Access Tuition

GCSE Chemistry

Rate Experiments

Question Paper

Time available: 60 minutes
Marks available: 57 marks

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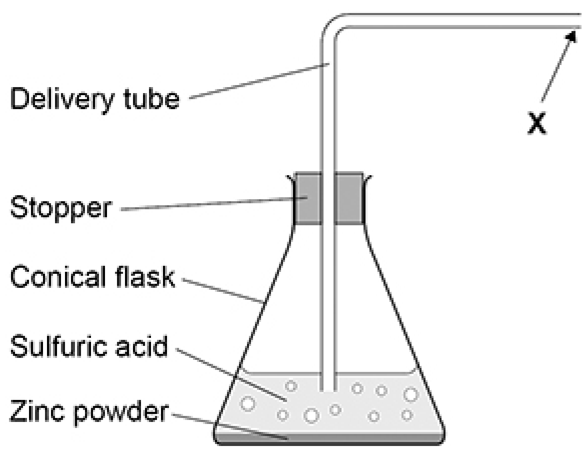
1. A student investigated the rate of the reaction between zinc and sulfuric acid.

This is the method used.

1. Pour 40 cm^3 of sulfuric acid into a conical flask.
2. Add 2.0 g of zinc powder to the conical flask.
3. Put the stopper in the conical flask.
4. Measure the volume of hydrogen gas collected every 30 seconds for 5 minutes.

Figure 1 shows part of the apparatus used.

Figure 1



(a) **X** shows where a piece of equipment is connected to measure the volume of hydrogen gas collected.

Complete **Figure 1** to show the equipment used.

(1)

(b) The student made an error setting up the delivery tube shown in **Figure 1**.

Describe the error **and** the problem this error would cause.

Error made ____

____

Problem caused ____

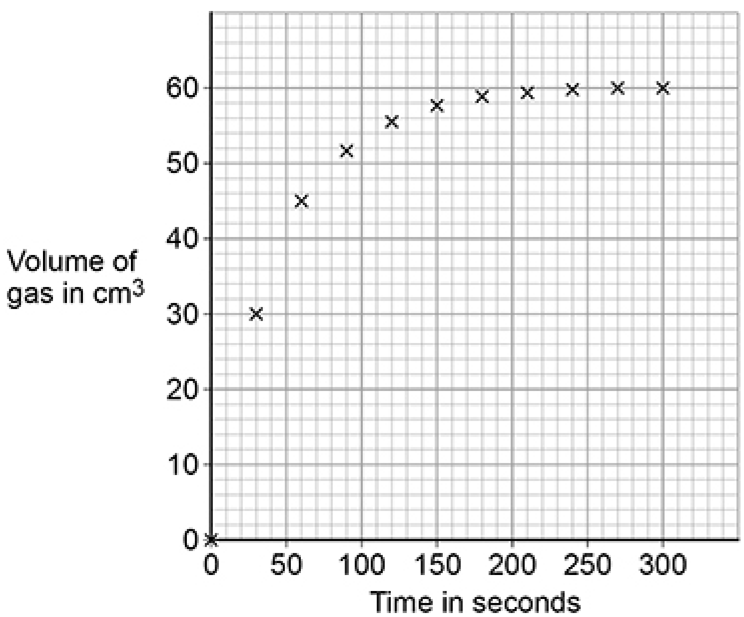
____

(2)

The student then set up the apparatus correctly.

Figure 2 shows the student's results.

Figure 2



(c) Complete **Figure 2** by drawing a line of best fit.

(1)

(d) Determine the mean rate of reaction between 0 seconds and 60 seconds.

Use the equation:

$$\text{mean rate of reaction} = \frac{\text{volume of gas formed}}{\text{time taken}}$$

Use data from **Figure 2**.

Give the unit.

Choose the answer from the box.

cm^3/ s	**g / s**	**s / cm^3**	**s / g**

____

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Mean rate of reaction = _______________ Unit __________

(4)

(e) The student repeated the investigation using sulfuric acid of a higher concentration.

The student plotted the results and drew a line of best fit.

How would the line of best fit for higher concentration compare with the line of best fit for lower concentration?

Tick (✓) **one** box.

The line of best fit for higher concentration would have a less steep slope.	☐
The line of best fit for higher concentration would have a steeper slope.	☐
The lines of best fit would have slopes with the same steepness.	☐

(1)

(Total 9 marks)

2. A student investigated how a change in concentration affects the rate of the reaction between zinc powder and sulfuric acid.

The equation for the reaction is:

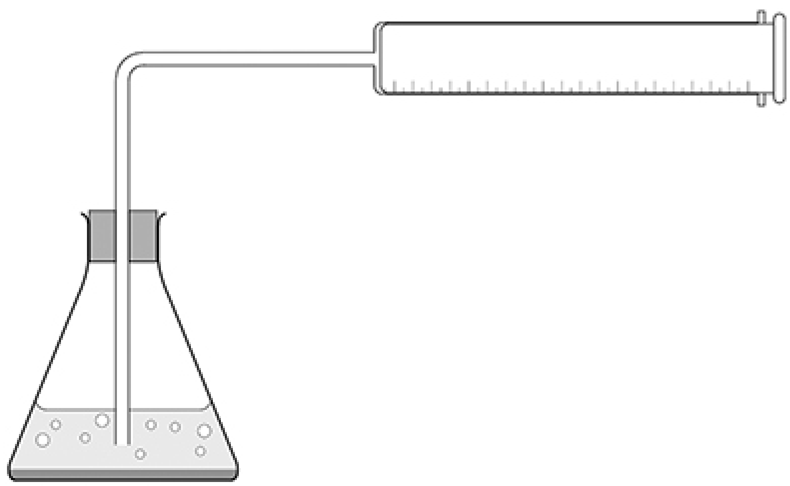
$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

This is the method used.

1. Pour 50 cm^3 of sulfuric acid of concentration 0.05 mol/dm^3 into a conical flask.
2. Add 0.2 g of zinc powder to the conical flask.
3. Put the stopper in the conical flask.
4. Measure the volume of gas collected every 30 seconds for 5 minutes.
5. Repeat steps 1 to 4 with sulfuric acid of concentration 0.10 mol/dm^3

Figure 1 shows the apparatus used.

Figure 1



(a) The student made an error in setting up the apparatus in **Figure 1**.

What error did the student make?

____

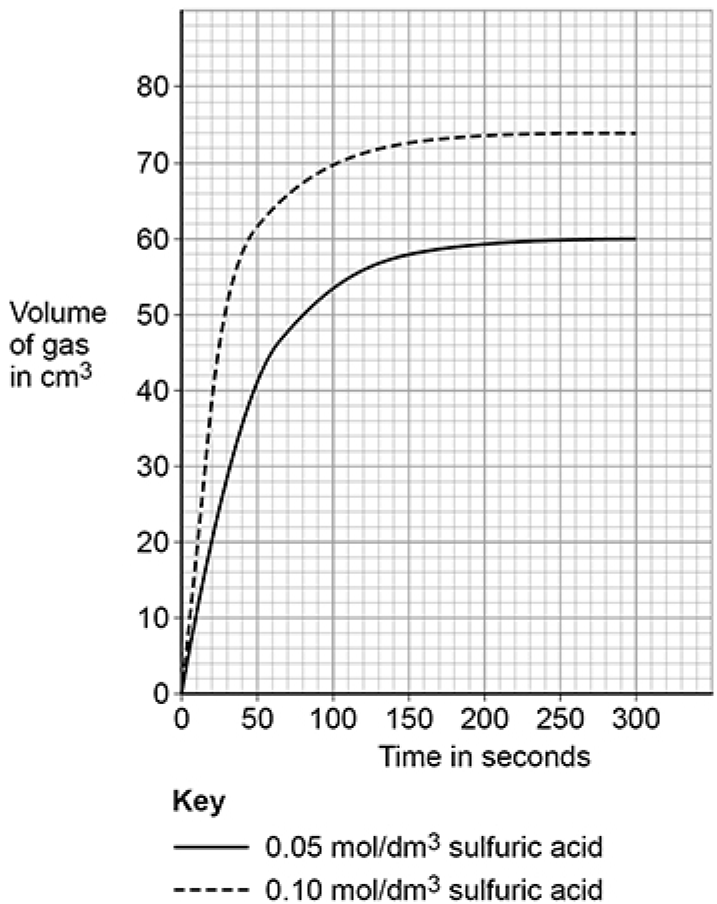
____

(1)

The student corrected the error.

Figure 2 shows the student's results.

Figure 2



(b) Explain why the lines of best fit on **Figure 2** become horizontal.

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(2)

(c) How does **Figure 2** show that zinc powder reacts more slowly with 0.05 mol/dm^3 sulfuric acid than with 0.10 mol/dm^3 sulfuric acid?

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(1)

(d) Determine the rate of the reaction for 0.05 mol/dm^3 sulfuric acid at 80 seconds.

Show your working on **Figure 2**.

Give your answer to 2 significant figures.

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Rate of reaction (2 significant figures) = _______________ cm^3/s

(5)

(e) The activation energy for the reaction between zinc and sulfuric acid is lowered if a solution containing metal ions is added.

What is the most likely formula of the metal ions added?

Tick (✓) **one** box.

Al^{3+} ☐

Ca^{2+} ☐

Cu^{2+} ☐

Na^{+} ☐

(1)

(Total 10 marks)

3. Some students investigated the rate of decomposition of hydrogen peroxide, H_2O_2

The equation for the reaction is:

$$2\ H_2O_2(aq) \rightarrow 2\ H_2O(l) + O_2(g)$$

The catalyst for the reaction is manganese dioxide.

(a) Describe a test to identify the gas produced in the reaction.

Give the result of the test.

Test ____

____

Result ____

____

(2)

Student **A** investigated the effect of the particle size of manganese dioxide on the rate of the reaction.

This is the method used.

1. Measure 25 cm^3 of 0.3 mol/dm^3 hydrogen peroxide solution into a conical flask.

2. Add a spatula of fine manganese dioxide powder to the conical flask.

3. Measure the volume of gas produced every minute for 10 minutes.

4. Repeat steps 1 to 3 with some coarse manganese dioxide lumps.

(b) The method student **A** used did not give valid results.

What **two** improvements could student **A** make to the method to give valid results?

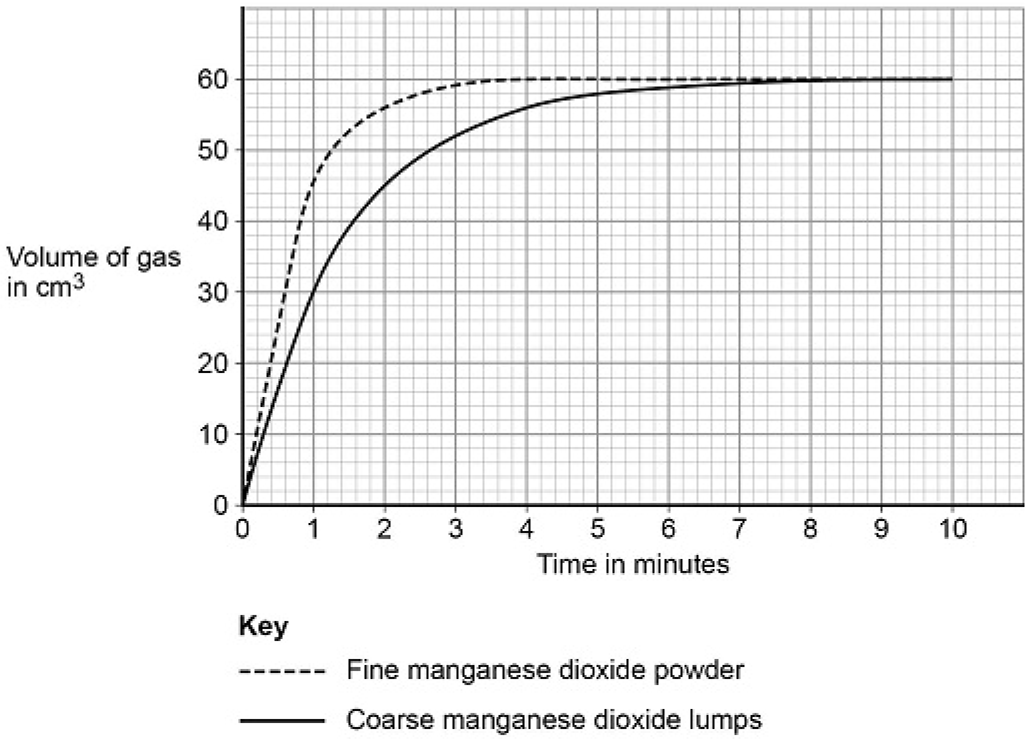
Tick (✓) **two** boxes.

Measure the increase in mass of the conical flask and contents.	☐
Measure the volume of gas produced every 2 minutes.	☐
Place the conical flask in a water bath at constant temperature.	☐
Use 0.05 mol/dm^3 hydrogen peroxide solution.	☐
Use a mass of 1 g manganese dioxide each time.	☐

(2)

Student **B** used a method which gave valid results.

The graph below shows student **B**'s results.



(c) Determine the mean rate of reaction in cm^3/s between 2 and 4 minutes for coarse manganese dioxide lumps.

Give your answer to 2 significant figures.

Use data from the graph.

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Mean rate of reaction = ______________________ cm^3/s

(3)

Hydrogen peroxide molecules must collide with manganese dioxide particles for catalysis to take place.

(d) Student **B** repeated the experiment with coarse lumps of manganese dioxide.

Student **B** used the same volume of 0.2 mol/dm^3 hydrogen peroxide instead of 0.3 mol/dm^3 hydrogen peroxide.

Sketch on the graph above the curve you would expect to see.

Assume that the reaction is complete after 9 minutes.

(2)

(e) The rate of reaction is different when manganese dioxide is used as a fine powder rather than coarse lumps.

Explain why.

You should answer in terms of collision theory.

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(2)

(Total 11 marks)

4. The symbol equation for the decomposition of hydrogen peroxide is:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

(a) This reaction is *exothermic*.

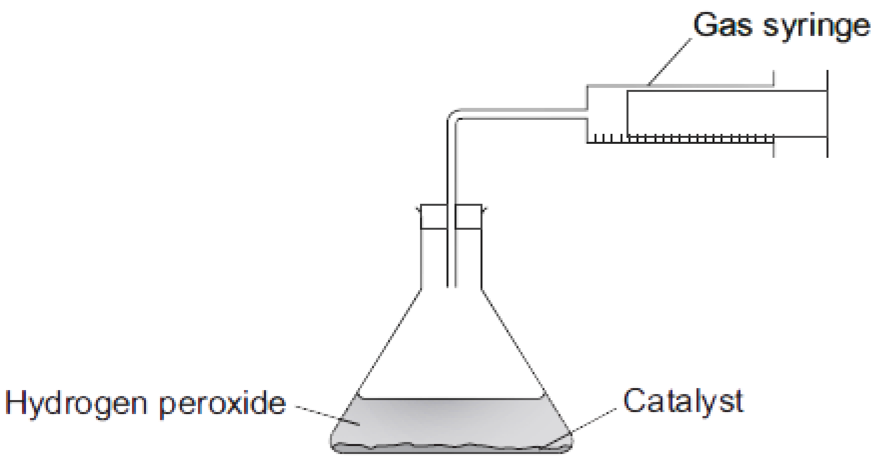
What is an *exothermic* reaction?

____

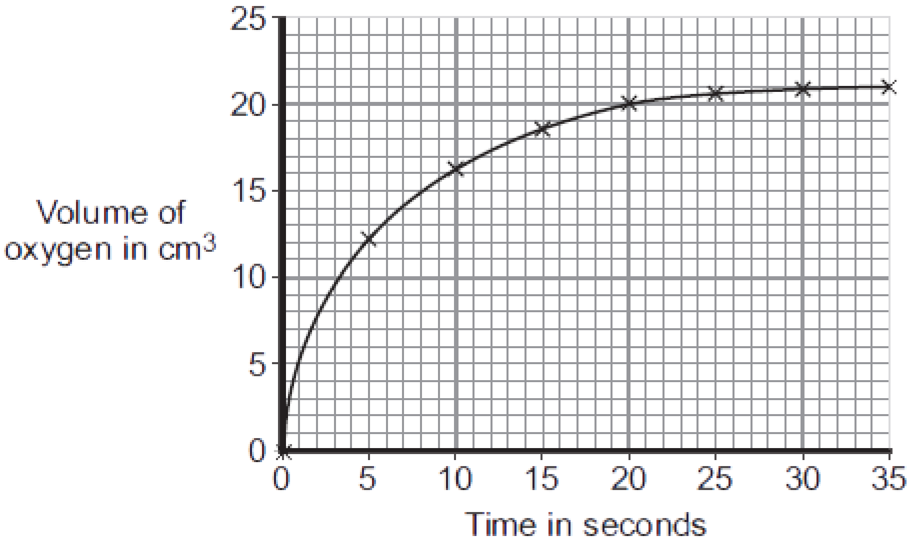
____

(1)

(b) A student measured the volume of oxygen produced by 50 cm^3 of hydrogen peroxide.



The graph shows the results.



(i) Use the graph to describe the changes in the rate of the reaction from 0 to 35 seconds.

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(3)

(ii) What was the total volume of oxygen gas collected?

______________________ cm^3

(1)

(iii) The student had calculated that the hydrogen peroxide used should produce 25 cm^3 of oxygen.

Calculate the percentage yield of oxygen.

___

___

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Answer = ________________ %

(2)

(c) An increase in the temperature of the hydrogen peroxide increases the rate of the reaction.

Use your knowledge of particles to explain why.

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(3)

(Total 10 marks)

5. This question is about the reaction between sodium thiosulfate solution and hydrochloric acid.

When hydrochloric acid is added to sodium thiosulfate solution, the mixture gradually becomes cloudy.

The equation for the reaction is:

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

(a) Sulfur is produced in the reaction.

Why does the mixture become cloudy?

___

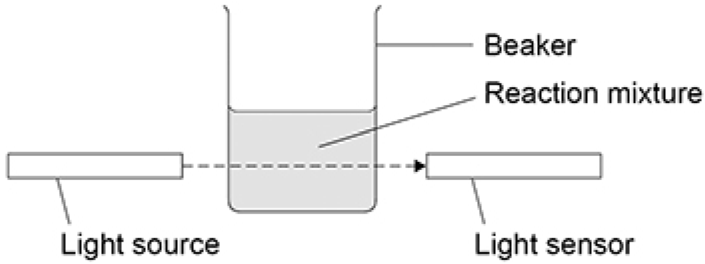
___

(1)

A student investigated the effect of changing the concentration of sodium thiosulfate solution on the rate of the reaction.

Figure 1 shows the apparatus used.

Figure 1



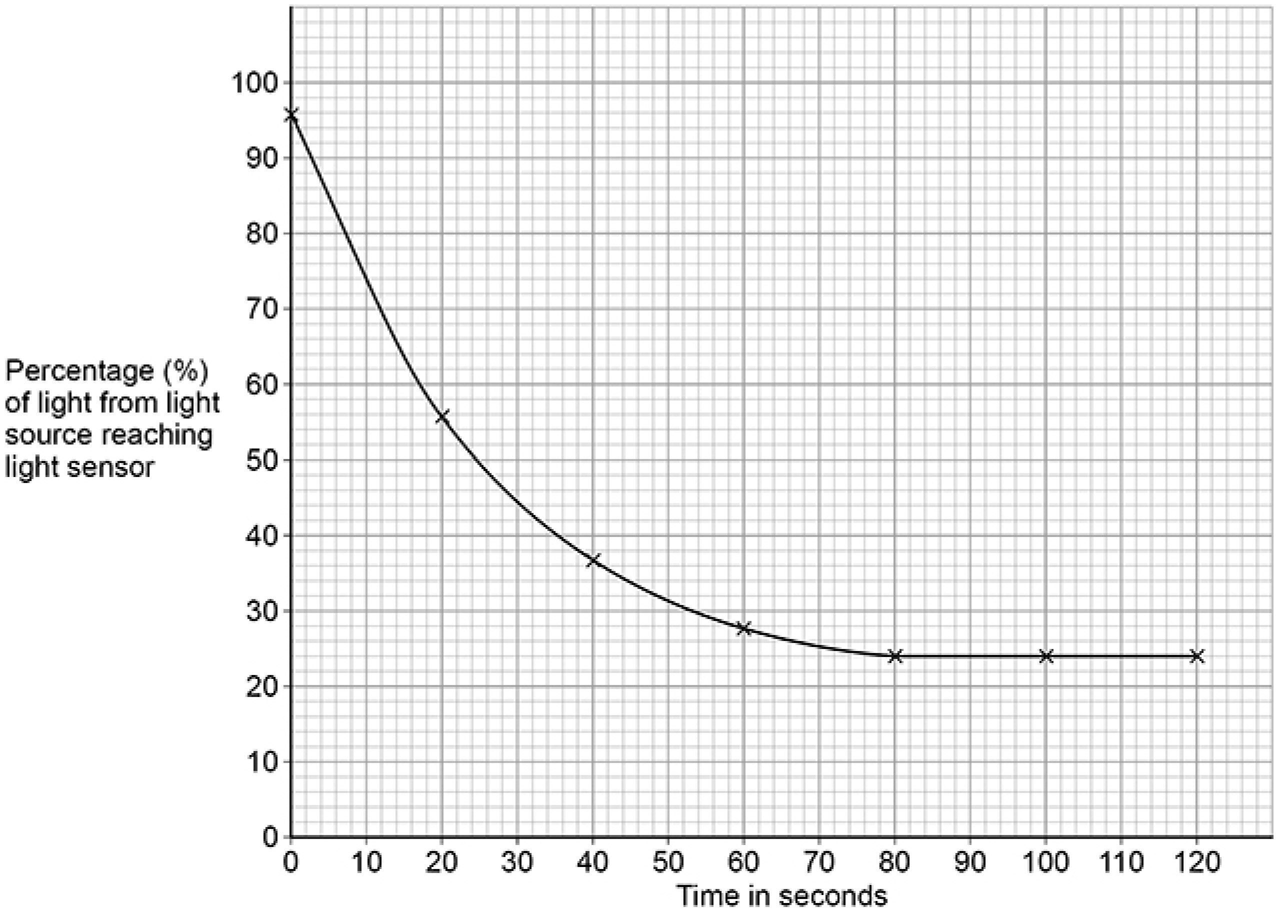
A smaller percentage of light from the light source reaches the light sensor as the mixture becomes more cloudy.

This is the method used.

1. Measure 50 cm^3 of 0.10 mol/dm^3 sodium thiosulfate solution into the beaker.
2. Add 10 cm^3 of hydrochloric acid to the sodium thiosulfate solution.
3. Immediately start a timer.
4. Record the percentage of light from the light source that reaches the light sensor every 20 seconds for 120 seconds.
5. Repeat steps 1 to 4 using 0.20 mol/dm^3 sodium thiosulfate solution.

Figure 2 shows the results for 0.10 mol/dm^3 sodium thiosulfate solution.

Figure 2



(b) The percentage of light reaching the light sensor decreases by 1% when 7.1×10^{-5} moles of sulfur is produced.

Determine the rate of reaction in mol/s for the production of sulfur at 30 seconds.

You should draw a tangent on **Figure 2**.

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Rate = ________________ mol/s

(5)

(c) Explain why the rate of reaction changes between 0 and 60 seconds.

Answer in terms of concentration.

Use **Figure 2**.

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(2)

Figure 3 is a repeat of **Figure 2**.

Figure 3

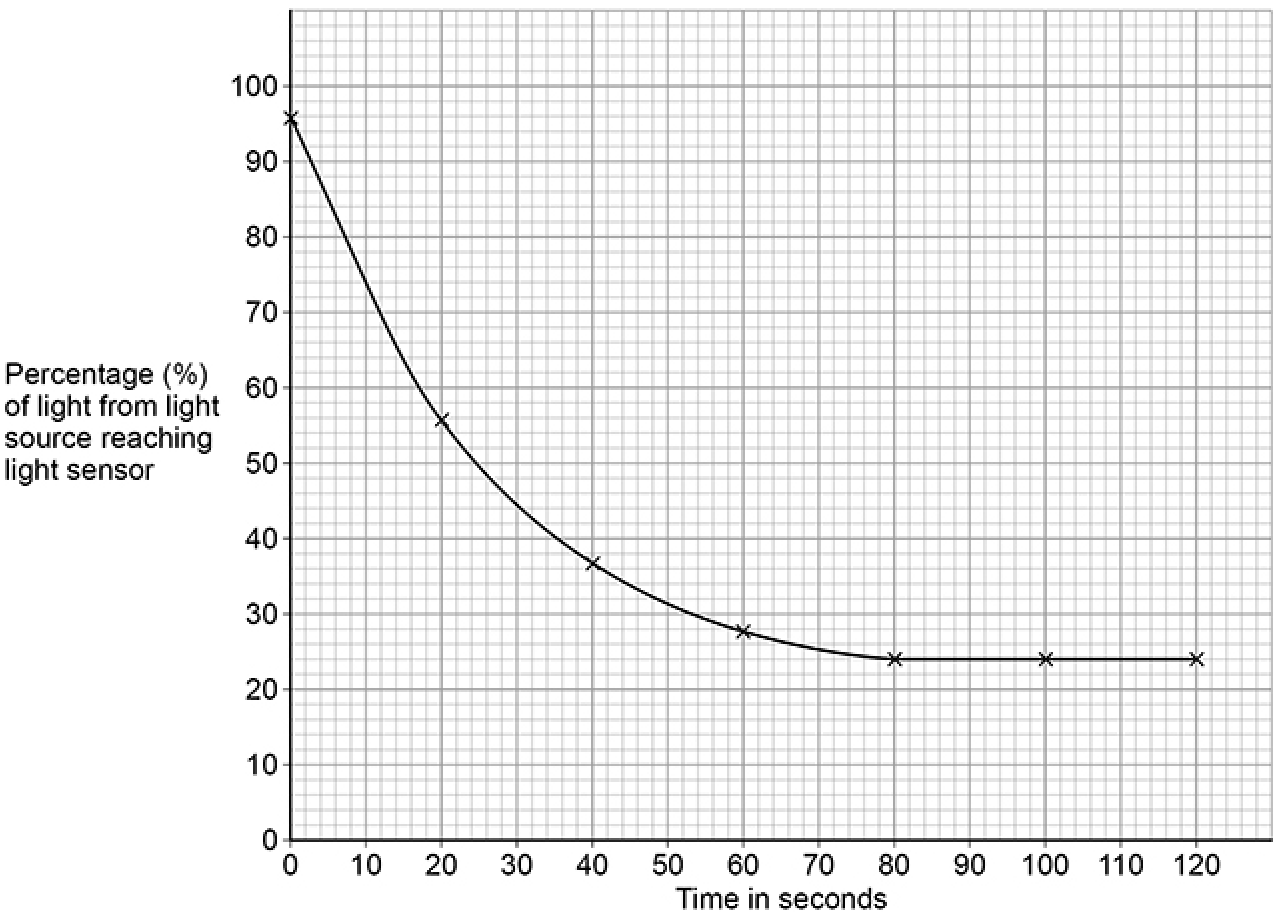


Figure 3 shows the results for 0.10 mol/dm^3 sodium thiosulfate solution.

Sodium thiosulfate solution was in excess in the investigation.

(d) The line of best fit on **Figure 3** is horizontal between 80 and 120 seconds because the reaction stopped.

Why did the reaction stop?

____

____

(1)

(e) Sketch a line on **Figure 3** to show the results you would predict for 0.20 mol/dm^3 sodium thiosulfate solution.

(2)

The same student did the investigation again the next day.

The student found that the same method produced different results for the percentage of light reaching the light sensor.

(f) How could the student improve the method so that the same percentages of light reached the light sensor?

Tick (✓) **one** box.

Record the percentage of light every 10 seconds.	☐
Stop light from other sources reaching the light sensor.	☐
Use a larger volume of sodium thiosulfate solution.	☐
Use a more sensitive light sensor.	☐

(1)

(g) The student improved the method so that similar results were obtained on different days.

What name is given to similar results obtained on different days under the same conditions by the same student?

Tick (✓) **one** box.

Anomalous	☐
Precise	☐
Repeatable	☐
Reproducible	☐

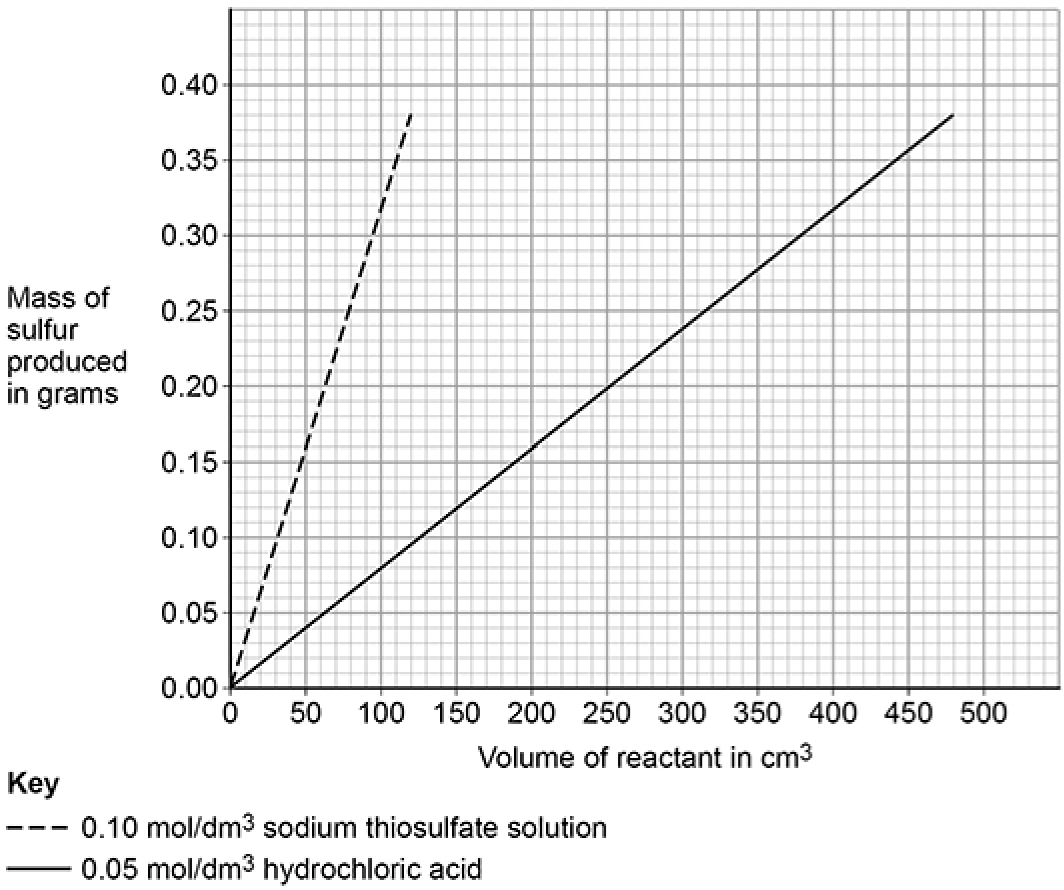
(1)

Figure 4 shows the volumes of:

- sodium thiosulfate solution of concentration 0.10 mol/dm^3
- hydrochloric acid of concentration 0.05 mol/dm^3

which completely react to produce different masses of sulfur.

Figure 4



(h) Which expression represents the relationship between the volume (V) of sodium thiosulfate solution used and the mass (m) of sulfur produced?

Use **Figure 4**.

Tick (✓) **one** box.

$V \propto m$	☐
$V \sim m$	☐
$V << m$	☐
$V = m$	☐

(1)

(i) Determine the simplest whole number ratio of the volumes of

sodium thiosulfate solution : hydrochloric acid

which completely react with each other.

Use **Figure 4**.

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Simplest whole number ratio = _______ **:** _______

(3)

(Total 17 marks)