Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

1974060307

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **October/November 2021**

1 hour 15 minutes

You must answer on the question paper.

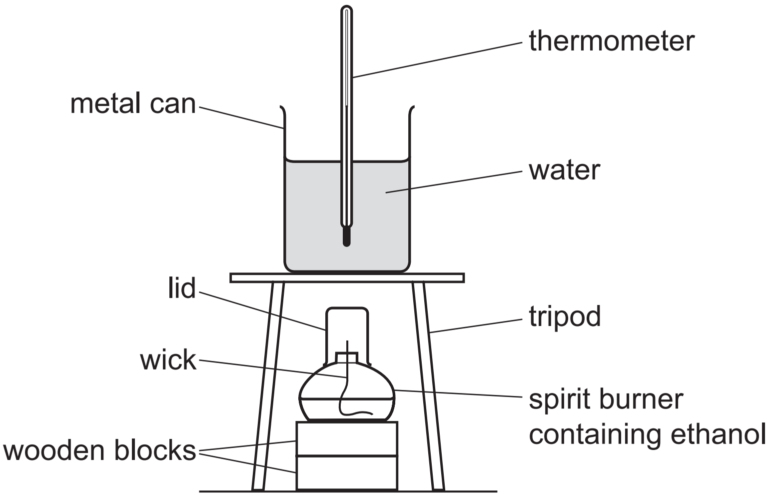
No additional materials are needed.

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, ΔH_c, of ethanol, C_2H_5OH, using the following apparatus.



A student carries out an experiment to determine the value for ΔH_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 cm^3 of water and place it into the metal can.
- Place a thermometer, with 0.1 °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 °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 / °C	maximum temperature of water / °C	change in temperature of water, ΔT / °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, ΔH_c, in $kJ\,mol^{-1}$.

Include a sign in your answer.

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

ΔH_c = ... $kJ\,mol^{-1}$ [2]

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

Show your working.

percentage error = ... [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 ΔH_c. Explain your answer.

....

....

....

.... [2]

(g) The value for ΔH_c of ethanol under standard conditions is –1367 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 ....

....

2 ....

....
[2]

(ii) It is possible to calculate ΔH_c of ethanol using average bond enthalpies and the chemical equation for the reaction.

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$

Using average bond enthalpies, ΔH_c of ethanol is –1297 kJ mol^{-1}.

Explain why this value is different from the actual value for ΔH_c of ethanol under standard conditions.

....

.... [1]

[Total: 11]

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

e.g. $CH_3CH_2CH_2CH_2Br(l) + NaOH(aq) \rightarrow CH_3CH_2CH_2CH_2OH(l) + NaBr(aq)$

A student carried out an experiment to compare the rate at which three halogenoalkanes, 1-chlorobutane, $CH_3CH_2CH_2CH_2Cl$, 1-bromobutane, $CH_3CH_2CH_2CH_2Br$, and 1-iodobutane, $CH_3CH_2CH_2CH_2I$, undergo hydrolysis. The method used was as follows:

- Place a 5 cm^3 sample of each halogenoalkane into separate test-tubes.
- Add 1 cm^3 of organic solvent to each test-tube.
- Add 2 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	$\frac{1}{\text{time}}$ / 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.

$$CH_3CH_2CH_2CH_2Cl(l) + NaOH(aq) \rightarrow CH_3CH_2CH_2CH_2OH(l) + NaCl(aq)$$

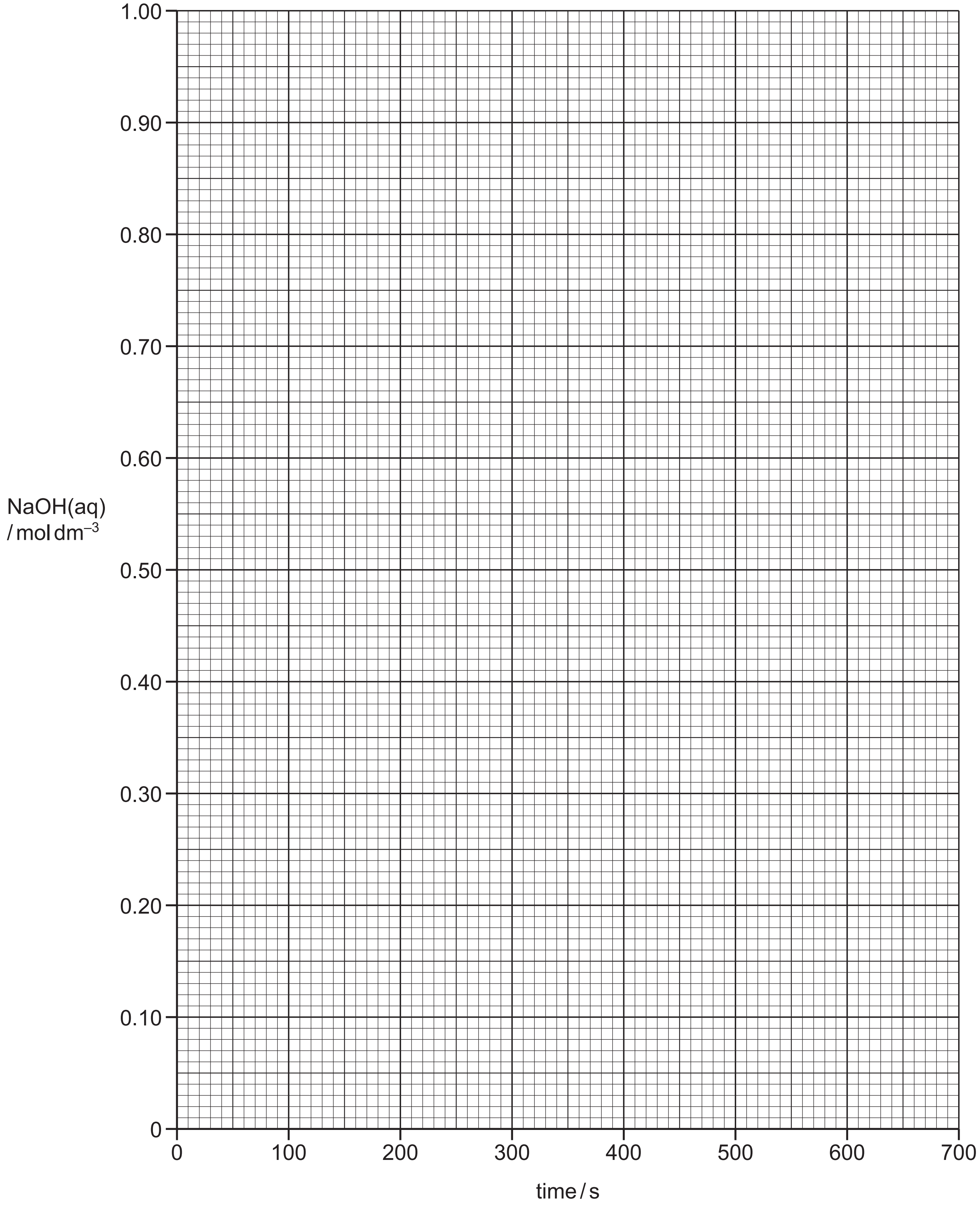
step 1 An excess of 1-chlorobutane was mixed with 1.00 mol dm^{-3} NaOH(aq), at room temperature.
step 2 A stop-clock was immediately started.
step 3 At intervals of 60 seconds the student took 10.00 cm^3 samples from the reaction mixture, for 11 minutes.
step 4 Each 10.00 cm^3 sample was immediately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

The results are shown.

time / s	concentration of NaOH(aq) / 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 (×) 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^3.

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

.... [1]

(ii) Suggest why the student did not remove 25.00 cm^3 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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