2 A student investigates how the rate of reaction of magnesium ribbon with dilute acid changes as the concentration of the acid is changed. The student uses five solutions of the same acid, **A**, **B**, **C**, **D**, and **E**. Each solution has a different concentration. The acid is in excess in all experiments.

The student does five experiments.

Experiment 1

- Use a 50 cm^3 measuring cylinder to pour 30 cm^3 of acid **A** into a 100 cm^3 conical flask.
- Add a coil of magnesium ribbon to the acid in the conical flask and immediately start a stop-watch.
- Continually swirl the mixture in the conical flask until the magnesium ribbon disappears completely. Immediately stop the stop-watch and record the time in seconds to the nearest second.
- Empty and rinse the conical flask with distilled water.

Experiment 2

- Repeat Experiment 1 using 30 cm^3 of acid **B** instead of acid **A**.

Experiment 3

- Repeat Experiment 1 using 30 cm^3 of acid **C** instead of acid **A**.

Experiment 4

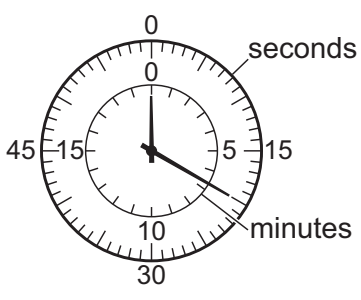
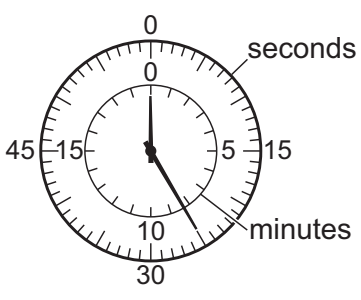
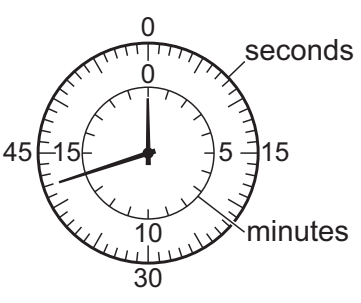
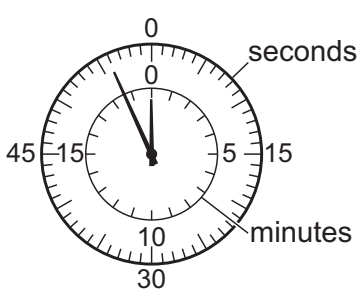
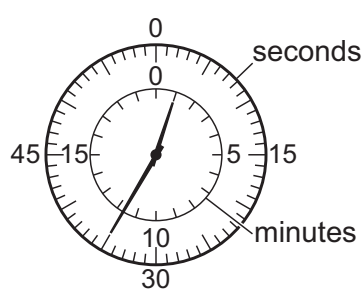
- Repeat Experiment 1 using 30 cm^3 of acid **D** instead of acid **A**.

Experiment 5

- Repeat Experiment 1 using 30 cm^3 of acid **E** instead of acid **A**.

(a) Use the stop-watch diagrams to complete Table 2.1

Table 2.1

experiment	acid	concentration of acid in mol / dm^3	stop-watch diagram	time for magnesium to disappear in s
1	**A**	2.0		
2	**B**	1.5		
3	**C**	1.0		
4	**D**	0.8		
5	**E**	0.5		

[2]

(b) Write a suitable scale on the *y*-axis and plot the results from Experiments 1 to 5 on Fig. 2.1.

Draw a line of best fit.

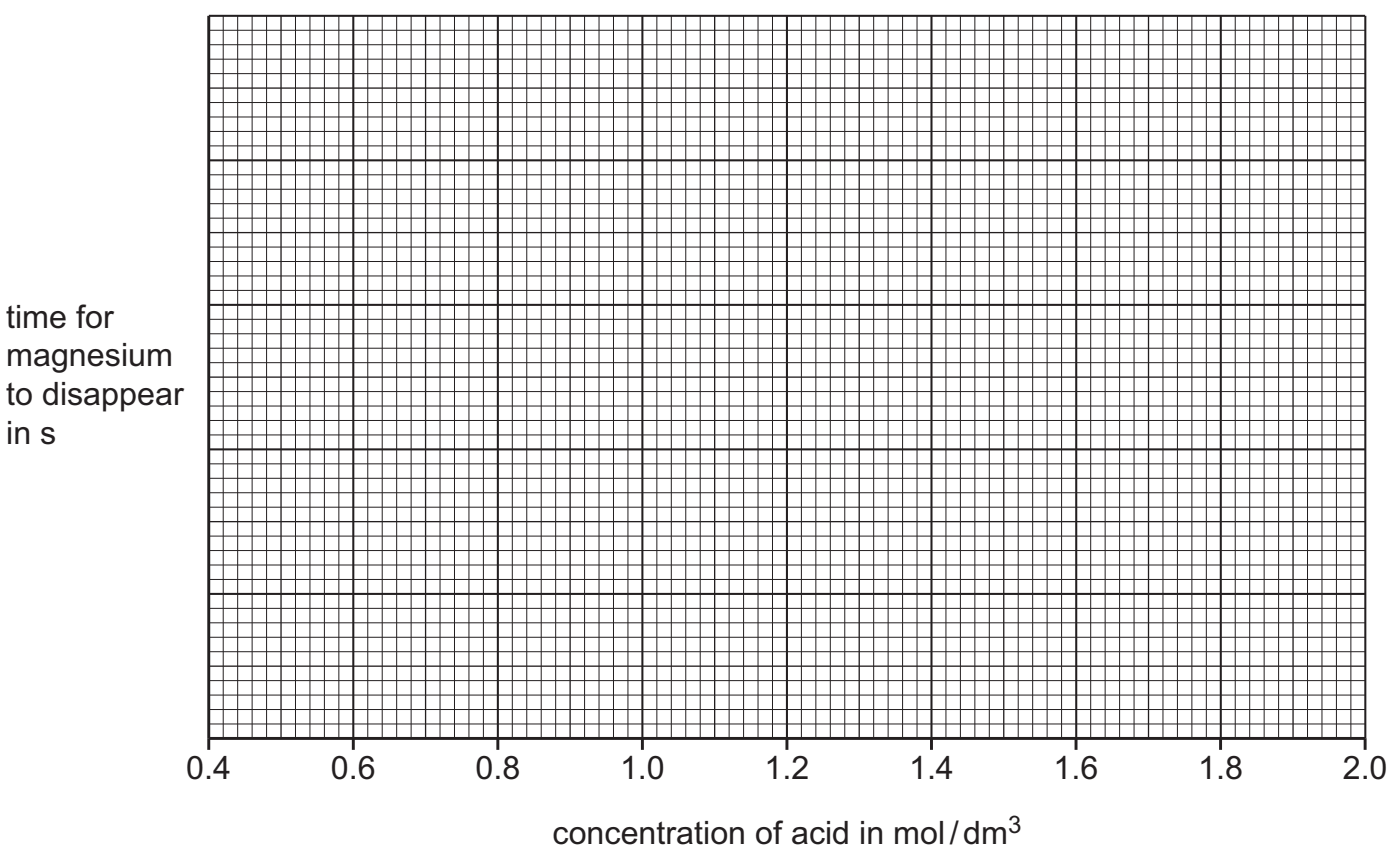


Fig. 2.1

[4]

(c) From your graph in Fig. 2.1, deduce the time for the magnesium to disappear when the concentration of the acid is 1.3 mol / dm^3.

Show clearly on Fig. 2.1 how you worked out your answer.

time for magnesium to disappear = ... s [2]

(d) The mean rate of reaction is calculated using the equation shown.

$$\text{mean rate of reaction} = \frac{\text{length of magnesium ribbon in cm}}{\text{time for magnesium to disappear in s}}$$

The length of each coil of magnesium ribbon used in all five experiments was 5 cm.

(i) Calculate the mean rate of reaction in Experiment 1. Give units for the rate you have calculated.

mean rate of reaction = ...

units .....
[2]

(ii) Deduce in which Experiment, 1, 2, 3, 4 or 5, the mean rate of reaction is the slowest.

..... [1]

(e) Explain why repeating each experiment is an improvement.

.....

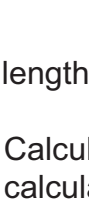
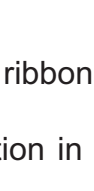
..... [1]

(f) The student does another experiment to find the temperature change when magnesium reacts with acid **A**.

- Use the measuring cylinder to pour 30 cm^3 of acid **A** into the 100 cm^3 conical flask.
- Measure the initial temperature of the acid in the conical flask.
- Add a coil of magnesium ribbon to the acid in the conical flask.
- Continually swirl the conical flask until the magnesium ribbon disappears completely.
- Measure the final temperature of the acid in the conical flask.

(i) Use the thermometer diagrams to complete Table 2.2.

Table 2.2

thermometer diagram for initial temperature	initial temperature / °C	thermometer diagram for final temperature	final temperature / °C	temperature change / °C
				

[2]

(ii) Explain why controlling the temperature of the acid so that it remains constant is an improvement.

.....

..... [1]

(iii) Explain why using a polystyrene cup instead of the 100 cm^3 conical flask does **not** control the temperature of the acid.

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..... [1]

(iv) Describe how the temperature of the acid can be controlled and kept constant.

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..... [1]

[Total: 17]