of reaction,  $\Delta H$
- Include the formulae of the reactants and products.



[2]

- (ii) 5.10 tonnes of  $\text{NH}_3$  are converted into  $\text{NO}$ .

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



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

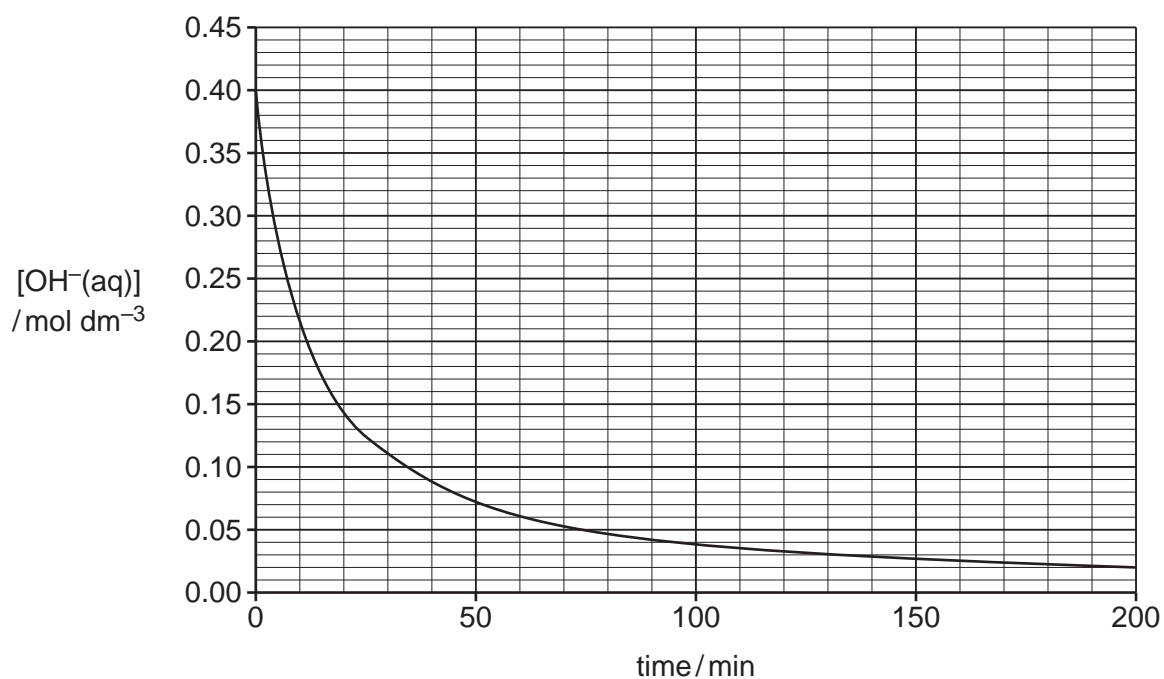
Calculate the mass of 1-bromobutane obtained.

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,  $[\text{OH}^-(\text{aq})]$ , changes during the reaction.



Using the graph, calculate the rate of reaction, in mol dm<sup>-3</sup> min<sup>-1</sup>, at 30 minutes.

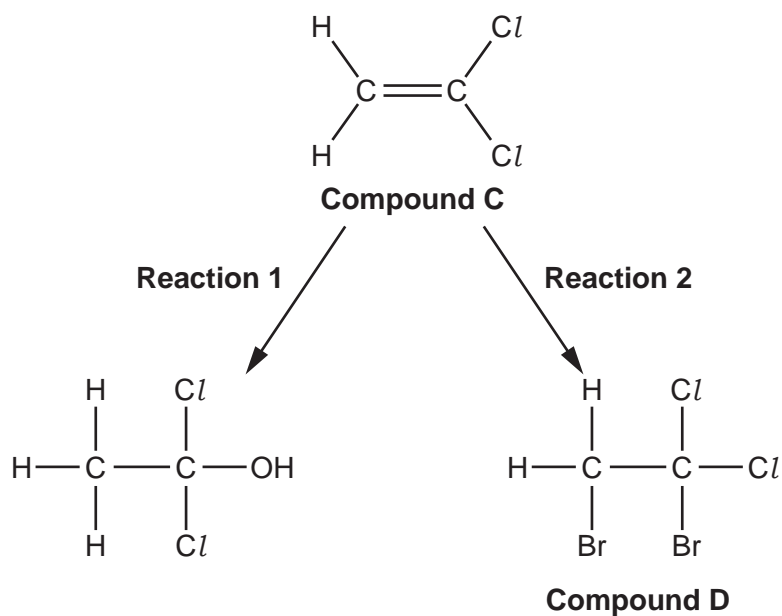
Show your working on the graph and in the space below.

rate of reaction = ..... mol dm<sup>-3</sup> min<sup>-1</sup> [2]

13  
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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**.

.....  
 ..... [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 .....

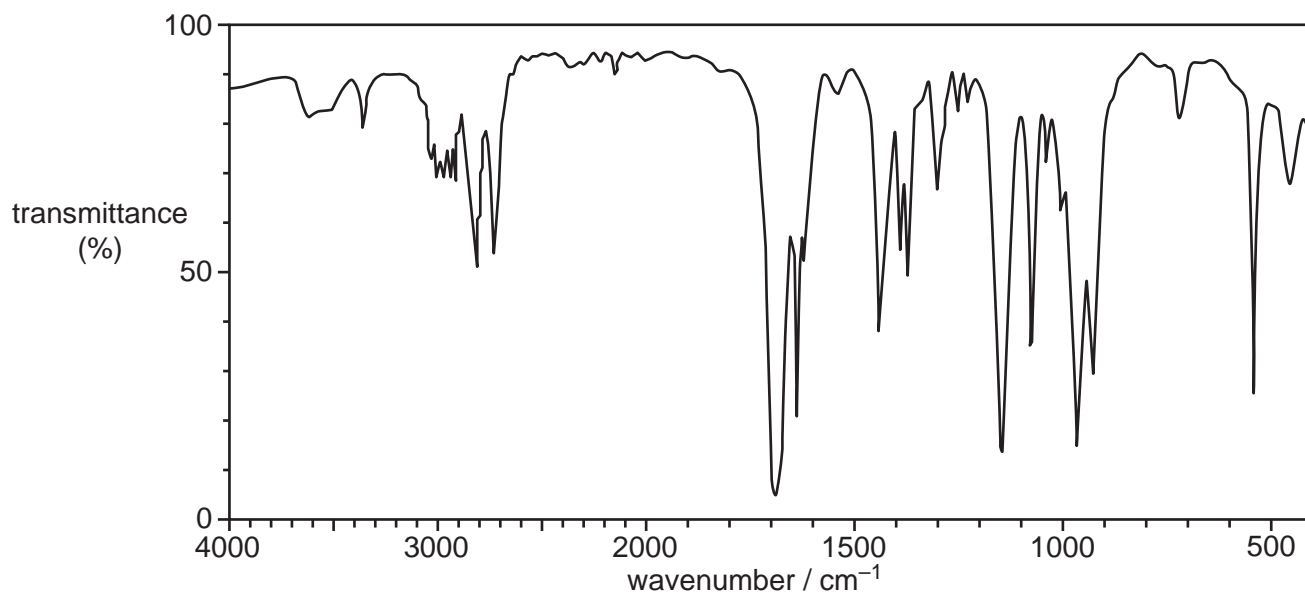
..... [2]

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

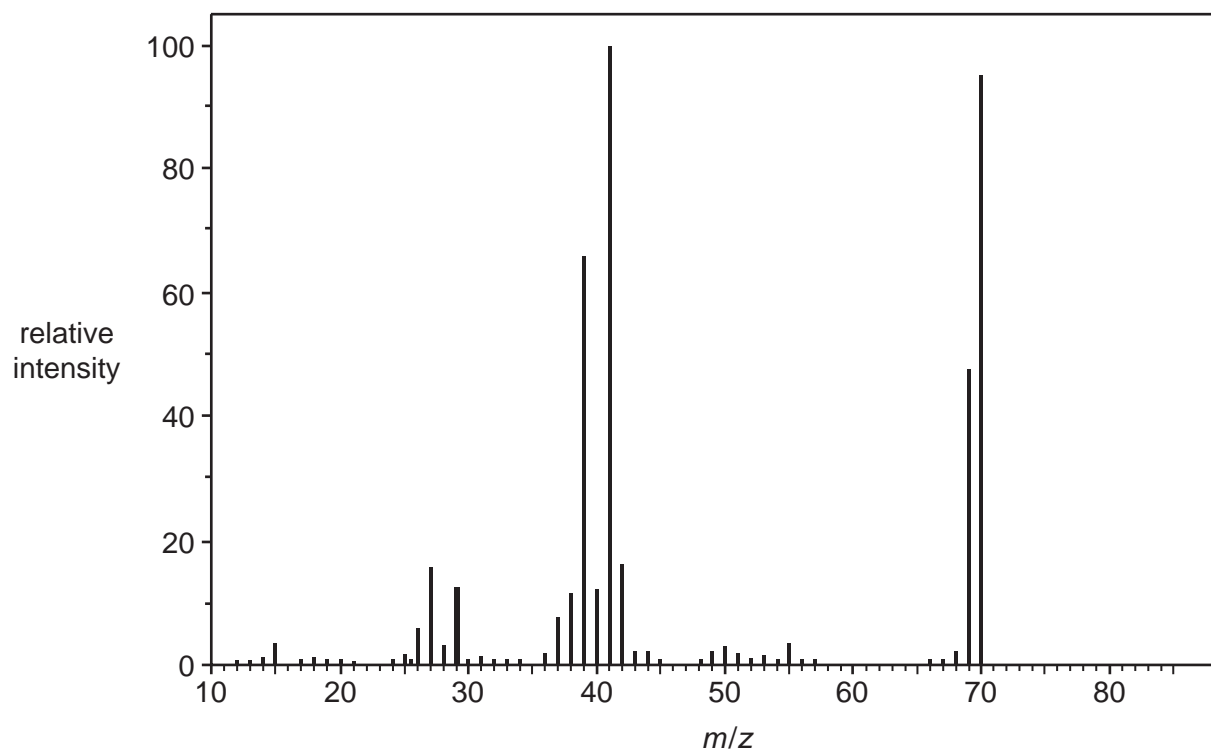
The results of elemental and spectral analysis of compound **F** are shown below.

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

### Infrared spectrum



### Mass spectrum







**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).

A large area of lined paper for writing. It consists of a vertical solid line on the left side, creating a margin. To the right of this line, there are numerous horizontal dotted lines spaced evenly down the page, providing a guide for writing.

A series of horizontal dotted lines for writing, spanning most of the page width. A solid vertical line is positioned on the left side, creating a margin.

A large area of the page is reserved for writing, featuring a vertical solid line on the left side and horizontal dotted lines extending across the page.



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