



# Cambridge International AS & A Level

CANDIDATE  
NAME

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CENTRE  
NUMBER

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CANDIDATE  
NUMBER

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**CHEMISTRY**

**9701/52**

Paper 5 Planning, Analysis and Evaluation

**October/November 2021**

**1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

## INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working, use appropriate units and use an appropriate number of significant figures.

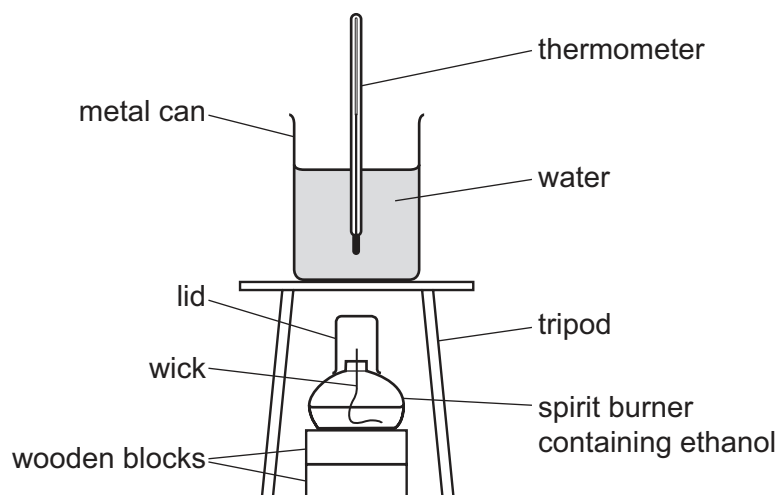
## INFORMATION

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **12** pages. Any blank pages are indicated.



- 1 It is possible to measure the enthalpy change of combustion,  $\Delta H_c$ , of ethanol,  $C_2H_5OH$ , using the following apparatus.



A student carries out an experiment to determine the value for  $\Delta H_c$  of ethanol using the following instructions:

- Weigh the spirit burner with ethanol and lid, record the starting mass to two decimal places.
- Measure  $100.00\text{ cm}^3$  of water and place it into the metal can.
- Place a thermometer, with  $0.1\text{ }^\circ\text{C}$  graduations, into the water and stir it, wait for 2 minutes.
- Record the temperature of the water.
- Light the wick and allow the flame to heat the water.
- Continue to stir the water using the thermometer.
- After the temperature has risen by approximately  $20\text{ }^\circ\text{C}$  place the lid on the flame to extinguish it.
- Record the maximum temperature of the water.
- Weigh the spirit burner and record the final mass.

The student obtained the following results.

initial temperature of water/ $^\circ\text{C}$	maximum temperature of water/ $^\circ\text{C}$	change in temperature of water, $\Delta T$ / $^\circ\text{C}$	initial mass of spirit burner/g	final mass of spirit burner/g	mass of ethanol burned/g
18.1	38.2		153.29	152.76	

(a) Complete the table. Record your answers to the correct number of decimal places. [1]

(b) Calculate the number of moles of ethanol burned. Give your answer to **three** significant figures.

[ $A_r$ : C, 12.0; H, 1.0; O, 16.0]

moles of ethanol = ..... [1]

- (c) Use the formula  $q = mc\Delta T$  to determine the energy change,  $q$ , that took place during the experiment. Use  $q$  and your answer to (b) to calculate the enthalpy change of combustion of ethanol,  $\Delta H_c$ , in  $\text{kJ mol}^{-1}$ .

Include a sign in your answer.

1.00  $\text{cm}^3$  of water has a mass of 1.00 g  
 $c = 4.18 \text{ J g}^{-1} \text{ K}^{-1}$

$$\Delta H_c = \dots\dots\dots \text{ kJ mol}^{-1} \quad [2]$$

- (d) Calculate the percentage error of the temperature change recorded in the table in (a).

Show your working.

$$\text{percentage error} = \dots\dots\dots [1]$$

- (e) State the effect, if any at all, on the accuracy of the experiment if the spirit burner was allowed to burn for longer. Explain your answer.

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

- (f) The flame was extinguished, but the lid of the spirit burner was not replaced immediately.

Predict how this would affect the value of  $\Delta H_c$ . Explain your answer.

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

(g) The value for  $\Delta H_c$  of ethanol under standard conditions is  $-1367 \text{ kJ mol}^{-1}$ .

- (i) Other than the reaction not being carried out under standard conditions, suggest **two** reasons why the value the student obtained in (c) is different from the actual value.

1 .....

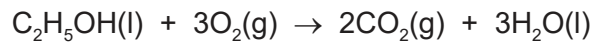
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2 .....

.....

[2]

- (ii) It is possible to calculate  $\Delta H_c$  of ethanol using average bond enthalpies and the chemical equation for the reaction.



Using average bond enthalpies,  $\Delta H_c$  of ethanol is  $-1297 \text{ kJ mol}^{-1}$ .

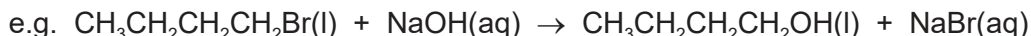
Explain why this value is different from the actual value for  $\Delta H_c$  of ethanol under standard conditions.

.....

..... [1]

[Total: 11]

2 Halogenoalkanes undergo hydrolysis with aqueous sodium hydroxide to form alcohols.



A student carried out an experiment to compare the rate at which three halogenoalkanes, 1-chlorobutane,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl}$ , 1-bromobutane,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$ , and 1-iodobutane,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{I}$ , undergo hydrolysis. The method used was as follows:

- Place a  $5\text{ cm}^3$  sample of each halogenoalkane into separate test-tubes.
- Add  $1\text{ cm}^3$  of organic solvent to each test-tube.
- Add  $2\text{ cm}^3$  aqueous sodium hydroxide to each test-tube.
- Add 3 drops of acid–base indicator to the mixture.
- Heat the test-tubes in a thermostatically controlled, electrically heated water bath.
- Record the time taken for the indicator to change colour.

(a) Give **two** reasons why the experiment was carried out using an electrically heated water bath.

1 .....

.....

2 .....

.....

[2]

(b) Sodium hydroxide is corrosive.

Apart from wearing safety glasses and a lab coat, state **one** safety precaution which must be taken when handling sodium hydroxide.

..... [1]

(c) Suggest why an organic solvent must be used in this experiment.

.....

..... [1]

(d) Why is acid–base indicator added to the reaction mixture?

.....

..... [1]

(e) The student obtained the following results.

halogenoalkane	time taken for indicator to change colour/s	$\frac{1}{\text{time}}/\text{s}^{-1}$
1-chlorobutane	417	
1-bromobutane	238	
1-iodobutane	135	

(i) Complete the table to show  $\frac{1}{\text{time}}$ . [1]

(ii)  $\frac{1}{\text{time}}$  can be used to represent rate of reaction.

Suggest what the  $\frac{1}{\text{time}}$  values tell you about the trend in carbon-halogen bond enthalpies.

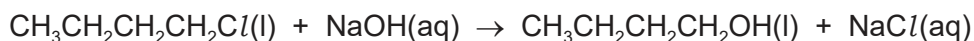
.....  
 ..... [1]

(f) Identify **one** additional variable that must be controlled in this experiment.

..... [1]

**Question 2 continues on the next page.**

- (g) The student decided to investigate the order of reaction with respect to aqueous sodium hydroxide.



- step 1 An excess of 1-chlorobutane was mixed with  $1.00 \text{ mol dm}^{-3}$   $\text{NaOH}(\text{aq})$ , at room temperature.
- step 2 A stop-clock was immediately started.
- step 3 At intervals of 60 seconds the student took  $10.00 \text{ cm}^3$  samples from the reaction mixture, for 11 minutes.
- step 4 Each  $10.00 \text{ cm}^3$  sample was immediately added to ice in a conical flask.
- step 5 The concentration of  $\text{NaOH}(\text{aq})$  in each sample was determined by titration.

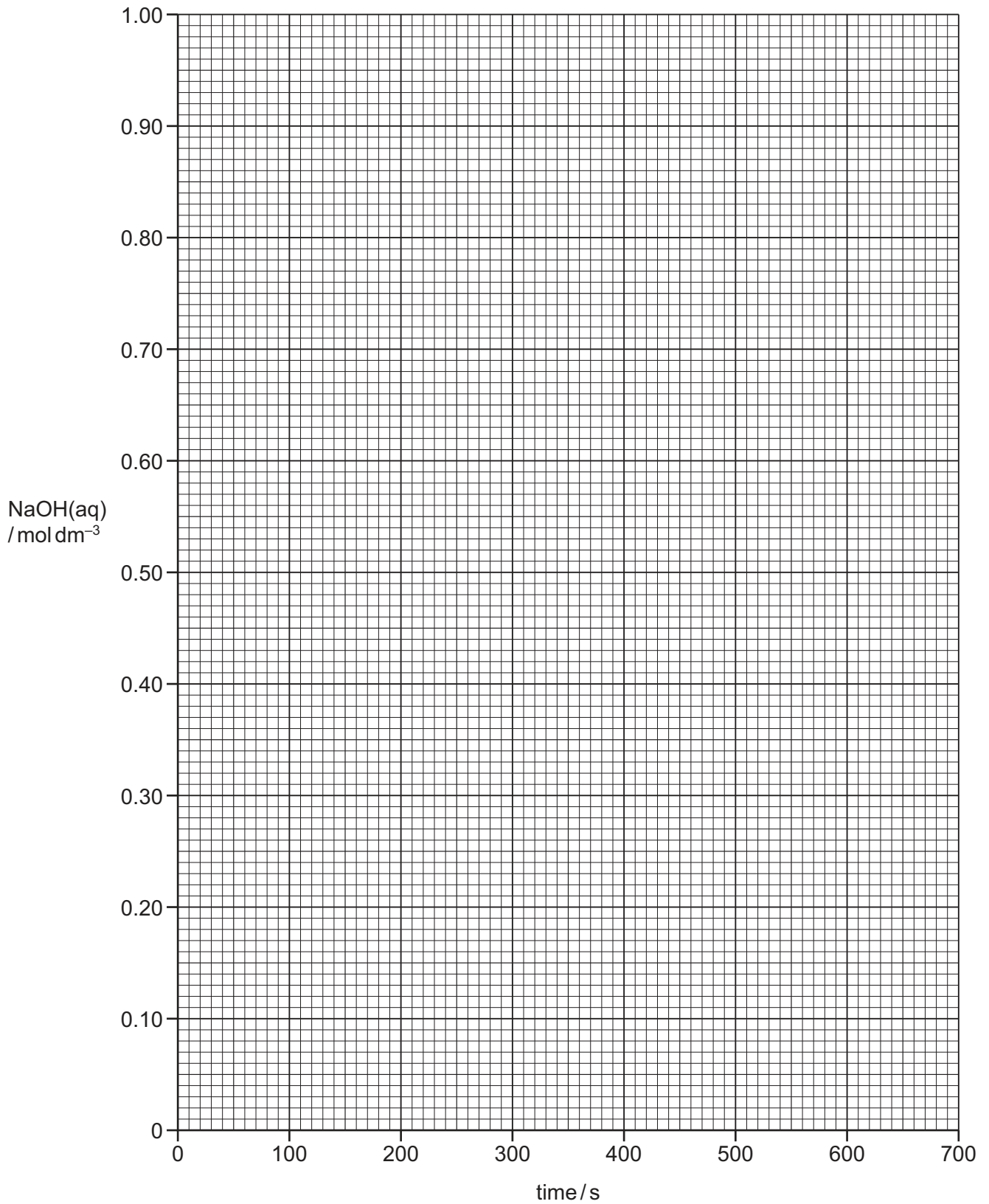
The results are shown.

time/s	concentration of $\text{NaOH}(\text{aq})/\text{mol dm}^{-3}$
0	1.00
60	0.75
120	0.62
180	0.51
240	0.39
300	0.31
360	0.24
420	0.19
480	0.12
540	0.13
600	0.11
660	0.09



(i) Plot a graph of concentration of NaOH(aq) ( $y$ -axis) against time ( $x$ -axis).

Use a cross (x) to plot each data point. Draw a curved line of best fit.



[2]

(ii) Circle the point which you consider to be most anomalous.

[1]

(iii) Suggest **one** reason for this anomalous point.

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

(iv) Draw construction lines on the graph to calculate two consecutive half-lives for this reaction.

first half-life = ..... s

second half-life = ..... s  
 [2]

(v) State whether you consider this to be a first-order reaction with respect to NaOH. Explain your answer.

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

(h) The total volume of the reaction mixture at the start of the experiment was 250 cm<sup>3</sup>.

(i) Name a piece of apparatus that could be used to remove 10.00 cm<sup>3</sup> samples from the reaction mixture.

..... [1]

(ii) Suggest why the student did not remove 25.00 cm<sup>3</sup> samples for titration from the reaction mixture.

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

(iii) Explain why each sample is added to ice in step 4.

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

(i) Another method for following the rate of a reaction is to measure changes in electrical conductivity.

Explain why this would not be a suitable method for following this reaction.

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

[Total: 19]



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