Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8628836894

CHEMISTRY **9701/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2016**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **9** printed pages and **3** blank pages.

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1 Lithium is a soft alkali metal which may be cut with a knife. It is usually stored under oil because it reacts rapidly with moisture and oxygen in the air.

Lithium is **corrosive** and may cause burns. **Lithium** is **highly flammable** and in large amounts reacts violently with water.

$$2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$$

This reaction can be used to determine the relative atomic mass of lithium by measuring the volume of hydrogen produced from a small amount of lithium.

(a) Draw the apparatus you could use to measure the volume of hydrogen produced, using standard laboratory equipment.

Label the chemicals in your diagram and show how the reactants can be kept apart until the reaction is started.

[3]

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(b) To successfully carry out this experiment a correct procedure must be followed. The lithium you will use is stored as large pieces under oil.

(i) Beginning with a large piece of lithium being removed from the oil, state how you would prepare a small piece of lithium for use in this experiment.

.....

..... [1]

(ii) By only observing the gas collecting apparatus, state how you would know the reaction had stopped.

.....

..... [1]

(iii) Other than eye protection, state two precautions you would take to make sure that the experiment proceeds safely.

1. .....

.....

2. .....

..... [2]

(iv) The relative atomic mass of lithium is known to be approximately 7.

What approximate volume of hydrogen gas would a 0.1 g mass of lithium produce?

(1 mol of gas occupies 24.0 dm^3 at room temperature and pressure.)

volume of $H_2(g)$ produced ..... [1]

(v) What would be the capacity (volume) of the gas collecting apparatus you would use for the volume of hydrogen produced in **(iv)**?

volume of gas collecting apparatus ..... [1]

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[Turn over

(c) Another method that can be used to determine the relative atomic mass of lithium is by titration of the lithium hydroxide produced during its reaction with water.

The following experimental procedure may be used.

1. Add 100.0 cm^3 of distilled water to a clean beaker.
2. Add a known mass of lithium to the distilled water.
3. After the reaction is complete, transfer 25.0 cm^3 of the solution of lithium hydroxide from the beaker to a clean conical flask.
4. Titrate this with an acid of known concentration.

(i) State how you would accurately measure the total volume of distilled water in step 1.

..... [1]

(ii) State how you would know that the reaction between lithium and distilled water was complete.

.....

..... [1]

(iii) State how you would transfer 25.0 cm^3 of the solution of lithium hydroxide into a clean conical flask in step 3.

..... [1]

(iv) State how you would ensure that your titration result was reliable.

.....

..... [1]

(d) To make sure that the beaker and the conical flask used in the experimental procedure in **(c)** are clean, a student decides to wash them out with some distilled water before starting the experiment.

Some water remains in the beaker. State the effect, if any, this would have on the calculated relative atomic mass of lithium. Explain your reasoning.

.....

.....

.....

Some water remains in the conical flask. State the effect, if any, this would have on the calculated relative atomic mass of lithium. Explain your reasoning.

.....

.....

.....
[2]

[Total: 15]

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2 Activation energy, E_A, is the minimum energy with which particles must collide so that a reaction occurs. The activation energy for the reaction of magnesium with aqueous hydrogen ions can be determined in the laboratory.

$$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$$

A magnesium strip is placed in dilute hydrochloric acid and the time taken (t), in seconds, for the magnesium to disappear is measured. The initial rate of reaction is calculated as $\frac{1}{\text{time}}$ $\left(\frac{1}{t}\right)$.

If the experiment is repeated at several different temperatures then the following mathematical relationship can be used to calculate E_A.

$$\log_{10}\left(\frac{1}{t}\right) = \frac{-E_A}{0.0191} \times \left(\frac{1}{T}\right)$$

T is the temperature measured in K.

$\frac{1}{t}$ is the initial rate of reaction in s^{-1}.

A graph of $\log_{10}\left(\frac{1}{t}\right)$ against $\frac{1}{T}$ can be plotted.

Experimental procedure

1. 25 cm^3 of dilute hydrochloric acid is added to a boiling tube.
2. The boiling tube is placed in a water bath until the dilute hydrochloric acid reaches a constant temperature. This temperature is recorded.
3. A magnesium strip of mass 0.10 g is added to the boiling tube, the mixture stirred and the time taken for the magnesium to disappear is recorded.
4. The temperature of the water bath is changed and the experiment is repeated.

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[Turn over

(a) The results of this experiment, carried out at different temperatures, are recorded in the table below.

Process the results to calculate the reciprocal of temperature $\left(\frac{1}{T}\right)$ and $\log_{10}\left(\frac{1}{t}\right)$. The first value of $\frac{1}{T}$ has been done for you.

Record $\frac{1}{T}$ in **standard form** to **three** significant figures.

Record $\log_{10}\left(\frac{1}{t}\right)$ to **two** decimal places. You should expect $\log_{10}\left(\frac{1}{t}\right)$ to be negative.

temperature /°C	time, t/s	temperature, T/K	$\frac{1}{T}$/K^{-1}	$\frac{1}{t}$/s^{-1}	$\log_{10}\left(\frac{1}{t}\right)$
15	83	288	3.47×10^{-3}	1.20×10^{-2}	
20	58	293		1.72×10^{-2}	
27	36	300		2.78×10^{-2}	
30	28	303		3.57×10^{-2}	
34	18	307		5.56×10^{-2}	
38	19	311		5.26×10^{-2}	
40	15	313		6.67×10^{-2}	
43	12	316		8.33×10^{-2}	
48	9	321		1.11×10^{-1}	
55	8	328		1.25×10^{-1}	

[3]

(b) Plot a graph on the grid on page 7 to show the relationship between $\log_{10}\left(\frac{1}{t}\right)$ and $\frac{1}{T}$.
Use a cross (**×**) to plot each data point.
Draw a line of best fit. [2]

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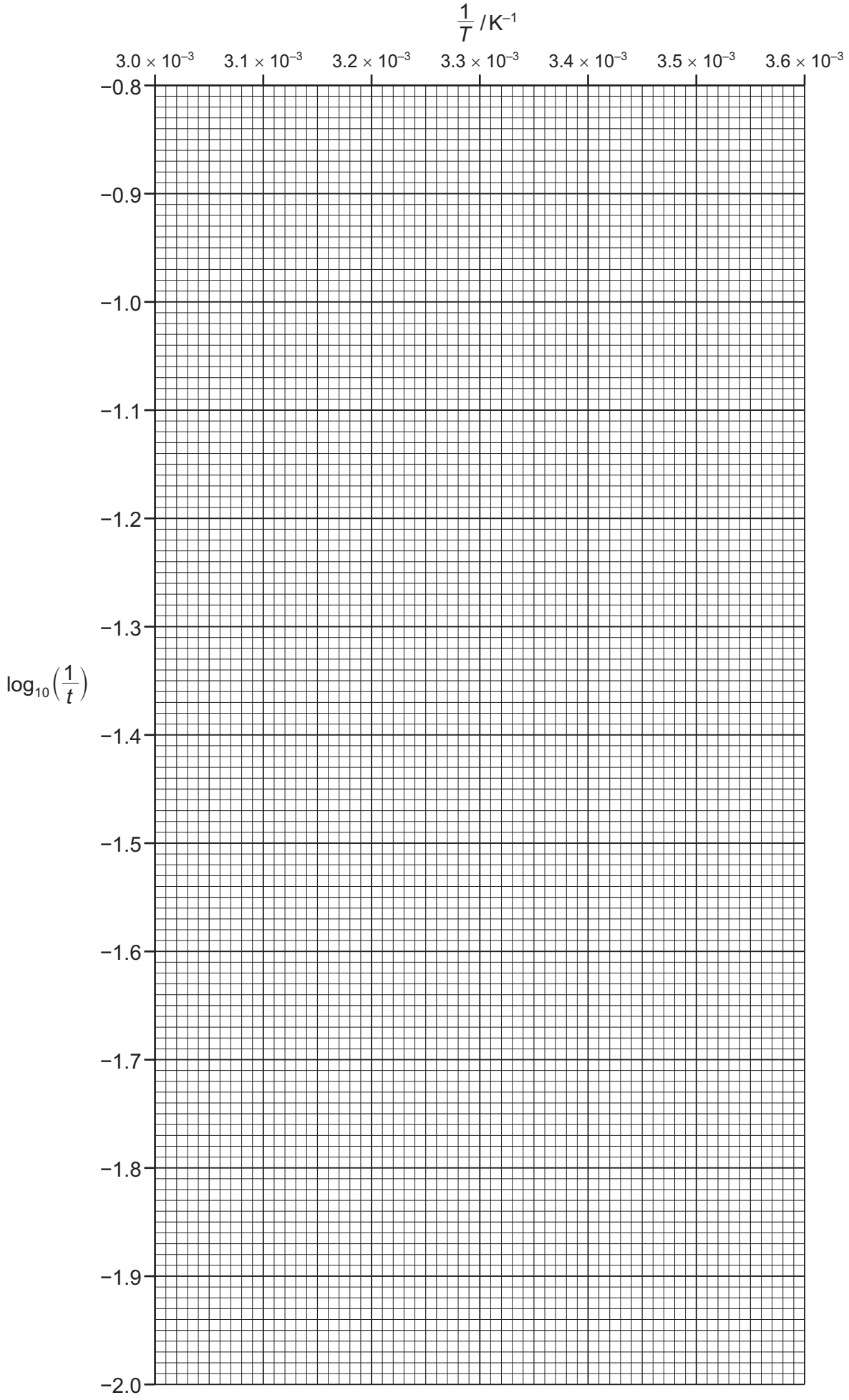
$\frac{1}{T}$ / K^{-1}
3.0 × 10^{-3}
3.1 × 10^{-3}
3.2 × 10^{-3}
3.3 × 10^{-3}
3.4 × 10^{-3}
3.5 × 10^{-3}
3.6 × 10^{-3}
−0.8
−0.9
−1.0
−1.1
−1.2
−1.3
$\log_{10}\left(\frac{1}{t}\right)$
−1.4
−1.5
−1.6
−1.7
−1.8
−1.9
−2.0

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(c) On your graph, circle the two points you consider to be the most anomalous. Label each one with a different letter. Explain what may have caused each of the anomalies you have identified, giving a different reason each time.
Make it clear in your answer to which point you are referring.

.....

.....

.....

..... [2]

(d) **(i)** Determine the gradient of your graph. State the co-ordinates of both points you used for your calculation.
Record the value of the gradient to **three** significant figures.

co-ordinates 1 .....

co-ordinates 2 .....

gradient = ...
[2]

(ii) Use your gradient from **(i)** and the mathematical relationship on page 5 to calculate the activation energy, E_A, in $kJ\,mol^{-1}$.
Include a sign in your answer.

E_A = ... $kJ\,mol^{-1}$ [2]

(e) State whether you consider the results to be reliable. Explain your answer.

.....

.....

..... [1]

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(f) Student X commented that data collected at higher temperatures in the experiment may be less accurate than that collected at lower temperatures.

State whether student X is correct. Explain why.

.....

.....

..... [1]

(g) If the magnesium strip is not stirred it floats to the surface of the hydrochloric acid.

State how this will affect the reaction time. Explain why.

.....

.....

..... [1]

(h) The experiment in **(a)** is repeated using dilute ethanoic acid instead of dilute hydrochloric acid. The concentration of both acids is equal. The same temperatures are used as in **(a)**.

State the effect this change in acid will have on the initial rate values. Give a reason for this.

.....

.....

..... [1]

[Total: 15]

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