16 Hydrogen peroxide solution decomposes very slowly at room temperature to produce oxygen gas. This gas forms a rising foam when liquid detergent is added.

Five test-tubes are half-filled with hydrogen peroxide solution. A drop of liquid detergent is added to each one.

Different metal oxides are added to four of the test-tubes and the height of the foam formed after one minute is measured. The results are shown.

metal oxide	height of foam / cm
no metal oxide added	0.1
aluminium oxide	0.1
calcium oxide	0.2
copper(II) oxide	2.3
manganese(IV) oxide	5.4

Which conclusion can be drawn from these results?

A Metal oxides do **not** affect the rate of this reaction.

B All metal oxides increase the rate of this reaction and act as catalysts.

C Manganese(IV) oxide is the best catalyst of the four metal oxides tested.

D Only transition element oxides increase the rate of this reaction.

IGCSE Chemistry: **w25 22**

16 Aqueous sodium thiosulfate, $Na_2S_2O_3$, reacts with dilute hydrochloric acid to form a yellow precipitate of sulfur.

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

The precipitate forms more quickly when the reactants are heated.

Which statements explain this observation?

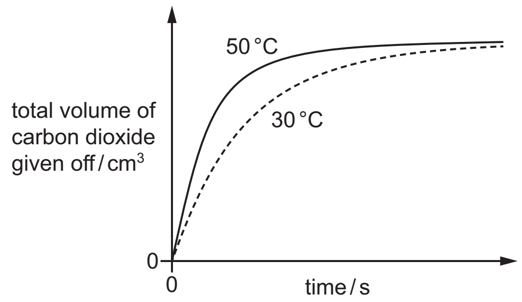
1 The reacting particles collide more frequently.

2 The collisions between reacting particles have more energy.

3 The activation energy of the reaction is lower.

A 1 and 2 **B** 1 and 3 **C** 1 only **D** 2 and 3

15 The graph shows the results of adding excess calcium carbonate to hydrochloric acid at 50 °C and at 30 °C. Only the temperature is changed.



Which row describes the reacting particles at 30 °C compared to those at 50 °C?

	frequency of collisions between particles	average kinetic energy of particles
A	higher	higher
B	higher	lower
C	lower	higher
D	lower	lower

IGCSE Chemistry: **s25 22**

15 Which statement describes the effect of adding a catalyst to a chemical reaction?

A The activation energy, E_a, of the reaction is increased.

B The enthalpy change, ΔH, of the reaction stays unchanged.

C The frequency of collisions between the particles is decreased.

D The kinetic energy of the particles is increased.

15 The rate of reaction between magnesium and dilute hydrochloric acid is increased by increasing the concentration of the acid.

How does this affect the reacting particles?

	collision rate of particles	proportion of particles with sufficient energy to react
A	increases	increases
B	increases	stays the same
C	stays the same	increases
D	stays the same	stays the same

IGCSE Chemistry: **s25 61**

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

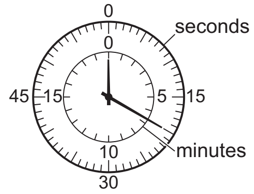
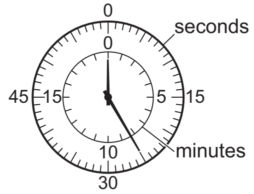
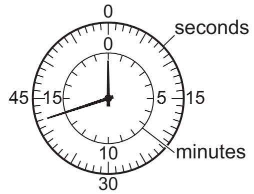
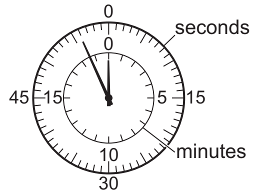
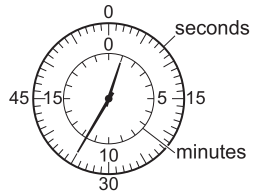
- Repeat Experiment 1 using 30 cm^3 of acid **D** instead of acid **A**.

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.

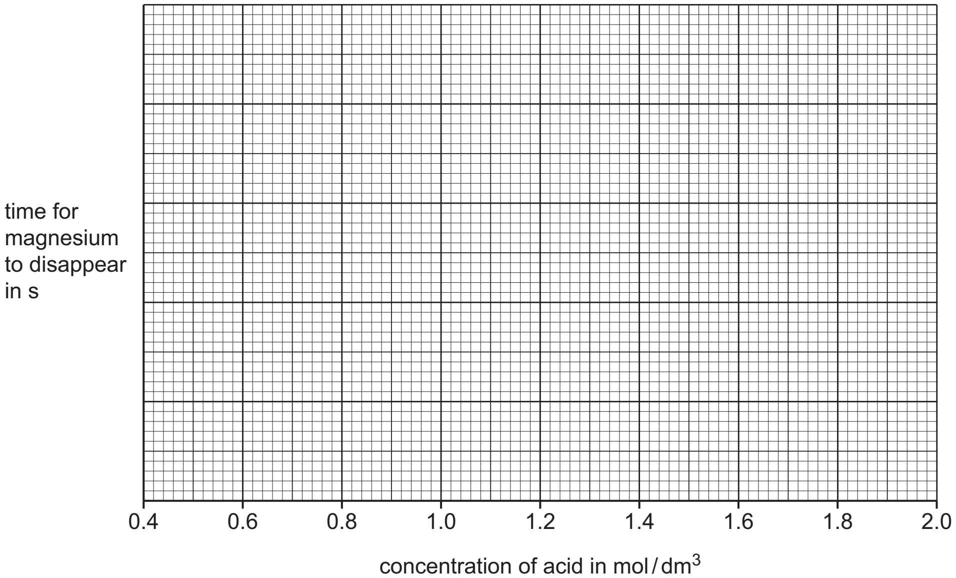


Fig. 2.1

[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.

....

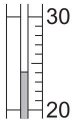
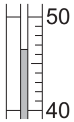
.... [1]

(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.

....

.... [1]

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

....

.... [1]

[Total: 17]

2 A student investigates how the rate of reaction between dilute hydrochloric acid and aqueous sodium thiosulfate changes as the concentration of the aqueous sodium thiosulfate decreases. During the reaction, the solution slowly becomes cloudy. As the solution becomes cloudy, it becomes more difficult to see through the solution.

The student does five experiments.

Experiment 1

- Use a 50 cm^3 measuring cylinder to pour 50 cm^3 of aqueous sodium thiosulfate into a 100 cm^3 beaker.
- Use a 10 cm^3 measuring cylinder to pour 5 cm^3 of dilute hydrochloric acid into the beaker containing the aqueous sodium thiosulfate.
- Immediately start a stop-watch and stir the contents of the beaker.
- Stand the beaker on a printed sheet and look down from above the beaker as shown in Fig. 2.1.

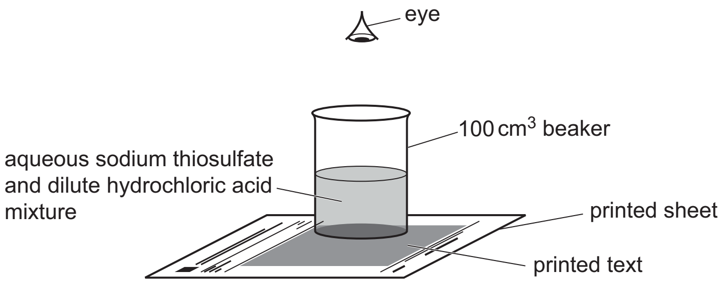


Fig. 2.1

- When the text on the printed sheet is **not** visible, stop the stop-watch and record the time to the nearest whole number of seconds.
- Empty the contents of the beaker and rinse the beaker with distilled water.

Experiment 2

- Repeat Experiment 1 using 40 cm^3 of aqueous sodium thiosulfate instead of 50 cm^3. Use the 50 cm^3 measuring cylinder to add 10 cm^3 of distilled water to the beaker **before** adding the dilute hydrochloric acid.

Experiment 3

- Repeat Experiment 2 using 30 cm^3 of aqueous sodium thiosulfate and 20 cm^3 of distilled water.

Experiment 4

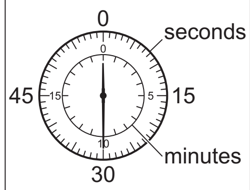
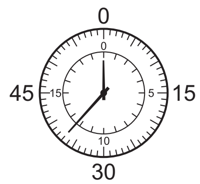
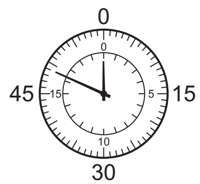
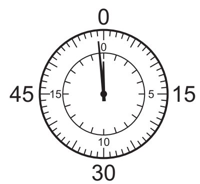
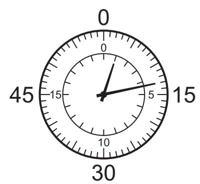
- Repeat Experiment 2 using 25 cm^3 of aqueous sodium thiosulfate and 25 cm^3 of distilled water.

Experiment 5

- Repeat Experiment 2 using 20 cm^3 of aqueous sodium thiosulfate and 30 cm^3 of distilled water.

(a) Use the information in the description of the experiments and the stop-watch diagrams to complete Table 2.1.

Table 2.1

experiment	volume of aqueous sodium thiosulfate / cm^3	volume of distilled water / cm^3	volume of dilute hydrochloric acid / cm^3	stop-watch diagram	time taken for text to **not** be visible / s
1	50	0	5		
2					
3					
4					
5					

[3]

(b) Write a suitable scale on the *y*-axis and plot the results from Experiments 1 to 5 on Fig. 2.2.

Draw a curve of best fit.

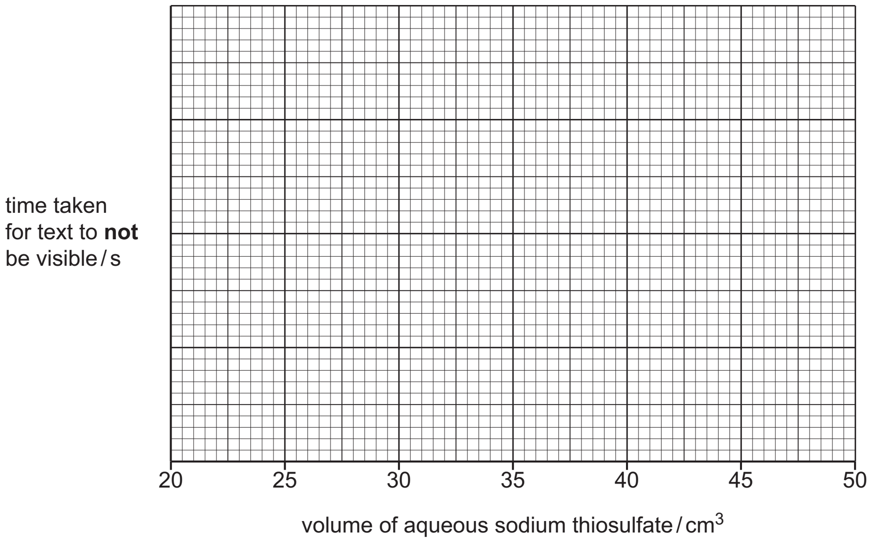


Fig. 2.2

[4]

(c) The relative rate of reaction in each experiment is calculated using the equation shown.

$$\text{relative rate of reaction} = \frac{1}{\text{time taken}}$$

(i) Calculate the relative rate of reaction in Experiment 1.
Do **not** give units for your answer.

relative rate of reaction = ... [1]

(ii) State in which Experiment, 1, 2, 3, 4 or 5, the relative rate of reaction was greatest.

.... [1]

(d) In each experiment the total volume of aqueous sodium thiosulfate and distilled water is constant.

(i) Calculate the volume of distilled water needed when the volume of aqueous sodium thiosulfate is 37 cm^3.

volume = ... [2]

(ii) From your graph in Fig. 2.2, deduce the time for the text to **not** be visible when the volume of aqueous sodium thiosulfate is 37 cm^3.

Show clearly on Fig. 2.2 how you worked out your answer.

time = ... s [2]

(iii) Explain why the total volume of aqueous sodium thiosulfate and distilled water is kept constant.

....

....

.... [1]

(e) **(i)** State why measuring the volume of the dilute hydrochloric acid with a burette instead of a measuring cylinder would be an improvement.

....

.... [1]

(ii) Explain why it is **not** possible to use a volumetric pipette to measure the volume of aqueous sodium thiosulfate in each experiment.

....

.... [1]

(f) Explain why it is important **not** to change the size of the beaker to a larger beaker during the investigation.

....

....

.... [2]

[Total: 18]

19 Which statements explain why increasing the temperature in a reaction involving gases increases the rate of reaction?

1 It increases the collision frequency between the gas particles.

2 It lowers the activation energy.

3 It increases the kinetic energy of the gas particles.

4 It increases the number of gas particles per unit volume.

A 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 2 and 4