

--	--	--	--	--

--	--	--	--

9701/51

May/June 2016

1 hour 15 minutes

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

DO **NOT** WRITE IN ANY BARCODES.

Use of a Data Booklet is unnecessary.

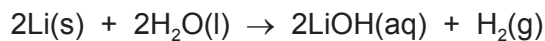
The number of marks is given in brackets [] at the end of each question or part question.

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

- 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.



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]

(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 dm³ at room temperature and pressure.)

volume of H₂(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]

- (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 cm³ 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 cm³ 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 cm³ 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]

- 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.



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.

- (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.

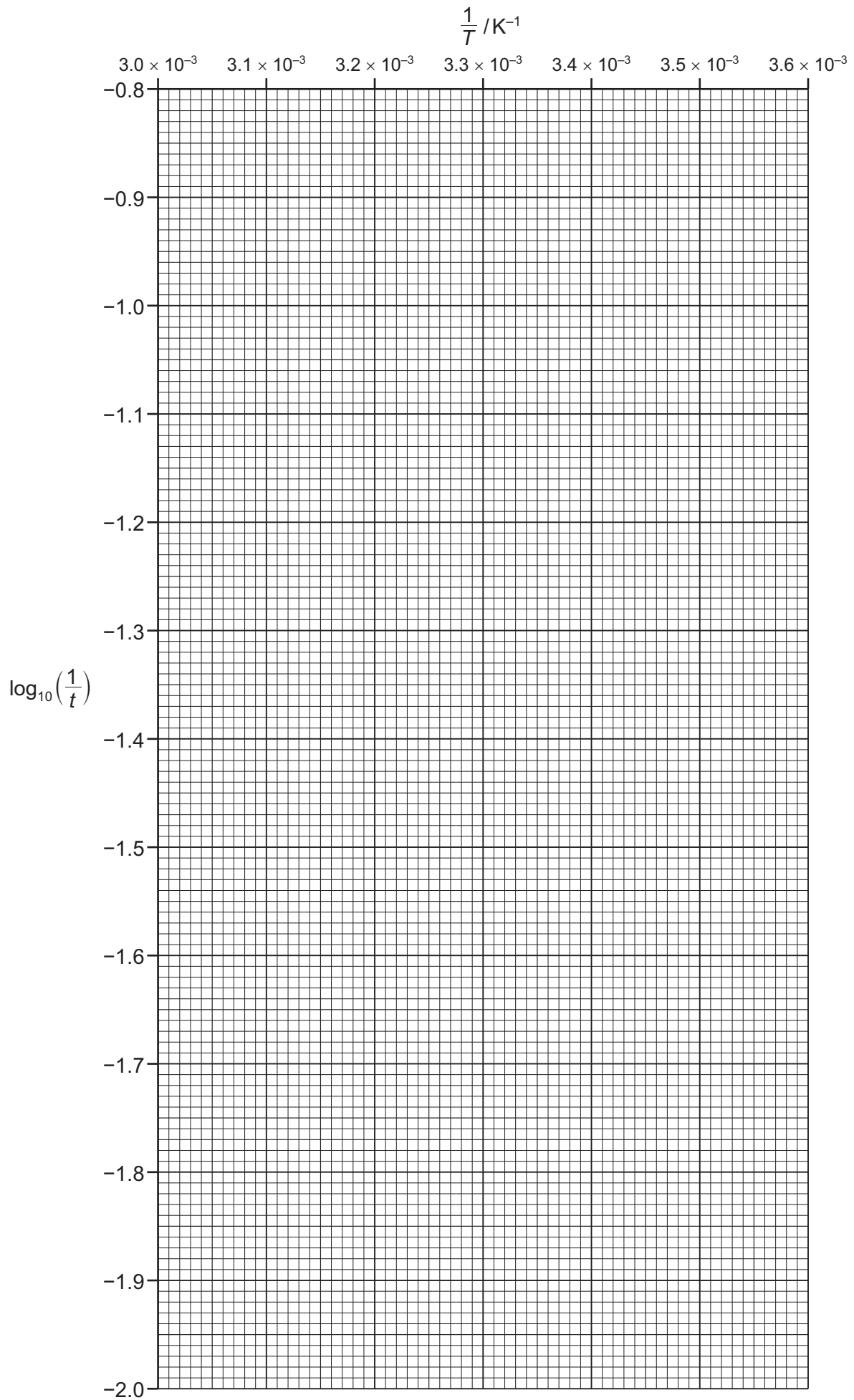
Record $\log_{10}\left(\frac{1}{t}\right)$ to **two** decimal places. You should expect $\log_{10}\left(\frac{1}{t}\right)$ to be negative.

temperature / $^{\circ}\text{C}$	time, t/s	temperature, T/K	$\frac{1}{T} / \text{K}^{-1}$	$\frac{1}{t} / \text{s}^{-1}$	$\log_{10}\left(\frac{1}{t}\right)$
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 (x) to plot each data point.
Draw a line of best fit.

[2]



- (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.

$E_A = \dots\dots\dots \text{kJ mol}^{-1}$ [2]

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

.....

 [1]

- (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]

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge International Examinations Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cie.org.uk after the live examination series.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.