Cambridge International AS & A Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

9054557589

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **October/November 2020**

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. Blank pages are indicated.

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[Turn over

1 Calcium hydroxide, $Ca(OH)_2$, is slightly soluble in water. Aqueous calcium hydroxide is also known as limewater. A student measures the concentration of saturated aqueous calcium hydroxide using the following method.

step 1 Add a spatula measure of solid calcium hydroxide to 250 cm^3 of distilled water in a conical flask. Stopper the flask and shake the flask thoroughly.

step 2 Leave the flask stoppered for 24 hours.

step 3 Filter the aqueous calcium hydroxide into a clean, dry beaker.

step 4 Transfer 25.00 cm^3 of the aqueous calcium hydroxide to a clean conical flask.

step 5 Carry out a titration with 0.100 mol dm^{-3} hydrochloric acid.

step 6 Record the volume of hydrochloric acid required to react with the aqueous calcium hydroxide.

(a) (i) Suggest why it is necessary for the flask to remain stoppered in **step 2**.

.... [1]

(ii) Suggest why the student leaves the solution for 24 hours in **step 2**.

....

.... [1]

(b) (i) The student finds that the mean titre is 10.65 cm^3.
The equation for the reaction is shown.

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

Calculate the number of moles of calcium hydroxide that reacted.

moles of $Ca(OH)_2$ = ... mol [1]

(ii) Calculate the concentration of the aqueous calcium hydroxide in g dm^{-3}.
[A_r: Ca, 40.1; O, 16.0; H; 1.0]

concentration of $Ca(OH)_2(aq)$ = ... g dm^{-3} [2]

(iii) In a chemistry data book, the student found the value for the concentration of a saturated solution of calcium hydroxide at 293 K to be higher than the value calculated in **(b)(ii)**.

Give **two** reasons why the data book value is higher than the value calculated in **(b)(ii)**. (Assume the student recorded all volumes correctly, carried out the titration accurately and recorded concordant titres.)

....

....

.... [2]

(c) A second student carried out the experiment but did not filter their solution correctly in **step 3**, leaving some undissolved calcium hydroxide suspended in the solution.

Predict and explain how this would affect the titre obtained in their experiment.

....

.... [1]

(d) Describe how to prepare exactly 250.0 cm^3 of 0.100 $mol\,dm^{-3}$ hydrochloric acid from 1.00 $mol\,dm^{-3}$ hydrochloric acid. Include the names and capacities of any suitable apparatus used.

....

....

....

.... [2]

[Total: 10]

2 Sodium thiosulfate reacts with excess dilute hydrochloric acid according to the following equation.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + S(s) + SO_2(g) + H_2O(l)$$

The reaction produces sulfur dioxide which is corrosive and toxic by inhalation.

The effect of temperature on the rate of this reaction can be investigated by the 'disappearing cross experiment' as follows.

step 1 Measure 10.00 cm^3 of 0.100 mol dm^{-3} $Na_2S_2O_3(aq)$ and transfer into a boiling tube.

step 2 Into a second boiling tube, transfer 10 cm^3 of 0.500 mol dm^{-3} $HCl(aq)$.

step 3 Heat both tubes in the same water-bath.

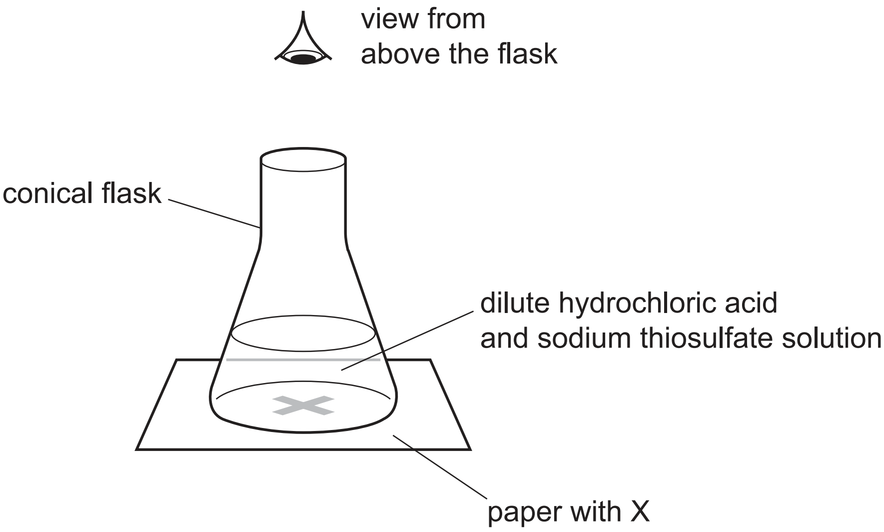
step 4 Place a conical flask on a piece of paper, on which is drawn a large X.

step 5 When the solutions reach the required temperature, remove them from the water-bath, pour the contents of both tubes into the conical flask and immediately start a timer.

step 6 The X on the paper should be viewed from above the flask as shown in the diagram.

step 7 When the X can no longer be seen, due to formation of solid sulfur, stop the timer.

step 8 Repeat the experiment using the same volumes and concentrations of solution at different temperatures.



(a) State **one** precaution that should be taken to reduce a hazard caused by one of the products of this reaction.

....

.... [1]

(b) Suggest appropriate equipment for measuring the required volumes of $Na_2S_2O_3(aq)$ and $HCl(aq)$ stated in the method.

$Na_2S_2O_3(aq)$ ....

$HCl(aq)$ ....
[1]

The student recorded their data in the table.

A	B	C	D	E	F
temperature / °C	temperature, T / K	time, t, for cross to disappear / s	rate of reaction $\left(\frac{1}{t}\right)$ / s^{-1}	$\frac{1}{T}$ / K^{-1}	2.303 log $\left(\frac{1}{t}\right)$
60	333	7.39	0.135		–2.00
50	323	13.46	0.0743		–2.60
41	314	21.12	0.0473		–3.05
36	309	40.45	0.0247		–3.70
27	300	49.40	0.0202		–3.90
21	294	70.11	0.0143		–4.25

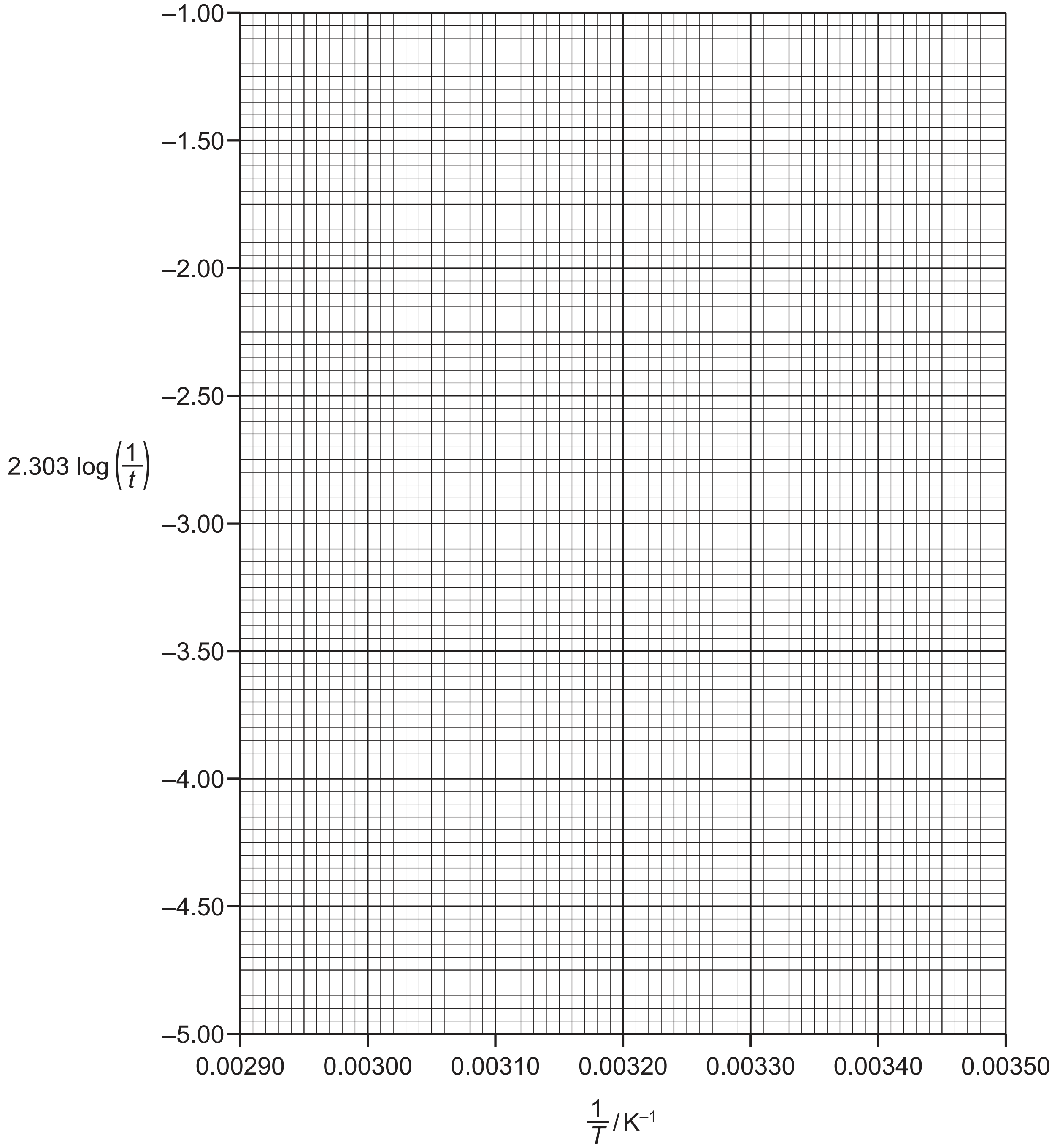
(c) Complete column E in the table, giving your values to **three significant figures**. [1]

(d) The activation energy, E_a, of the reaction between sodium thiosulfate and hydrochloric acid can be calculated using the equation shown.

$$2.303 \log\left(\frac{1}{t}\right) = -E_a / RT$$

$R = 8.31\,J\,K^{-1}\,mol^{-1}$

(i) Plot a graph of $2.303 \log\left(\frac{1}{t}\right)$ on the *y*-axis and $\frac{1}{T}$ on the *x*-axis. Draw a line of best fit.



[2]

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

Suggest **two** possible errors in how the procedure was carried out which could have caused this anomalous point.

1 ....

....

2 ....

....
[2]

(iii) Use the graph to determine the gradient of the line of best fit.

State the coordinates of both points you used in your calculation. These must be selected from your line of best fit.

Give the gradient to **three significant figures**.

coordinates 1 .... coordinates 2 ....

gradient = ... K
[2]

(iv) Use the gradient you have calculated and the equation to calculate E_a, in kJ mol^{-1}, for the reaction.

Give your answer to **two significant figures**. Include a sign.

E_a = ... kJ mol^{-1} [3]

(e) A student repeats the experiment at 60 °C but with a different concentration of $Na_2S_2O_3$(aq). The new solution is named solution **B**. The time taken until X can no longer be seen is 11.52 s.

Assume no error was made in the timing.

State whether the concentration of solution **B** is more or less than 0.10 mol dm^{-3}.

Explain your answer.

....

....

.... [1]

(f) It is more appropriate for the values in column C of the table on page 6 to be recorded to the nearest second.

Suggest **one** reason for this.

....

.... [1]

[Total: 14]

3 A student investigates the reaction between magnesium and hydrochloric acid to determine the order of reaction with respect to hydrochloric acid.

The student is supplied with 2.00 mol dm^{-3} hydrochloric acid and six identical, clean pieces of magnesium ribbon.

In experiment 1, the student places 50 cm^{3} of 2.00 mol dm^{-3} hydrochloric acid in a 100 cm^{3} beaker and adds a piece of magnesium ribbon to the acid in the beaker. The student records how long it takes for the magnesium ribbon to disappear.

The student carries out five further experiments, diluting the 2.00 mol dm^{-3} hydrochloric acid each time to provide results from five different concentrations of acid.

The student carries out each experiment in a 100 cm^{3} beaker.

(a) (i) Complete the table so the student can use it to record the reaction time for each experiment. The table should include suggested volumes of acid and water for each experiment. Columns should be suitably labelled.

experiment number			
1			
2			
3			
4			
5			
6			

[2]

(ii) Identify the dependent variable in this experiment.

.... [1]

(iii) Apart from the magnesium ribbon, identify **one** variable that should be controlled in these experiments.

.... [1]

(b) Explain why the student's proposed method of determining the reaction time may lead to inaccuracies in the recorded results.

....

.... [1]

(c) Suggest **one** other variable that could be measured to determine the order of the reaction.

....

.... [1]

[Total: 6]

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