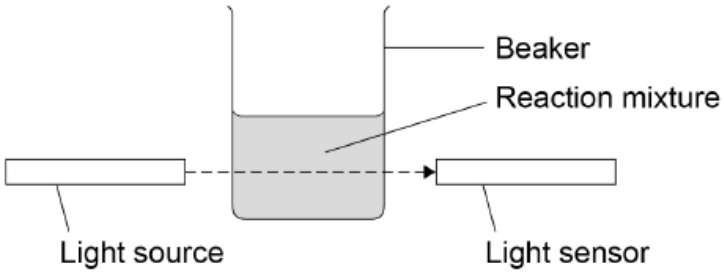
The rate and extent of chemical reaction – GCSE Chemistry

1. No.6

0 6 A student investigated the rate of reaction between sodium thiosulfate solution and hydrochloric acid.

Figure 7 shows the apparatus used.

Figure 7



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

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 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.

0 6 . 1 Balance the equation for this reaction.

[1 mark]

$$Na_2S_2O_3 + 2\,HCl \rightarrow \_\_\_\_\ NaCl + H_2O + SO_2 + S$$

0 6 . 2 The mixture becomes cloudy because the sulfur produced is a solid.

What is the state symbol for a solid?

[1 mark]

Tick (✓) **one** box.

(aq) ☐

(g) ☐

(l) ☐

(s) ☐

0 6 . 3 The student monitored the cloudiness of the reaction mixture using a light sensor.

What other piece of equipment could be used to monitor the cloudiness of the reaction mixture?

[1 mark]

Tick (✓) **one** box.

A balance ☐

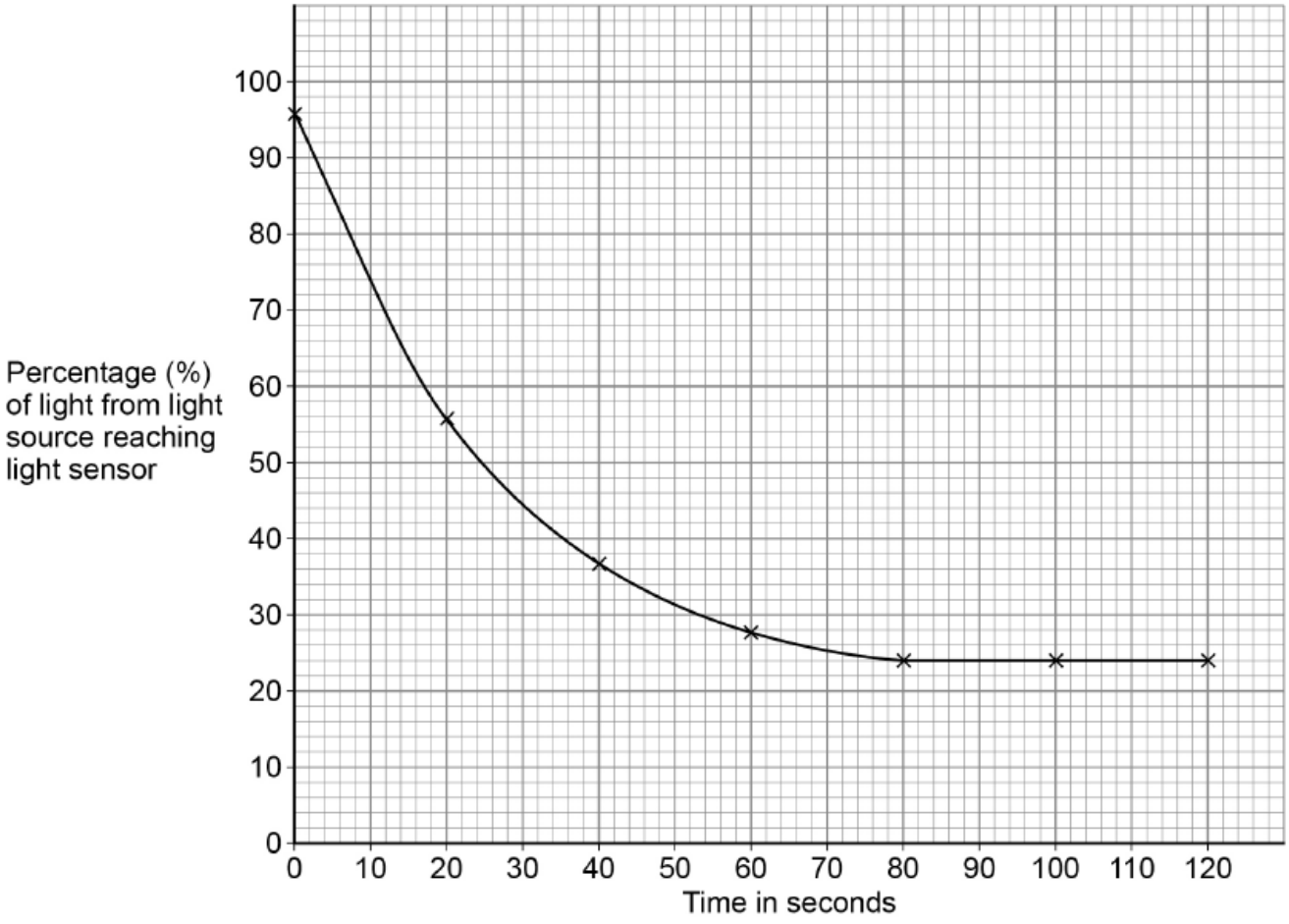
A cross on a piece of paper ☐

A gas syringe ☐

A thermometer ☐

Figure 8 shows the results.

Figure 8



0 6 . 4 What happened to the rate of reaction between 40 and 60 seconds?

Use **Figure 8**.

[1 mark]

Tick (✓) **one** box.

The rate of reaction decreased. ☐

The rate of reaction stayed at zero. ☐

The rate of reaction increased. ☐

0 6 . 5 The student stopped taking measurements after 120 seconds because the percentage of light reaching the sensor stayed constant.

Why did the percentage of light reaching the sensor stay constant?

[1 mark]

Tick (✓) **one** box.

No light was reaching the sensor. ☐

One of the reactants was used up. ☐

The reaction was too vigorous. ☐

0 6 . 6 The student repeated the experiment using sodium thiosulfate solution of a higher concentration.

How would the line of best fit for sodium thiosulfate solution of a higher concentration compare with the line of best fit on **Figure 8**?

[1 mark]

Tick (✓) **one** box.

Initially the line of best fit would be less steep. ☐

Initially the line of best fit would be the same steepness. ☐

Initially the line of best fit would be steeper. ☐

0 6 . 7 The student then investigated the effect of changing the temperature on the rate of reaction.

The student used sodium thiosulfate solution and hydrochloric acid which had been kept in an ice bath.

Which are **two** effects of using reactants kept in an ice bath rather than at room temperature?

[2 marks]

Tick (✓) **two** boxes.

- Fewer reactant particles have the activation energy. ☐
- The reactant particles collide more frequently. ☐
- The reactant particles have more energy. ☐
- The reactant particles move more slowly. ☐
- There are fewer reactant particles in the same volume. ☐

2. No.9

0 9 A student investigated the change in mass when hydrated cobalt chloride was heated.

The word equation for the reaction is:

hydrated cobalt chloride ⇌ anhydrous cobalt chloride + water

This is the method used.

1. Add 2.0 g of hydrated cobalt chloride to an empty test tube.

2. Measure the mass of the test tube and contents.

3. Heat the test tube and contents gently for 30 seconds.

4. Allow the test tube and contents to cool.

5. Measure the mass of the test tube and contents.

6. Repeat steps 3 to 5 until the mass of the test tube and contents does not change.

Table 9 shows the results.

Table 9

Total heating time in seconds	Mass of test tube and contents in grams
0	26.5
30	26.2
60	25.9
90	25.6
120	25.6

0 9 . 1 Determine the mass of the empty test tube.

[1 mark]

Mass of empty test tube = _____ g

0 9 . 2 Explain why the mass of the test tube and contents decreased.

[2 marks]

0 9 . 3 Suggest why the test tube and contents were heated until the mass did not change.

[1 mark]

Energy is taken in from the surroundings when hydrated cobalt chloride is heated.

0 9 . 4 When 238 g of hydrated cobalt chloride is heated until the mass does not change, 88.1 kJ of energy is taken in.

The student heated 2.00 g of hydrated cobalt chloride until the mass did not change.

Calculate the energy taken in during this reaction.

Give your answer to 3 significant figures.

[3 marks]

Energy taken in (3 significant figures) = _____ kJ

0 9 . 5 What type of reaction takes place when hydrated cobalt chloride is heated?

[1 mark]

3. No.2

0 2 A student investigated the change in mass when hydrated cobalt chloride was heated.

The word equation for the reaction is:

hydrated cobalt chloride ⇌ anhydrous cobalt chloride + water

This is the method used.

1. Add 2.0 g of hydrated cobalt chloride to an empty test tube.

2. Measure the mass of the test tube and contents.

3. Heat the test tube and contents gently for 30 seconds.

4. Allow the test tube and contents to cool.

5. Measure the mass of the test tube and contents.

6. Repeat steps 3 to 5 until the mass of the test tube and contents does not change.

Table 1 shows the results.

Table 1

Total heating time in seconds	Mass of test tube and contents in grams
0	26.5
30	26.2
60	25.9
90	25.6
120	25.6

0 2 . 1 Determine the mass of the empty test tube.

[1 mark]

Mass of empty test tube = _____ g

0 2 . 2 Explain why the mass of the test tube and contents decreased.

[2 marks]

0 2 . 3 Suggest why the test tube and contents were heated until the mass did not change.

[1 mark]

Energy is taken in from the surroundings when hydrated cobalt chloride is heated.

0 2 . 4 When 238 g of hydrated cobalt chloride is heated until the mass does not change, 88.1 kJ of energy is taken in.

The student heated 2.00 g of hydrated cobalt chloride until the mass did not change.

Calculate the energy taken in during this reaction.

Give your answer to 3 significant figures.

[3 marks]

Energy taken in (3 significant figures) = _____ kJ

0 2 . 5 What type of reaction takes place when hydrated cobalt chloride is heated?

[1 mark]

4. No.8

0 8 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:

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

0 8 . 1 Sulfur is produced in the reaction.

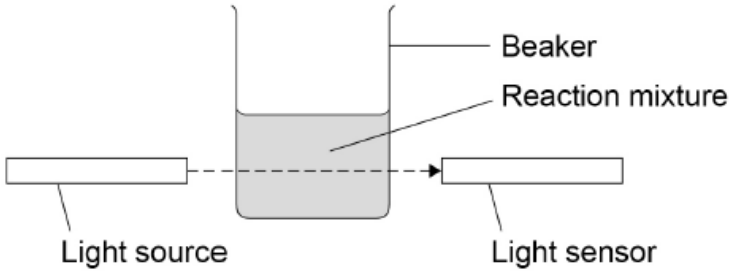
Why does the mixture become cloudy?

[1 mark]

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

Figure 6 shows the apparatus used.

Figure 6



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.

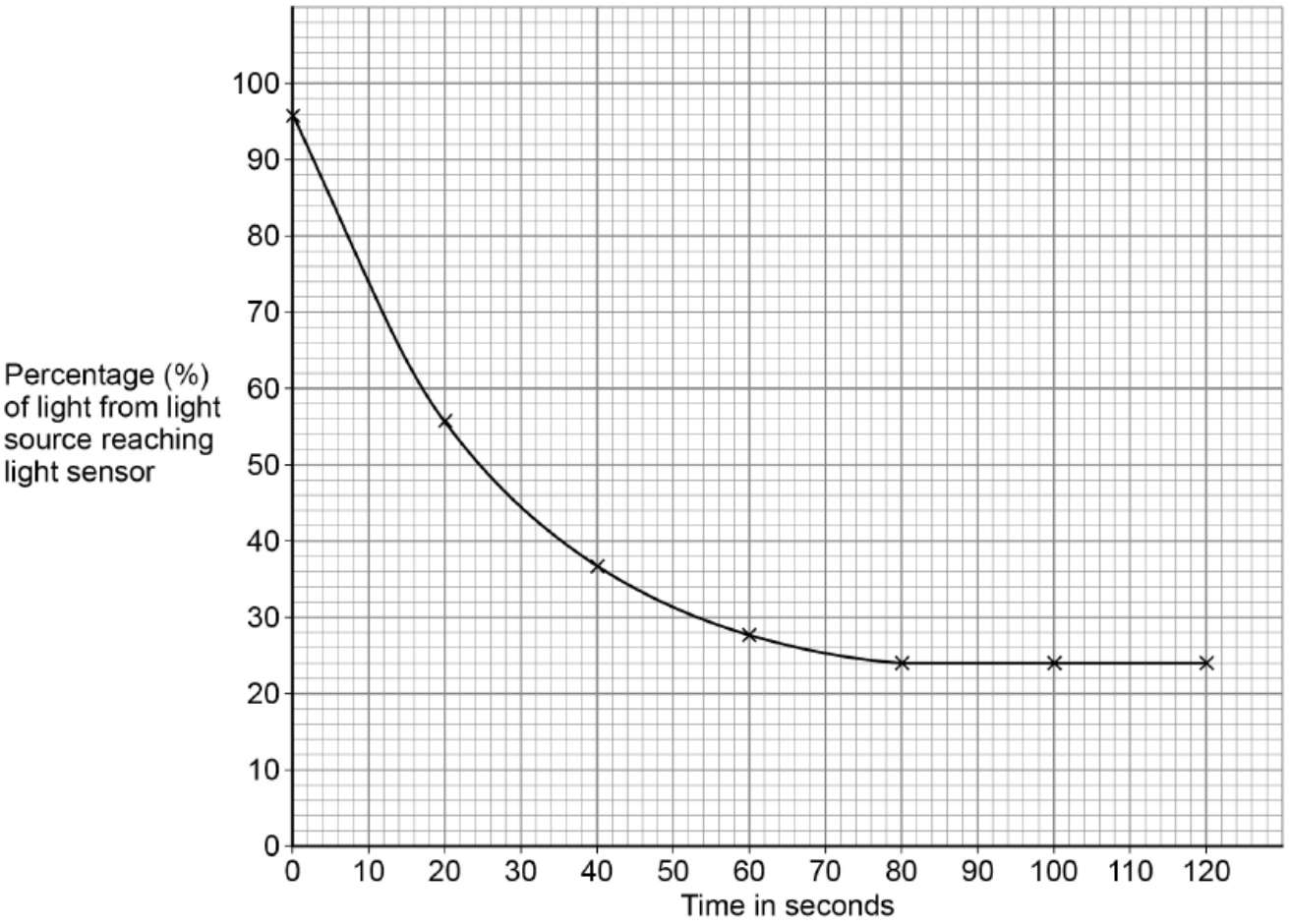
3. Immediately start a timer.

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

Figure 7



0 8 . 2 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 7**.

[5 marks]

Rate = _____ mol/s

0 8 . 3 Explain why the rate of reaction changes between 0 and 60 seconds.

Answer in terms of concentration.

Use **Figure 7**.

[2 marks]

Figure 8 is a repeat of **Figure 7**.

Figure 8

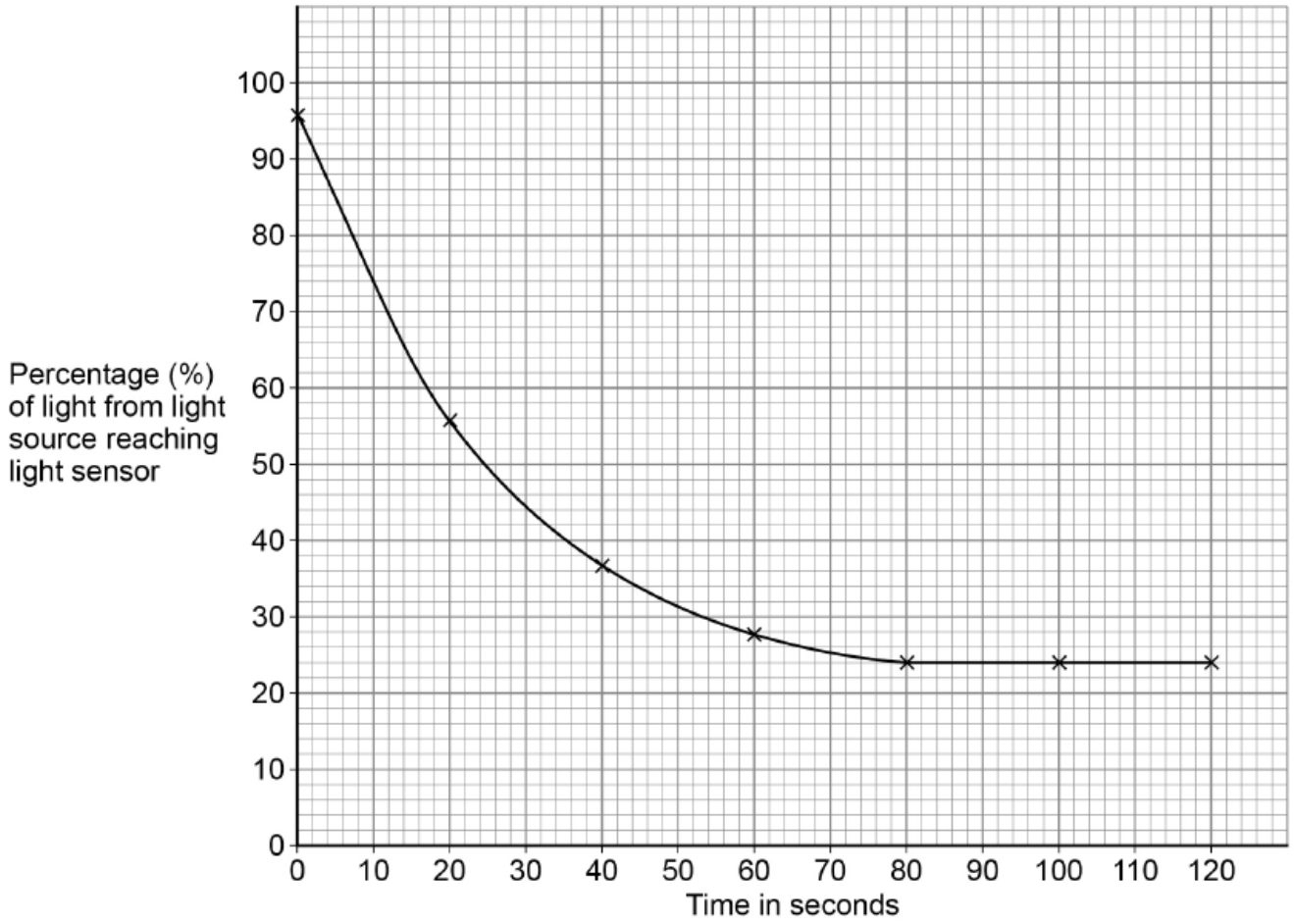


Figure 8 shows the results for 0.10 mol/dm^3 sodium thiosulfate solution.

Sodium thiosulfate solution was in excess in the investigation.

0 8 . 4 The line of best fit on **Figure 8** is horizontal between 80 and 120 seconds because the reaction stopped.

Why did the reaction stop?

[1 mark]

0 8 . 5 Sketch a line on **Figure 8** to show the results you would predict for 0.20 mol/dm^3 sodium thiosulfate solution.

[2 marks]

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.

0 8 . 6 How could the student improve the method so that the same percentages of light reached the light sensor?

[1 mark]

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. ☐

0 8 . 7 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?

[1 mark]

Tick (✓) **one** box.

Anomalous ☐

Precise ☐

Repeatable ☐

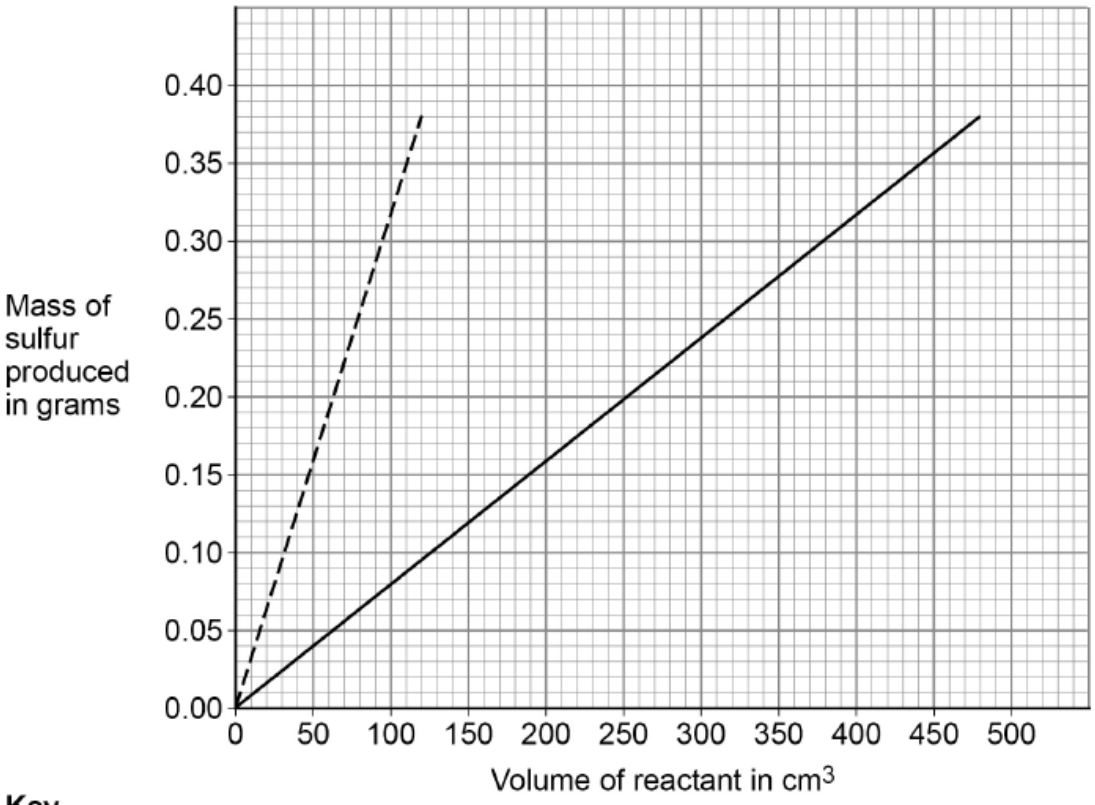
Reproducible ☐

Figure 9 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 9



0 8 . 8 Which expression represents the relationship between the volume (V) of sodium thiosulfate solution used and the mass (m) of sulfur produced?

Use **Figure 9**.

[1 mark]

Tick (✓) **one** box.

$V \propto m$ ☐

$V \sim m$ ☐

$V << m$ ☐

$V = m$ ☐

0 8 . 9 Determine the simplest whole number ratio of the volumes of

sodium thiosulfate solution : hydrochloric acid

which completely react with each other.

Use **Figure 9**.

[3 marks]

Simplest whole number ratio = _____ : _____