AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.6.1.2

Factors which affect the rates of chemical reactions

Past-paper questions

Tier	**Foundation**
Question groups	**23**
Available paper years	**2008–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

4.6.1.2 Factors which affect the rates of chemical reactions

Question 01

January 2008 | CHY2F | Original Q6 | Legacy

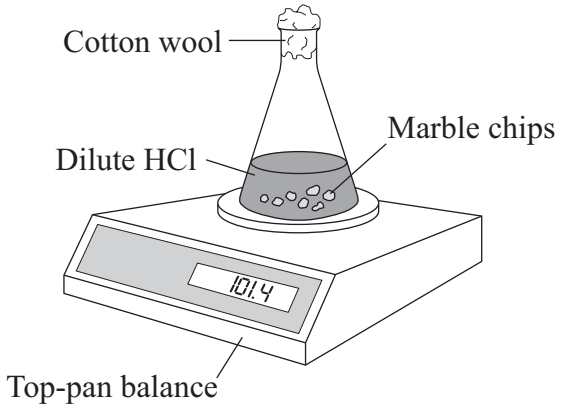
6 A student investigated the rate of reaction between marble and hydrochloric acid.

The student used an excess of marble.

The reaction can be represented by this equation.

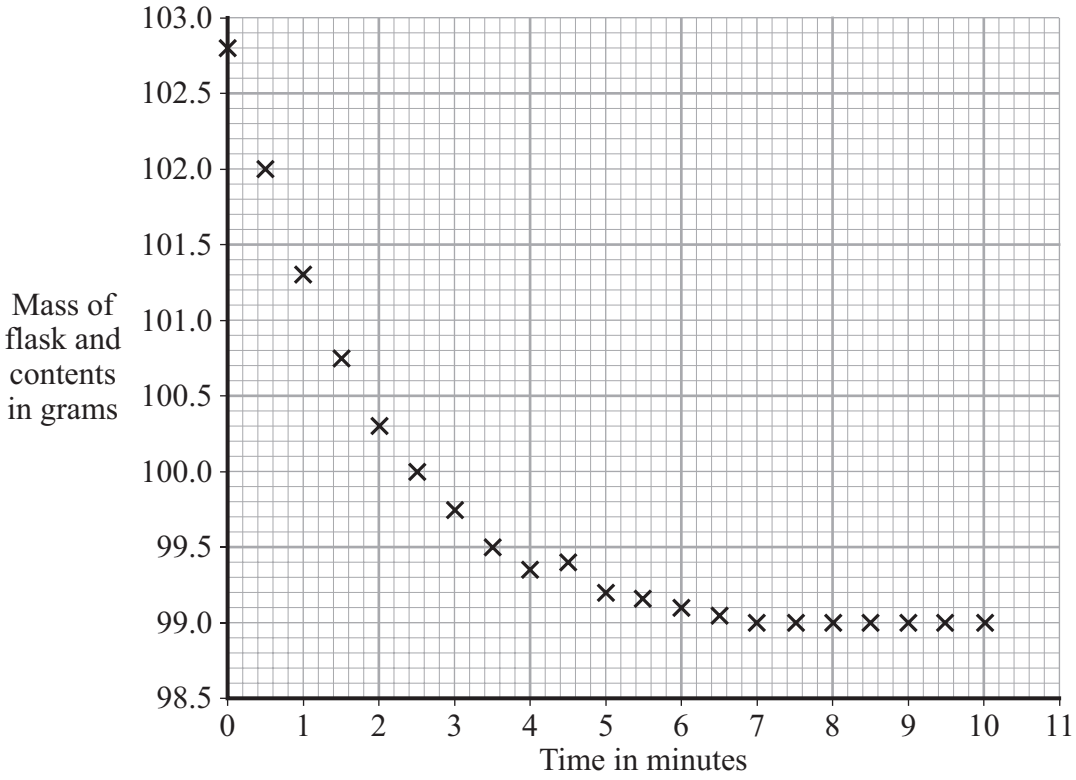
$CaCO_3$ (s) + 2HCl (aq) → $CaCl_2$ (aq) + H_2O (l) + CO_2 (g)

The student used the apparatus shown in the diagram.



The student measured the mass of the flask and contents every half minute for ten minutes.

The results are shown on the graph. Use the graph to answer the questions.



4.6.1.2 Factors which affect the rates of chemical reactions

Question 01 · continued

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(a) **Complete the graph** opposite by drawing a line of best fit.

(1 mark)

(b) Why did the mass of the flask and contents decrease with time?

.....

.....

(1 mark)

(c) After how many minutes had all the acid been used up?

..... minutes

(1 mark)

(d) The student repeated the experiment at a higher temperature. All other variables were kept the same as in the first experiment. The rate of reaction was much faster.

(i) Draw a line **on the graph** opposite to show what the results for this second experiment might look like.

(2 marks)

(ii) Why does an increase in temperature increase the rate of reaction?

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(3 marks)

8

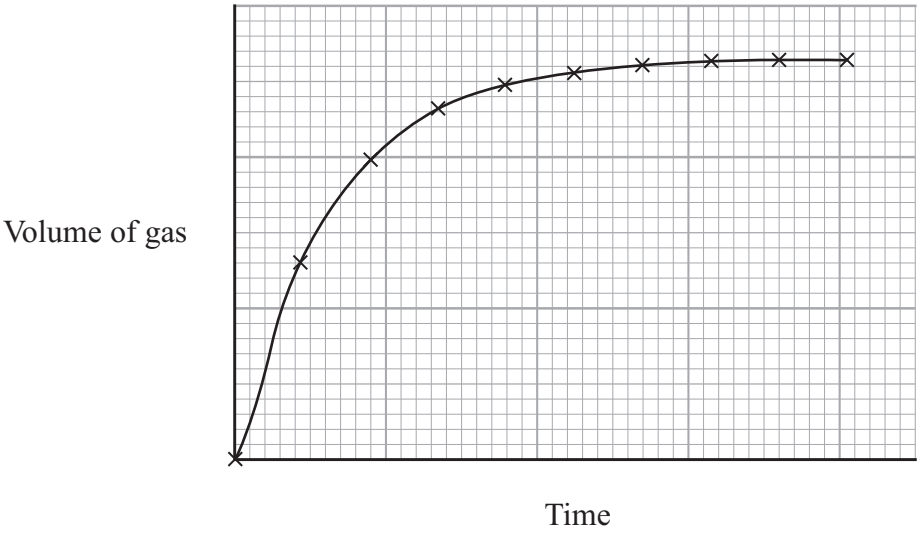
4.6.1.2 Factors which affect the rates of chemical reactions

Question 02

June 2008 | CHY2F | Original Q2 | Legacy

2 Pieces of zinc react with dilute acid to form hydrogen gas.

The graph shows how the volume of hydrogen gas produced changes with time.



2 (a) Describe, as fully as you can, how the volume of gas produced changes with time.

.....

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.....

(2 marks)

2 (b) A student wants to make the reaction take place faster.
Some suggestions are given in the table.

Put ticks (✓) next to the **two** suggestions that would make the reaction take place faster.

Suggestions	(✓)
Use bigger pieces of zinc.	
Use a more concentrated acid.	
Use zinc powder.	
Decrease the temperature of the acid.	

(2 marks)

4

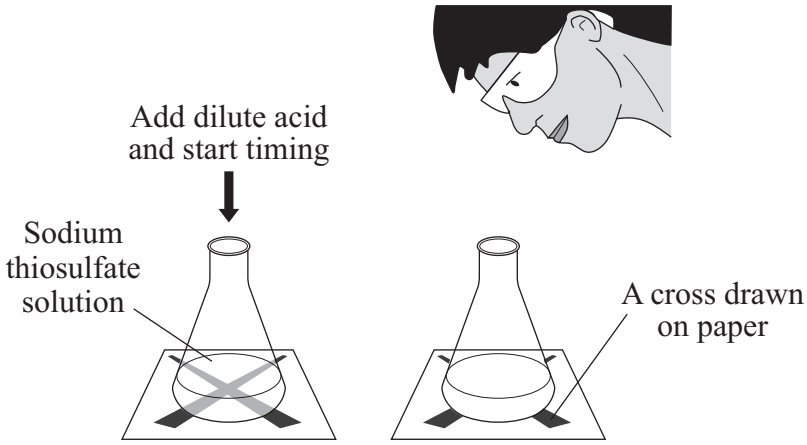
4.6.1.2 Factors which affect the rates of chemical reactions

Question 03

June 2009 | CHY2F | Original Q7 | Legacy

7 Sodium thiosulfate solution reacts with hydrochloric acid. As the reaction takes place the solution slowly turns cloudy.

The diagram shows a method of measuring the rate of this reaction.



A student used this method to investigate how changing the concentration of the sodium thiosulfate solution affects the rate of this reaction.

The student used different concentrations of sodium thiosulfate solution. All the other variables were kept the same.

The results are shown on the graph on the opposite page.

7 (a) (i) Draw a line of best fit on the graph. *(1 mark)*

7 (a) (ii) Suggest **two** reasons why all of the points do not lie on the line of best fit.

1 .....

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2 .....

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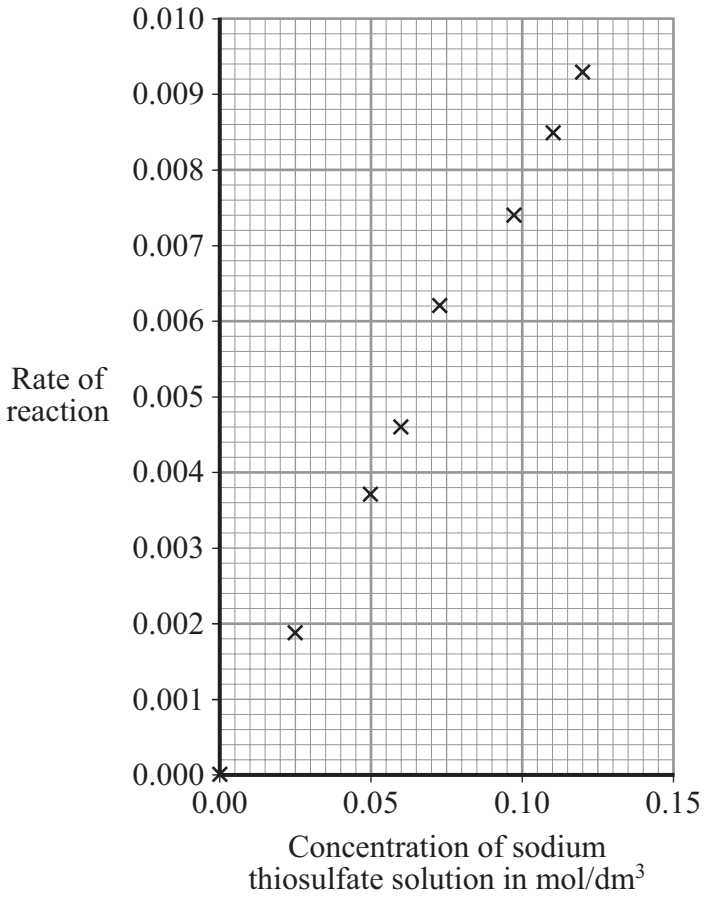
(2 marks)

4.6.1.2 Factors which affect the rates of chemical reactions

Question 03 · continued

for mark



7 (b) (i) In a conclusion to the investigation the student stated that:

'The rate of this reaction is directly proportional to the concentration of the sodium thiosulfate solution.'

How does the graph support this conclusion?

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(1 mark)

7 (b) (ii) Explain, in terms of particles, why the rate of reaction increases when the concentration of sodium thiosulfate is increased.

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(2 marks)

6

4.6.1.2 Factors which affect the rates of chemical reactions

Question 04

June 2010 | CHY2F | Original Q3 | Legacy

3 The picture shows a student with two glow sticks.



Glow sticks contain several chemicals. When a glow stick is bent the chemicals mix. A chemical reaction takes place which causes light to be given out.

A student investigated three glow sticks. One was placed in water at 5 ºC, one in water at 40 ºC and one in water at 70 ºC.

The results are shown in the table.

Temperature in ºC	Effect on glow stick	
	Brightness of light	Time it gave out light, in hours
5	dim	7
40	bright	3
70	very bright	1

3 (a) How did increasing the temperature affect the brightness of the glow stick?

.....

.....

(1 mark)

3 (b) How did increasing the temperature affect the time it gave out light?

.....

.....

(1 mark)

4.6.1.2 Factors which affect the rates of chemical reactions

Question 04 · continued

3 (c) The student was asked why an **increase** in temperature changes the rate of the chemical reaction. The student listed five ideas. Only **three** of them are correct.

Put ticks (✓) next to the **three** correct ideas.

Ideas	Tick (✓)
The particles will collide more often.	
The particles will be more concentrated.	
The particles will move faster.	
The particles will have more energy.	
The particles will get bigger.	

(3 marks)

3 (d) Suggest **one** way the student could improve this investigation.

.....

.....

(1 mark)

6

4.6.1.2 Factors which affect the rates of chemical reactions

Question 05

7 A student investigated the rate of reaction between sodium thiosulfate and dilute hydrochloric acid.

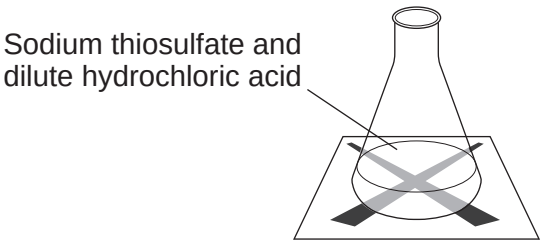
The student placed a conical flask over a cross on a piece of paper.

The student mixed the solutions in the flask.

The solution slowly went cloudy.

The student timed how long it took until the cross could not be seen.





The equation for the reaction is:

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

sodium thiosulfate + hydrochloric acid → sodium chloride + water + sulfur dioxide + sulfur

7 (a) Explain why the solution goes cloudy.

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(2 marks)

4.6.1.2 Factors which affect the rates of chemical reactions

Question 05 · continued

7 (b) The student repeated the experiment with different concentrations of sodium thiosulfate.

Concentration of sodium thiosulfate in moles per dm^3	Time taken until the cross could not be seen in seconds			
	Trial 1	Trial 2	Trial 3	Mean
0.040	71	67	69	69
0.060	42	45	45	44
0.080	31	41	33	

7 (b) (i) Calculate the mean time for 0.080 moles per dm^3 of sodium thiosulfate.

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Mean = ... seconds
(2 marks)

7 (b) (ii) Describe and explain, in terms of particles and collisions, the effect that increasing the concentration of sodium thiosulfate has on the rate of the reaction.

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(3 marks)

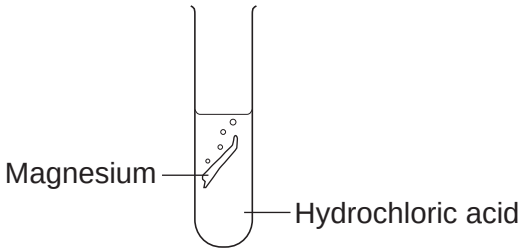
7

4.6.1.2 Factors which affect the rates of chemical reactions

Question 06

June 2013 | CH2FP | Original Q6 | Legacy

6 A student investigated the reaction between magnesium and hydrochloric acid.



The equation for the reaction is:

$$\underset{\text{magnesium}}{Mg(s)} + \underset{\text{hydrochloric acid}}{2\,HCl(aq)} \longrightarrow \underset{\text{magnesium chloride}}{MgCl_2(aq)} + \underset{\text{hydrogen}}{H_2(g)}$$

6 (a) Give **two** observations the student could make during the reaction.

1 .....

.....

2 .....

.....

(2 marks)

6 (b) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

The student investigated how the rate of this reaction changed when the concentration of hydrochloric acid was changed.

Write a plan the student could use.

In your plan you should:

- describe how you would carry out the investigation and make it a fair test
- describe the measurements you would make.

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4.6.1.2 Factors which affect the rates of chemical reactions

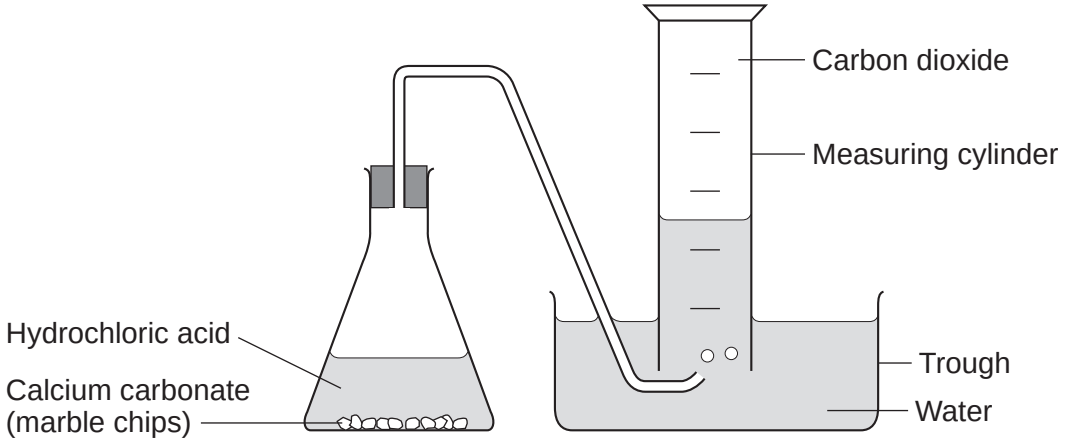
Question 07

June 2015 | CH2FP | Original Q5 | Legacy

5 A student investigated the rate of reaction between calcium carbonate (marble chips) and hydrochloric acid.

The student used the apparatus shown in **Figure 8**.

Figure 8



The student:

- recorded the volume of gas collected every 5 seconds
- repeated the experiment using hydrochloric acid at different temperatures.

The equation for the reaction is:

$$CaCO_3(s) + 2\,HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

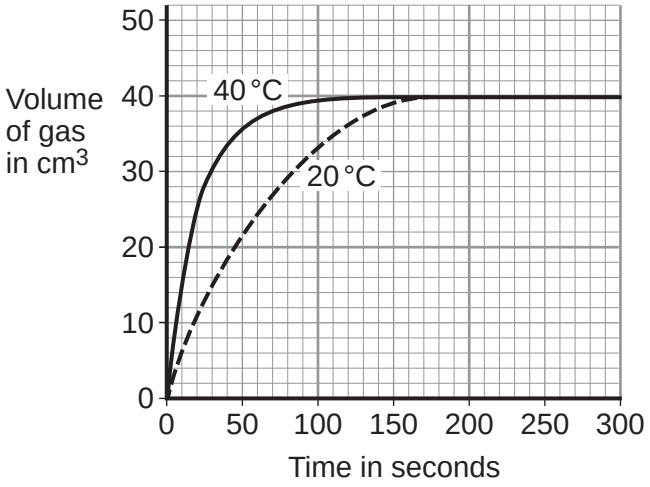
4.6.1.2 Factors which affect the rates of chemical reactions

Question 07 · continued

5 (a) The student plotted results for the hydrochloric acid at 20 °C and 40 °C on a graph.

Figure 9 shows the student's graph.

Figure 9



Use information from **Figure 9** to answer these questions.

5 (a) (i) State **one** conclusion the student could make about the effect of temperature on the rate of the reaction.

[1 mark]

.....

.....

5 (a) (ii) Give **one** reason why the student could make this conclusion.

[1 mark]

.....

.....

5 (a) (iii) For the hydrochloric acid at 60 °C the student had collected 30 cm^3 after 15 seconds.

Calculate the average rate of reaction from 0 to 15 seconds.

[1 mark]

.....

.....

Rate of reaction = ... cm^3 per second

4.6.1.2 Factors which affect the rates of chemical reactions

Question 07 · continued

5 (b) The student then investigated how the surface area of marble chips affected the rate of reaction.

5 (b) (i) Which **two** variables should the student keep constant?

[2 marks]

Tick (✓) **two** boxes.

- Amount of water in the trough ☐
- Concentration of acid ☐
- Mass of marble chips ☐
- Size of marble chips ☐
- Volume of measuring cylinder ☐

5 (b) (ii) Explain, in terms of particles and collisions, the effect that increasing the surface area of the marble chips has on the rate of reaction.

[2 marks]

.....

.....

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.....

5 (c) Calcium carbonate is a catalyst for the industrial production of biodiesel.

Give **one** reason why using a catalyst reduces costs.

[1 mark]

.....

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4.6.1.2 Factors which affect the rates of chemical reactions

Question 08

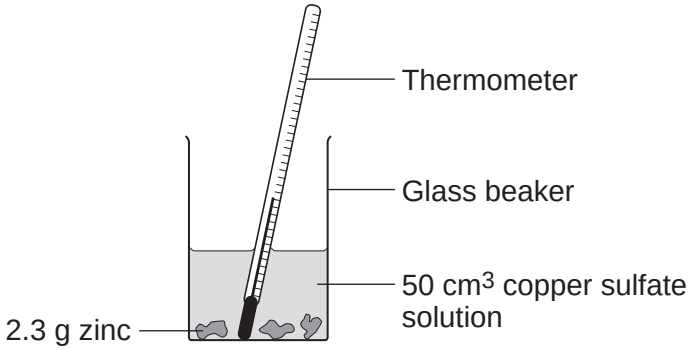
June 2015 | CH2FP | Original Q6 | Legacy

6 A student investigated the temperature change when zinc reacts with copper sulfate solution.

The student used a different concentration of copper sulfate solution for each experiment.

The student used the apparatus shown in **Figure 10**.

Figure 10



The student:

- measured 50 cm^3 copper sulfate solution into a glass beaker
- measured the temperature of the copper sulfate solution
- added 2.3 g zinc
- measured the highest temperature
- repeated the experiment using copper sulfate solution with different concentrations.

The equation for the reaction is:

$$Zn(s) + CuSO_4(aq) \longrightarrow Cu(s) + ZnSO_4(aq)$$

zinc + copper sulfate solution ⟶ copper + zinc sulfate solution

6 (a) The thermometer reading changes during the reaction.

Give **one** other change the student could **see** during the reaction.

[1 mark]

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Question 6 continues on the next page

4.6.1.2 Factors which affect the rates of chemical reactions

Question 08 · continued

6 (b) Suggest **one** improvement the student could make to the apparatus in **Figure 10**.

Give a reason why this improves the investigation.

[2 marks]

Improvement .....

.....

Reason .....

.....

6 (c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

The student's results are shown in **Table 2**.

Table 2

Experiment number	Concentration of copper sulfate in moles per dm^3	Increase in temperature in °C
1	0.1	5
2	0.2	10
3	0.3	12
4	0.4	20
5	0.5	25
6	0.6	30
7	0.7	35
8	0.8	35
9	0.9	35
10	1.0	35

4.6.1.2 Factors which affect the rates of chemical reactions

Question 08 · continued

Describe **and** explain the trends shown in the student's results.

[6 marks]

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Extra space .....

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9

4.6.1.2 Factors which affect the rates of chemical reactions

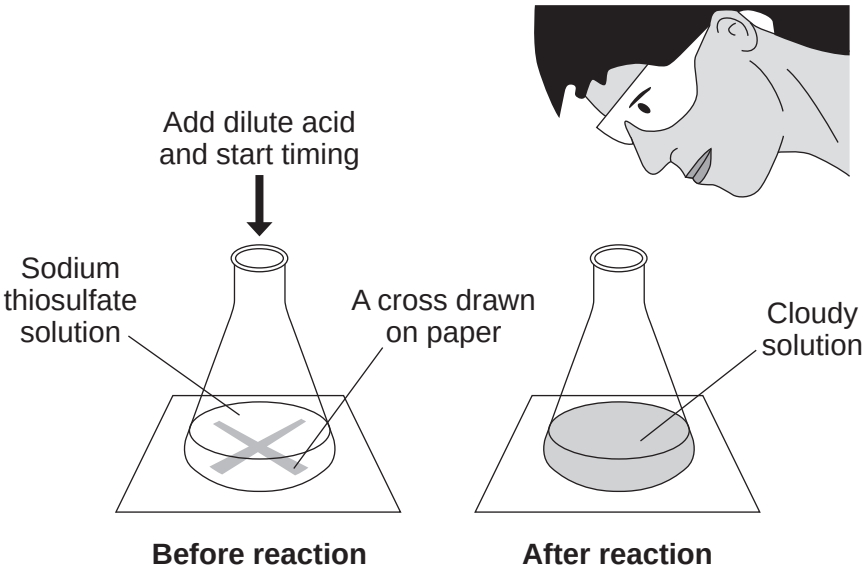
Question 09

June 2016 | CH2FP | Original Q4 | Legacy

4 A student investigated the effect of temperature on the rate of a reaction.

Figure 9 shows an experiment.

Figure 9



The student:

- put 50 cm^3 sodium thiosulfate solution into a conical flask
- heated the sodium thiosulfate solution to the required temperature
- put the flask on a cross drawn on a piece of paper
- added 5 cm^3 dilute hydrochloric acid and started a stopclock
- stopped the stopclock when the cross could no longer be seen
- repeated the experiment at different temperatures.

4.6.1.2 Factors which affect the rates of chemical reactions

Question 09 · continued

The equation for the reaction is:

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

sodium thiosulfate	hydrochloric acid	sodium chloride	water	sulfur dioxide	sulfur

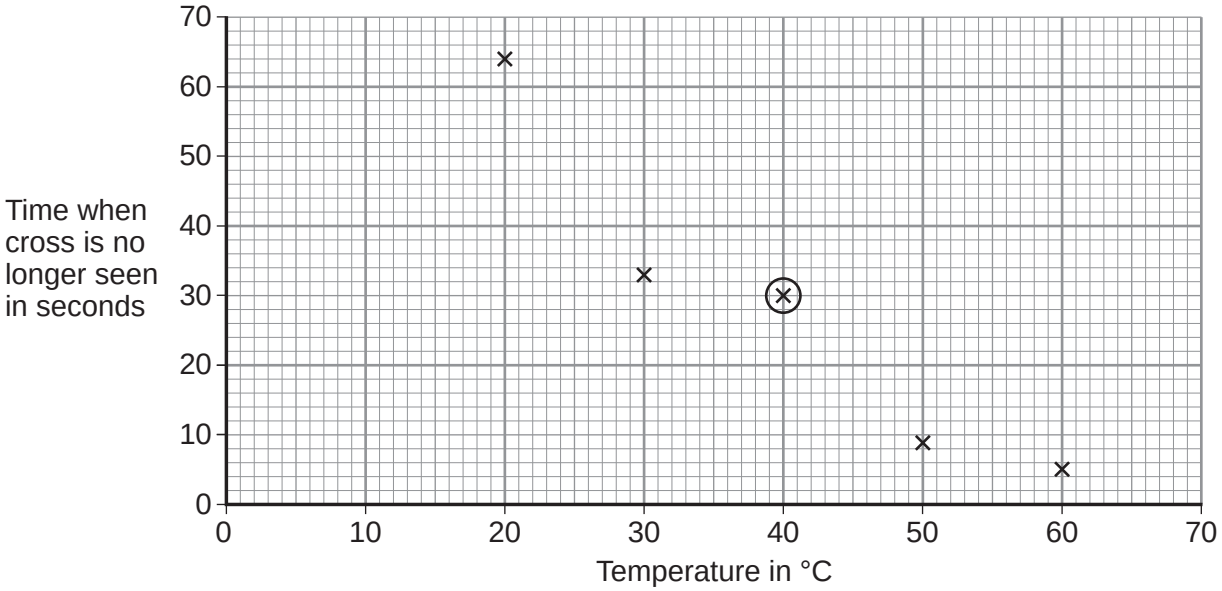
4 (a) Which product is a gas?

[1 mark]

_____

4 (b) **Figure 10** shows the results of this experiment at five different temperatures. The circled result point is anomalous.

Figure 10



4 (b) (i) Draw a line of best fit on **Figure 10** to show how the reaction time varied with reaction temperature.

[1 mark]

4 (b) (ii) Give a possible reason for the anomalous result at 40 °C.

[1 mark]

_____

_____

Question 4 continues on the next page

4.6.1.2 Factors which affect the rates of chemical reactions

Question 09 · continued June 2016 | CH2FP | Original Q4 | Legacy

4 (b) (iii) The reaction at 20 °C produced 0.32 g of sulfur in 64 seconds.

Calculate the rate of the reaction at 20 °C using the equation:

$$\text{Rate of reaction} = \frac{\text{mass of sulfur}}{\text{time}}$$

[2 marks]

Rate of reaction = _____ grams per second

4 (b) (iv) Give **two** reasons why the rate of the reaction increases as the temperature increases.

[2 marks]

Tick (✓) **two** boxes.

- The particles move faster. ☐
- The particles collide less often. ☐
- All the particles have the same energy. ☐
- The particles collide with more energy. ☐
- The number of particles increases. ☐

4 (b) (v) Use the correct answer from the box to complete the sentence.

[1 mark]

activation	collision	exothermic

The minimum amount of energy particles must have to react is called the _____ energy.

8

4.6.1.2 Factors which affect the rates of chemical reactions

Question 10

June 2017 | CH2FP | Original Q5 | Legacy

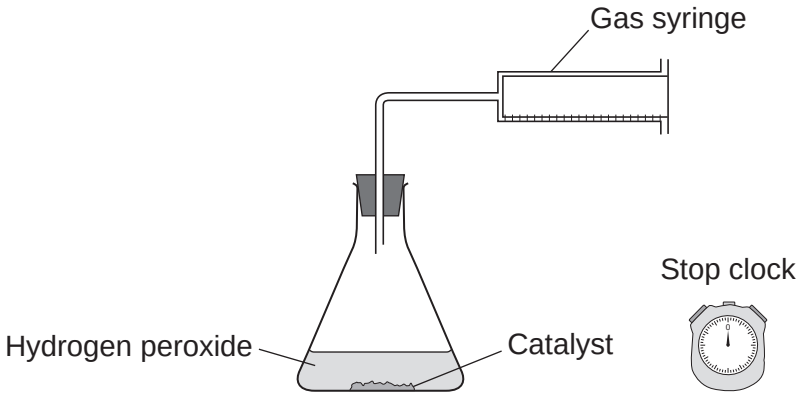
5 This question is about rates of reaction.

The equation for the decomposition of hydrogen peroxide is:

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

Figure 10 shows the apparatus a student used to investigate the rate of reaction for the decomposition of hydrogen peroxide.

Figure 10



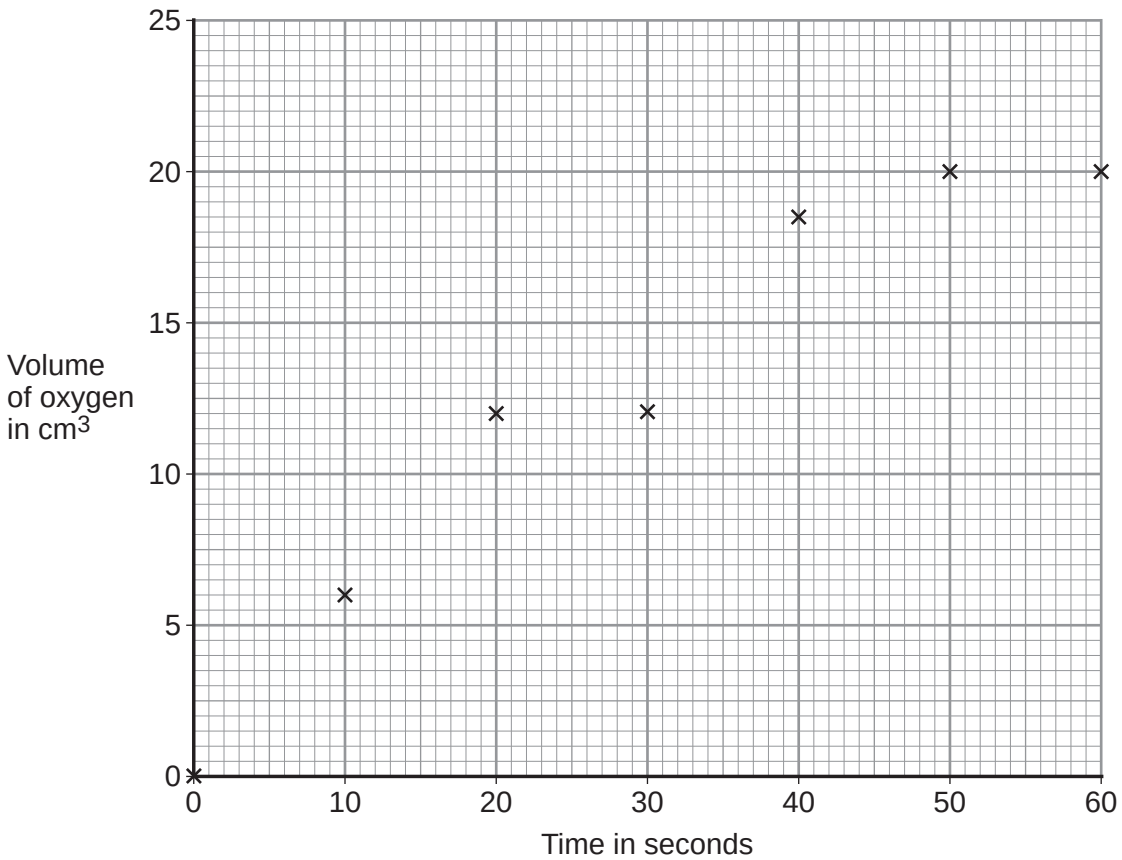
Question 5 continues on the next page

4.6.1.2 Factors which affect the rates of chemical reactions

Question 10 · continued

The graph in **Figure 11** shows the results.

Figure 11



5 (a) (i) Draw a smooth curve of best fit on **Figure 11**.

[1 mark]

5 (a) (ii) Give the volume of oxygen produced at 25 seconds.

[1 mark]

Volume of oxygen = _____ cm^3

5 (a) (iii) After how many seconds does the reaction stop?

[1 mark]

Time = _____ seconds

4.6.1.2 Factors which affect the rates of chemical reactions

Question 10 · continued

5 (a) (iv) The student concluded that the rate of reaction decreases with time.

Explain how the results support this conclusion.

[2 marks]

5 (a) (v) Calculate the mean rate of reaction during the first 10 seconds.

[1 mark]

Mean rate of reaction = _____ cm^3 per second

5 (b) The student investigated the effect of concentration on the rate of the reaction.

The student repeated the experiment with greater concentrations of hydrogen peroxide.

5 (b) (i) The catalyst was kept the same. Give **two** other control variables.

[2 marks]

Question 5 continues on the next page

4.6.1.2 Factors which affect the rates of chemical reactions

Question 10 · continued

5 (b) (ii) State and explain, in terms of particles and collisions, how a greater concentration affects the rate of the reaction.

[3 marks]

5 (c) Describe how increasing the amount of catalyst affects the results in **Figure 11**.

[2 marks]

13

4.6.1.2 Factors which affect the rates of chemical reactions

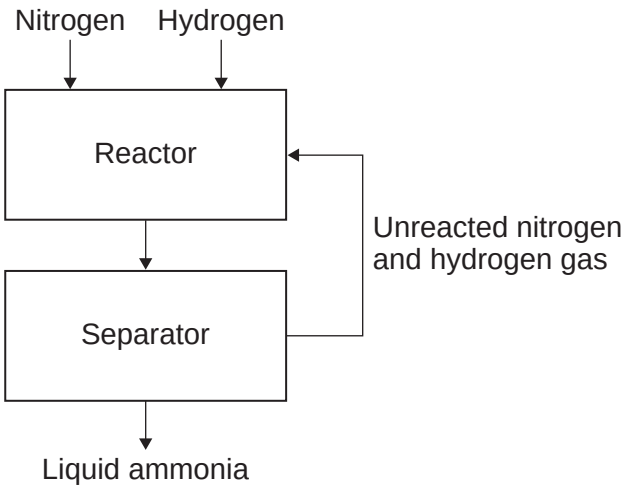
Question 11

June 2017 | CH3FP | Original Q3 | Legacy

3 This question is about the Haber process.

Figure 3 shows a flow diagram of the Haber process.

Figure 3



3 (a) (i) Use the correct answer from the box to complete the sentence.

[1 mark]

air	crude oil	natural gas	water

Nitrogen for the Haber process is obtained from _____ .

4.6.1.2 Factors which affect the rates of chemical reactions

Question 11 · continued

3 (a) (ii) Iron is used as a catalyst in the reactor.

How does a catalyst speed up a reaction?

[1 mark]

Tick (✓) **one** box.

Changes the pressure in the reactor ☐

Lowers the activation energy ☐

Makes the particles move faster ☐

3 (a) (iii) Describe how the ammonia is separated from the other gases.

[2 marks]

_____

_____

_____

_____

3 (b) Complete the word equation for the reaction in the Haber process.

[1 mark]

nitrogen + _____ ⇌ _____

Question 3 continues on the next page

Question 11 · continued

3 (c) **Figure 4** shows how, in the Haber process, the rate of reaction changes as the temperature and pressure increase.

Figure 4

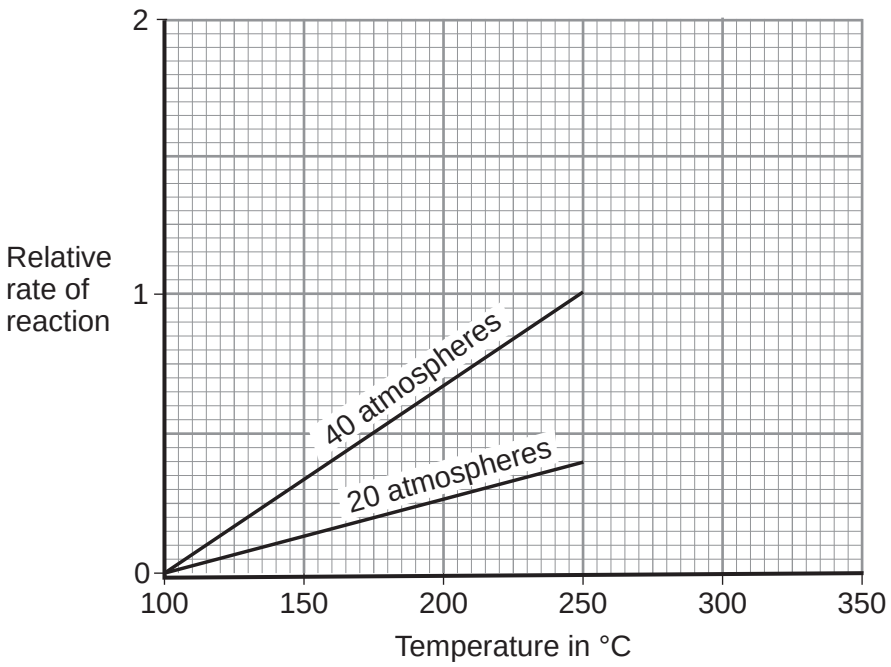


Table 1 shows the relative rate of reaction at 80 atmospheres at different temperatures.

Table 1

Temperature in °C	Relative rate of reaction
100	0.0
150	0.5
200	1.0
250	1.7
300	2.0

4.6.1.2 Factors which affect the rates of chemical reactions

Question 11 · continued

3 (c) (i) Plot the data in **Table 1** on the graph in **Figure 4**.

[2 marks]

3 (c) (ii) Draw a straight line of best fit for the points you have plotted.

[1 mark]

3 (c) (iii) What is the relative rate of reaction at 20 atmospheres and 300 °C?

Show your working on **Figure 4**.

[2 marks]

Relative rate of reaction = _____

3 (c) (iv) Describe how the rate of reaction changes as the pressure increases.

[1 mark]

_____

_____

11

4.6.1.2 Factors which affect the rates of chemical reactions

Question 12

June 2018 | 8462/1F | Original Q6

0 6 A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

This is the method used.

1. Measure 50 cm^3 of the copper sulfate solution into a polystyrene cup.
2. Record the starting temperature of the copper sulfate solution.
3. Add the metal and stir the solution.
4. Record the highest temperature the mixture reaches.
5. Calculate the temperature increase for the reaction.
6. Repeat steps 1-5 with different metals.

0 6 . 1 Draw **one** line from each type of variable to the name of the variable in the investigation.

[2 marks]

Type of variable	Name of variable in the investigation
	Concentration of solution
Dependent variable	Particle size of solid
	Temperature change
Independent variable	Type of metal
	Volume of solution

4.6.1.2 Factors which affect the rates of chemical reactions

Question 12 · continued

0 6 . 2 The student used a polystyrene cup and **not** a glass beaker.

Why did this make the investigation more accurate?

[1 mark]

Tick **one** box.

- Glass is breakable ☐
- Glass is transparent ☐
- Polystyrene is a better insulator ☐
- Polystyrene is less dense ☐

Question 6 continues on the next page

4.6.1.2 Factors which affect the rates of chemical reactions

Question 12 · continued

Table 5 shows the student's results.

Table 5

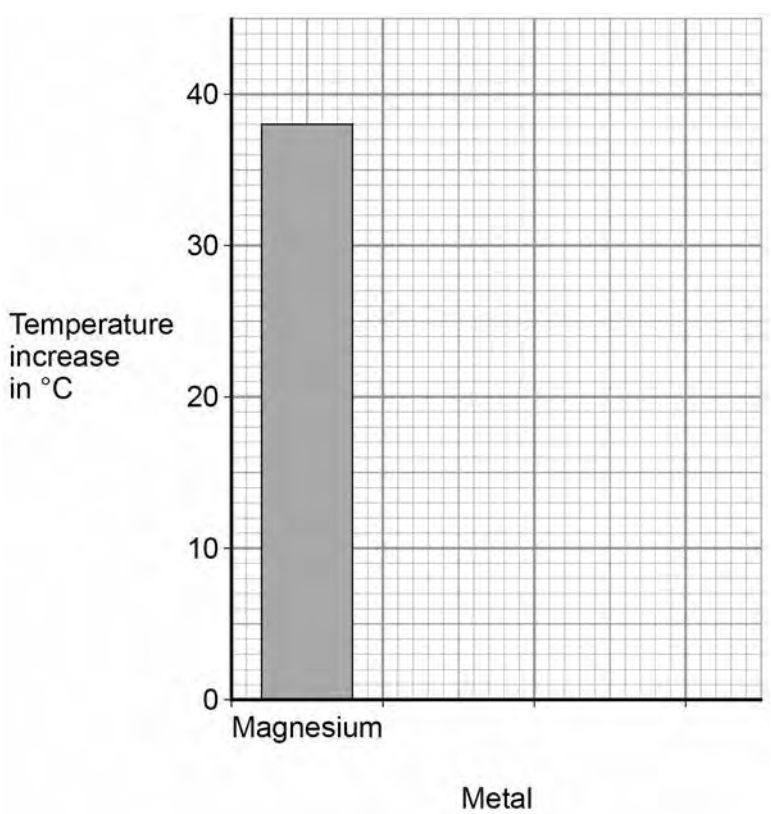
Metal	Temperature increase in °C
Magnesium	38
Nickel	8
Zinc	16

0 6 . 3 Complete **Figure 9**.

Use data from **Table 5**.

[2 marks]

Figure 9



4.6.1.2 Factors which affect the rates of chemical reactions

Question 12 · continued

0 6 . 4 The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give **one** reason why this conclusion is **not** correct.

[1 mark]

0 6 . 5 The temperature increase depends on the reactivity of the metal.

Write the metals magnesium, nickel and zinc in order of reactivity.

Use **Table 5**.

[1 mark]

Most reactive _____

_____

Least reactive _____

0 6 . 6 **Y** is an unknown metal.

Describe a method to find the position of **Y** in the reactivity series in Question **06.5**

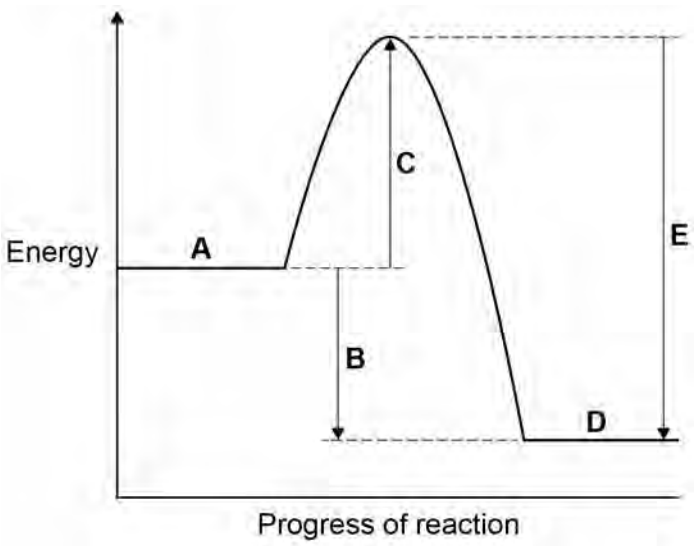
[3 marks]

4.6.1.2 Factors which affect the rates of chemical reactions

Question 12 · continued

Figure 10 shows the reaction profile for the reaction between zinc and copper sulfate solution.

Figure 10



0 6 . 7 Which letter represents the products of the reaction?

[1 mark]

Tick **one** box.

A		B		C		D		E	

0 6 . 8 Which letter represents the activation energy?

[1 mark]

Tick **one** box.

A		B		C		D		E	

12

4.6.1.2 Factors which affect the rates of chemical reactions

Question 13

June 2018 | 8462/2F | Original Q7

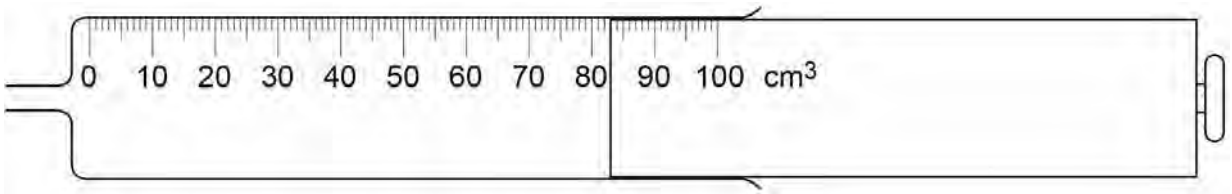
0 7 A student investigated how concentration affects the rate of reaction between magnesium and hydrochloric acid.

This is the method used.

1. Place hydrochloric acid in a conical flask.
2. Add magnesium powder.
3. Collect the gas produced in a gas syringe.
4. Measure the volume of gas every 40 seconds for 160 seconds.
5. Repeat steps 1–4 three more times.
6. Repeat steps 1–5 with hydrochloric acid of a higher concentration.

0 7 . 1 **Figure 5** shows a gas syringe.

Figure 5



What is the volume of gas in the syringe?

[1 mark]

Volume = _____ cm^3

0 7 . 2 Which **two** variables should the student keep the same to make the investigation a fair test?

[2 marks]

Tick **two** boxes.

- Concentration of hydrochloric acid ☐
- Mass of magnesium powder ☐
- Temperature of hydrochloric acid ☐
- Time for reaction to end ☐
- Volume of gas collected ☐

Question 13 · continued

Table 5 shows the student's results for the experiment with hydrochloric acid of a lower concentration.

Table 5

Time in seconds	Volume of gas collected in cm^3				
	Test 1	Test 2	Test 3	Test 4	Mean
0	0	0	0	0	0
40	46	30	47	49	**X**
80	78	83	83	82	82
120	98	94	96	95	96
160	100	100	100	100	100

0 7 . 3 Calculate mean value **X** in **Table 5**.

Do **not** include the anomalous result in your calculation.

Give your answer to 2 significant figures.

[2 marks]

X = _____ cm^3

4.6.1.2 Factors which affect the rates of chemical reactions

Question 13 · continued

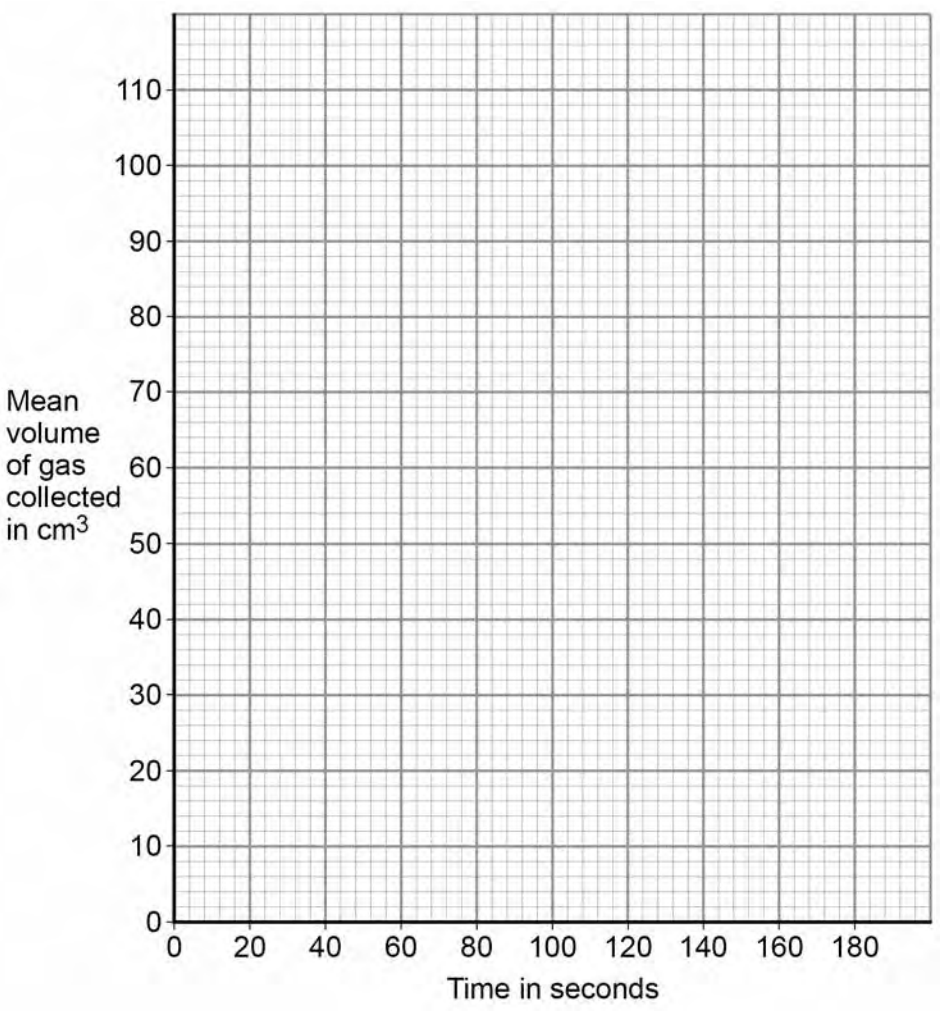
0 7 . 4 Plot the data from **Table 5** on **Figure 6**.

You should include your answer to Question **07.3**.

You do **not** need to draw a line of best fit.

[2 marks]

Figure 6



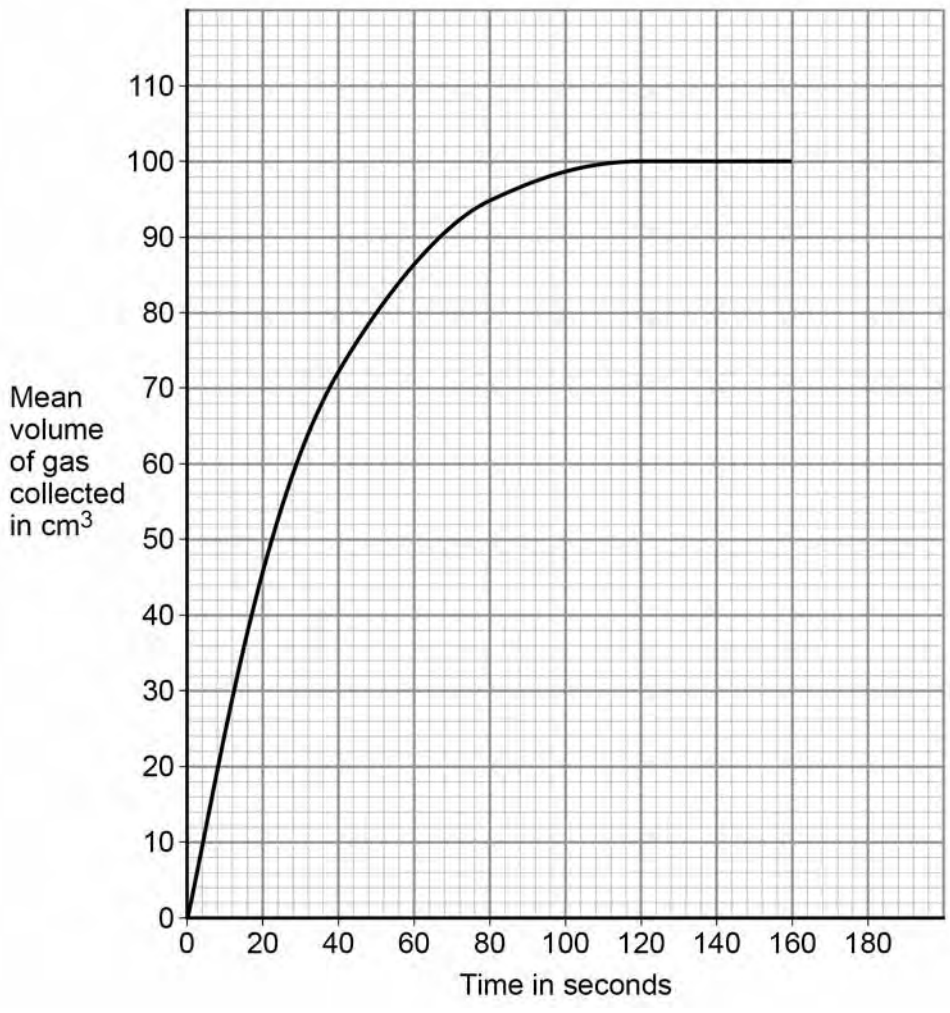
Question 7 continues on the next page

4.6.1.2 Factors which affect the rates of chemical reactions

Question 13 · continued

Figure 7 shows results of the experiment with the hydrochloric acid of a higher concentration.

Figure 7



0 7 . 5 Calculate the mean rate of reaction between 0 and 50 seconds.

Use **Figure 7** and the equation:

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

[2 marks]

Mean rate of reaction = _____ cm^3/s

4.6.1.2 Factors which affect the rates of chemical reactions

Question 13 · continued

0 7 . 6 Describe how the **rate of reaction** changes between 0 and 160 seconds.

Use **Figure 7**.

[3 marks]

0 7 . 7 The student concludes that the rate of reaction is greater when the concentration of hydrochloric acid is higher.

Why is the rate of reaction greater when the concentration of hydrochloric acid is higher?

[2 marks]

Tick **two** boxes.

- The particles are moving faster ☐
- The particles have more energy ☐
- The surface area of magnesium is smaller ☐
- There are more particle collisions each second ☐
- There are more particles in the same volume ☐

Question 7 continues on the next page

4.6.1.2 Factors which affect the rates of chemical reactions

Question 13 · continued

0 7 . 8 The student tests the gas produced by bubbling it through limewater.

No change is seen in the limewater.

Give **one** conclusion the student can make about the gas.

[1 mark]

_____

_____

0 7 . 9 The student tests the gas produced using a burning splint.

Name the gas the student is testing for.

Give the result of a positive test for this gas.

[2 marks]

Name of gas _____

Result _____

_____

4.6.1.2 Factors which affect the rates of chemical reactions

Question 13 · continued

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

4.6.1.2 Factors which affect the rates of chemical reactions

Question 14

June 2019 | 8462/2F | Original Q7

0 7 Some students investigated the rate of decomposition of hydrogen peroxide.

The equation for the reaction is:

hydrogen peroxide → water + oxygen

0 7 . 1 Complete the sentence.

Choose an answer from the box.

[1 mark]

a burning splint	**a glowing splint**
damp litmus paper	**limewater**

The students tested the gas produced to show that it was oxygen.

The students used _____ .

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

This is the method used.

1. Measure 25 cm^3 hydrogen peroxide solution into a conical flask.

2. Add some fine manganese dioxide powder to the conical flask.

3. Measure the volume of oxygen produced every 30 seconds for 10 minutes.

4. Repeat steps 1 to 3 two more times.

5. Repeat steps 1 to 4 with coarse manganese dioxide lumps.

4.6.1.2 Factors which affect the rates of chemical reactions

Question 14 · continued

0 7 . 2 The method student **A** used did **not** give repeatable results.

How could student **A** make the results repeatable?

[1 mark]

Tick (✓) **one** box.

Student **A** should make measurements every 2 minutes. ☐

Student **A** should measure the mass of manganese dioxide. ☐

Student **A** should use 50 cm^3 hydrogen peroxide. ☐

Student **A** should use a beaker instead of a conical flask. ☐

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

0 7 . 3 How could student **B** improve the accuracy of these results?

[1 mark]

Tick (✓) **one** box.

Calculate a mean but do not include any anomalous results. ☐

Calculate a mean but do not include the first set of results. ☐

Record the results in a table and plot the results on a bar chart. ☐

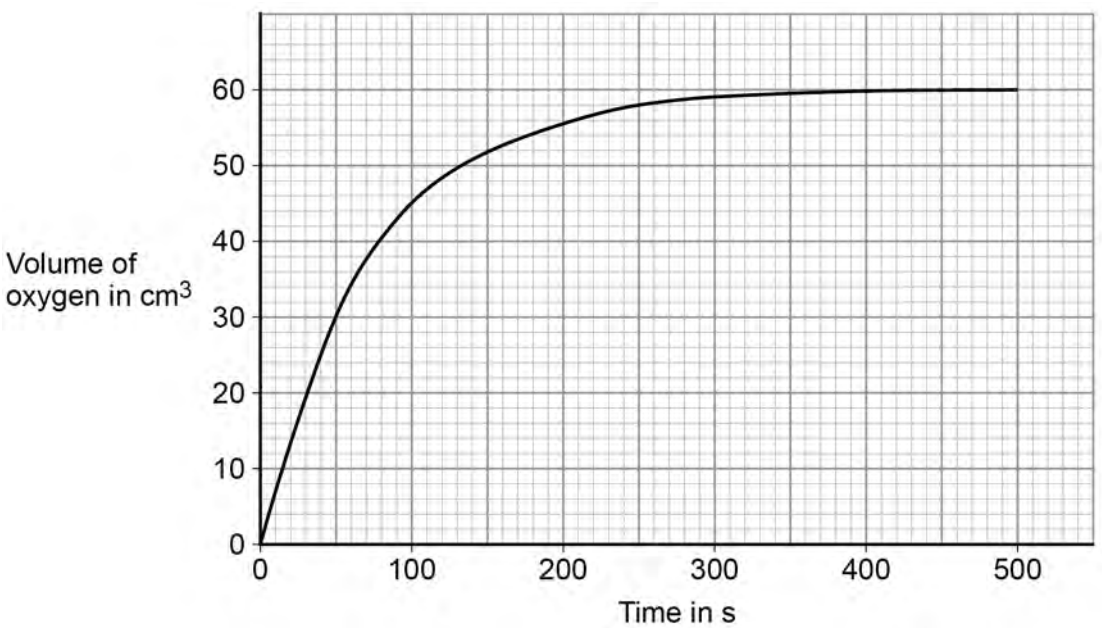
Record the results in a table and plot the results on a line graph. ☐

4.6.1.2 Factors which affect the rates of chemical reactions

Question 14 · continued

Figure 5 shows student **B**'s results for coarse manganese dioxide lumps.

Figure 5



0 7 . 4 Calculate the mean rate of reaction between 30 and 250 seconds for coarse manganese dioxide lumps.

Use **Figure 5** and the equation:

$$\text{Mean rate of reaction} = \frac{\text{Volume of oxygen formed}}{\text{Time taken}}$$

Give your answer to 3 significant figures.

[4 marks]

Volume of oxygen formed _____

Time taken _____

_____

_____

_____

_____

Mean rate of reaction = _____ cm^3/s

4.6.1.2 Factors which affect the rates of chemical reactions

Question 14 · continued

0 7 . 5 Fine manganese dioxide powder produces a higher rate of reaction than coarse manganese dioxide lumps.

Sketch on **Figure 5** the results you would expect for student **B**'s experiment with fine manganese dioxide powder.

[2 marks]

0 7 . 6 Hydrogen peroxide molecules collide with manganese dioxide particles during the reaction.

Why does fine manganese dioxide powder produce a higher rate of reaction than coarse manganese dioxide lumps?

[1 mark]

Tick (✓) **one** box.

- Fine manganese dioxide powder has a larger surface area. ☐
- Fine manganese dioxide powder has larger particles. ☐
- Fine manganese dioxide powder produces less frequent collisions. ☐

4.6.1.2 Factors which affect the rates of chemical reactions

Question 15

June 2019 | 8462/2F | Original Q10

1 0 This question is about rate of reaction.

A student investigated the rate of the reaction between magnesium and dilute hydrochloric acid.

The equation for the reaction is:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

1 0 . 1 Which state symbol in the equation for the reaction does **not** represent one of the three states of matter?

[1 mark]

The student determined the rate of production of hydrogen gas.

1 0 . 2 What **two** pieces of measuring apparatus could the student use to find the rate of production of hydrogen gas?

[2 marks]

1 _____

2 _____

Question 10 continues on the next page

4.6.1.2 Factors which affect the rates of chemical reactions

Question 15 · continued

Table 6 shows the results of the investigation.

Table 6

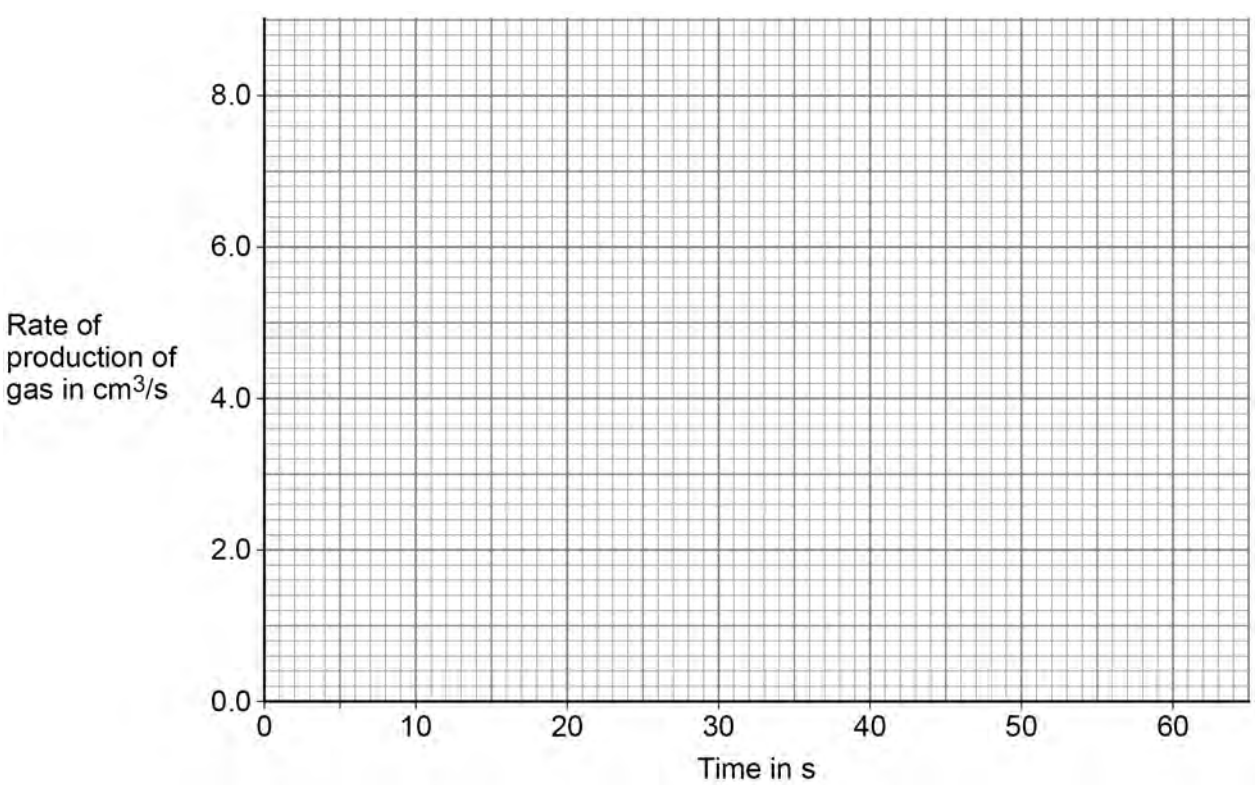
Time in s	Rate of production of gas in cm^3/s
10	6.9
20	3.9
30	2.0
40	0.9
50	0.3
60	0.0

1 0 . 3 Plot the data from **Table 6** on **Figure 8**.

You should draw a line of best fit.

[3 marks]

Figure 8



4.6.1.2 Factors which affect the rates of chemical reactions

Question 15 · continued

1 0 . 4 Give **three** conclusions that can be drawn about the rate of reaction between magnesium and dilute hydrochloric acid in this investigation.

Use data from **Figure 8** and **Table 6**.

[3 marks]

1 _____

_____

2 _____

_____

3 _____

_____

1 0 . 5 The student repeated the investigation using dilute hydrochloric acid at a higher temperature.

All the other variables were kept the same.

Which **two** statements are correct?

[2 marks]

Tick (✓) **two** boxes.

More bubbles were produced in the first 10 seconds. ☐

The activation energy for the reaction was higher. ☐

The magnesium was used up more quickly. ☐

The reaction finished at the same time. ☐

The total volume of gas collected was greater. ☐

11

4.6.1.2 Factors which affect the rates of chemical reactions

Question 16

November 2020 | 8462/2F | Original Q3

0 3 This question is about the rate of the reaction between hydrochloric acid and calcium carbonate.

A student investigated the effect of changing the size of calcium carbonate lumps on the rate of this reaction.

This is the method used.

1. Pour hydrochloric acid into a conical flask up to the 50 cm^3 line.
2. Add 10.0 g of small calcium carbonate lumps to the conical flask.
3. Attach a gas syringe to the conical flask.
4. Measure the volume of gas produced every 20 seconds for 100 seconds.
5. Repeat steps 1 to 4 using 10.0 g of large calcium carbonate lumps.

0 3 . 1 The student used the 50 cm^3 line on the conical flask to measure the volume of hydrochloric acid.

Suggest a piece of equipment the student could use to make the measurement of volume more accurate.

[1 mark]

0 3 . 2 Carbon dioxide gas is produced in the reaction between hydrochloric acid and calcium carbonate.

Which test is used to identify carbon dioxide gas?

[1 mark]

Tick (✓) **one** box.

- A burning splint pops ☐
- A glowing splint relights ☐
- Damp litmus paper is bleached ☐
- Limewater turns milky ☐

Question 16 · continued

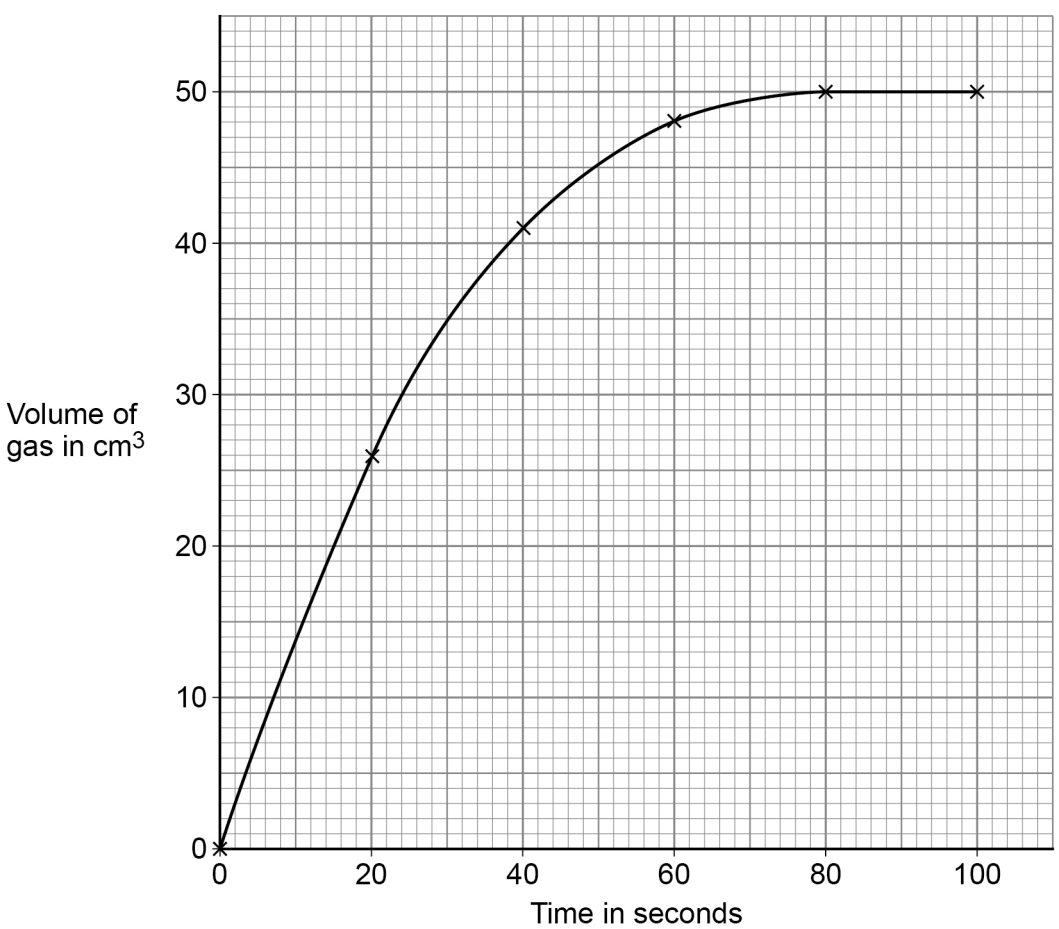
Table 2 shows the student's results for large calcium carbonate lumps.

Table 2

Time in seconds	Volume of gas in cm^3
0	0
20	16
40	30
60	40
80	46
100	48

Figure 4 shows the student's results for small calcium carbonate lumps.

Figure 4



4.6.1.2 Factors which affect the rates of chemical reactions

Question 16 · continued

0 3 . 3 Complete **Figure 4**.

You should:

- plot the data for large calcium carbonate lumps from **Table 2** on **Figure 4**
- draw a line of best fit for large calcium carbonate lumps.

[3 marks]

0 3 . 4 Determine the mean rate of reaction using **small** calcium carbonate lumps between 0 seconds and 60 seconds.

Use the equation:

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

Use **Figure 4**.

[3 marks]

Mean rate of reaction = _____ cm^3/s

0 3 . 5 Describe what happens to the volume of gas collected using **small** calcium carbonate lumps:

- between 0 and 20 seconds
- between 80 and 100 seconds.

Use **Figure 4**.

[2 marks]

Between 0 and 20 seconds _____

Between 80 and 100 seconds _____

Question 16 · continued

0 3 . 6 The balance used to weigh 10.0 g of calcium carbonate lumps caused an error.

The balance always read 0.2 g before being used.

What type of error was caused by the balance?

[1 mark]

Tick (✓) **one** box.

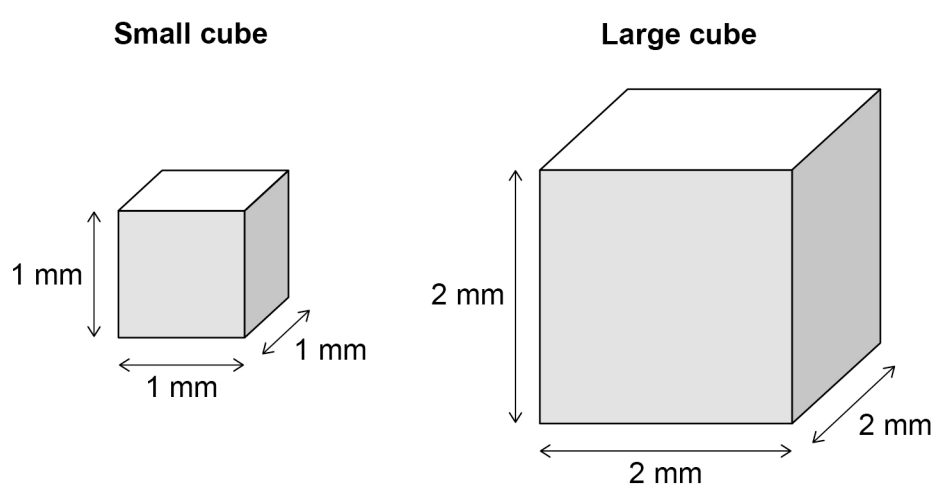
Human error ☐

Random error ☐

Systematic error ☐

Figure 5 shows the dimensions of two cubes of calcium carbonate.

Figure 5



4.6.1.2 Factors which affect the rates of chemical reactions

Question 16 · continued

0 3 . 7 A cube of calcium carbonate has six faces.

Calculate the total surface area of the **large** cube of calcium carbonate.

Use **Figure 5**.

[3 marks]

Total surface area = _____ mm^2

0 3 . 8 The large cube of calcium carbonate was divided into eight smaller cubes.

The eight smaller cubes have a greater total surface area than the one large cube.

Compare the rate of reaction when using the eight smaller cubes with the rate of reaction when using the large cube.

Complete the sentence.

Choose the answer from the box.

[1 mark]

faster	**slower**	**the same**

The rate of reaction of the eight smaller cubes is _____.

15

4.6.1.2 Factors which affect the rates of chemical reactions

Question 17

November 2021 | 8462/2F | Original Q4

0 4 This question is about reactions between gases.

When hydrogen gas is heated with iodine gas, hydrogen iodide gas is produced.

The equation for this reversible reaction is:

$$\text{hydrogen} + \text{iodine} \rightleftharpoons \text{hydrogen iodide}$$

This reversible reaction reaches equilibrium in a sealed container.

0 4 . 1 How does the equation show that the reaction is reversible?

[1 mark]

0 4 . 2 Which **two** statements are correct when the reaction reaches equilibrium?

[2 marks]

Tick (✓) **two** boxes.

- The forward reaction and reverse reaction are both exothermic. ☐
- The gases have escaped from the container. ☐
- The hydrogen no longer reacts with iodine. ☐
- The mass of each substance does not change. ☐
- The rates of the forward reaction and reverse reaction are equal. ☐

4.6.1.2 Factors which affect the rates of chemical reactions

Question 17 · continued

0 4 . 3 The initial mixture of hydrogen and iodine in the sealed container is purple.

Hydrogen iodide is colourless.

How will the colour of the mixture in the sealed container have changed when equilibrium is reached?

[1 mark]

Tick (✓) **one** box.

The mixture will have become a deeper purple. ☐

The mixture will have become a paler purple. ☐

The mixture will have become colourless. ☐

0 4 . 4 The rate of reaction between gases is affected by changing the pressure.

Complete the sentences.

[3 marks]

When the pressure of the reacting gases is increased,

the rate of reaction _____.

This is because at higher pressures the distance

between the particles _____.

This means that the frequency of collisions _____.

0 4 . 5 Give **one** other way of changing the rate of reaction between gases.

You should **not** refer to pressure in your answer.

[1 mark]

_____

_____

8

4.6.1.2 Factors which affect the rates of chemical reactions

Question 18

November 2021 | 8462/2F | Original Q5

0 5 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.

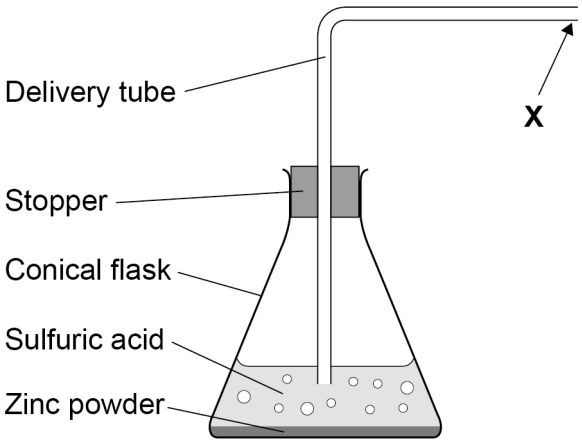
2. Add 2.0 g of zinc powder to the conical flask.

3. Put the stopper in the conical flask.

4. Measure the volume of hydrogen gas collected every 30 seconds for 5 minutes.

Figure 4 shows part of the apparatus used.

Figure 4



4.6.1.2 Factors which affect the rates of chemical reactions

Question 18 · continued

0 5 . 1 **X** shows where a piece of equipment is connected to measure the volume of hydrogen gas collected.

Complete **Figure 4** to show the equipment used.

[1 mark]

0 5 . 2 The student made an error setting up the delivery tube shown in **Figure 4**.

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

[2 marks]

Error made _____

_____

Problem caused _____

_____

Question 5 continues on the next page

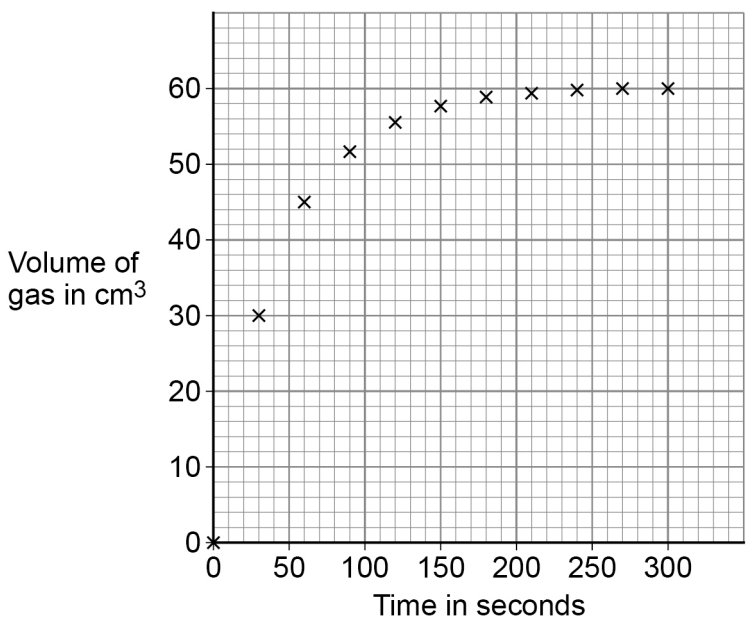
4.6.1.2 Factors which affect the rates of chemical reactions

Question 18 · continued

The student then set up the apparatus correctly.

Figure 5 shows the student's results.

Figure 5



0 5 . 3 Complete **Figure 5** by drawing a line of best fit.

[1 mark]

4.6.1.2 Factors which affect the rates of chemical reactions

Question 18 · continued

0 5 . 4 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 5**.

Give the unit.

Choose the answer from the box.

[4 marks]

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

Mean rate of reaction = _____ Unit _____

0 5 . 5 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?

[1 mark]

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. ☐

9

4.6.1.2 Factors which affect the rates of chemical reactions

Question 19

November 2021 | 8462/2F | Original Q7

0 7 This question is about organic compounds.

0 7 . 1 Butane is an alkane with small molecules.

Complete the sentence.

Choose the answer from the box.

[1 mark]

fertiliser	**formulation**	**fuel**

Butane can be used as a _____.

0 7 . 2 Poly(propene) is a polymer.

What is the name of the monomer used to produce poly(propene)?

[1 mark]

Tick (✓) **one** box.

Propane ☐

Propanoic acid ☐

Propanol ☐

Propene ☐

4.6.1.2 Factors which affect the rates of chemical reactions

Question 19 · continued November 2021 | 8462/2F | Original Q7

Ethene and steam react to produce ethanol.

The equation for the reversible reaction is:

ethene + steam ⇌ ethanol

0 7 . 3 The reaction produces a maximum theoretical mass of 400 kg of ethanol from 243 kg of ethene and 157 kg of steam.

A company produces 380 kg of ethanol from 243 kg of ethene and 157 kg of steam.

The percentage yield of ethanol is less than 100%

Calculate the percentage yield of ethanol.

Use the equation:

$$\text{percentage yield of ethanol} = \frac{\text{mass of ethanol actually made}}{\text{maximum theoretical mass of ethanol}} \times 100$$

[2 marks]

Percentage yield = _____ %

0 7 . 4 What are **two** possible reasons why the percentage yield of ethanol is less than 100%?

[2 marks]

Tick (✓) **two** boxes.

- Ethanol is the only product of the reaction. ☐
- Ethanol is very unreactive. ☐
- Some ethanol changes back into ethene and steam. ☐
- Some ethanol escapes from the apparatus. ☐
- Some ethanol reacts with steam. ☐

4.6.1.2 Factors which affect the rates of chemical reactions

Question 19 · continued

0 7 . 5 Ethanol burns in oxygen.

Balance the equation for the reaction.

[1 mark]

$$C_2H_5OH + ___ O_2 \rightarrow 3H_2O + 2CO_2$$

0 7 . 6 Two processes for producing ethanol are:

- fermentation
- hydration (reacting ethene with steam).

Table 5 shows information about the processes.

Table 5

Feature	Process	
	Fermentation	Hydration
Raw material	sugar	crude oil
Energy usage	low	high
Rate of reaction	slow	fast
Purity of ethanol	15%	98%

Give **two** advantages and **two** disadvantages of using fermentation to produce ethanol.

[4 marks]

Advantage of fermentation 1 _____

_____

Advantage of fermentation 2 _____

_____

Disadvantage of fermentation 1 _____

_____

Disadvantage of fermentation 2 _____

_____

11

4.6.1.2 Factors which affect the rates of chemical reactions

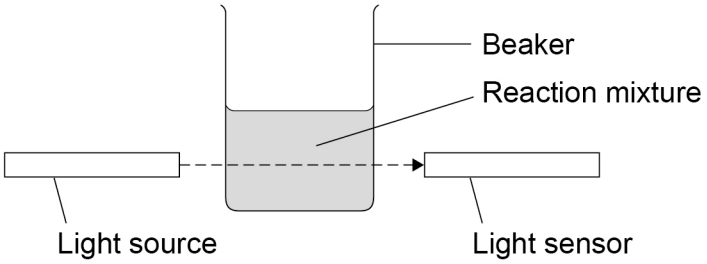
Question 20

June 2022 | 8462/2F | Original Q6

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]

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

4.6.1.2 Factors which affect the rates of chemical reactions

Question 20 · continued

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 ☐

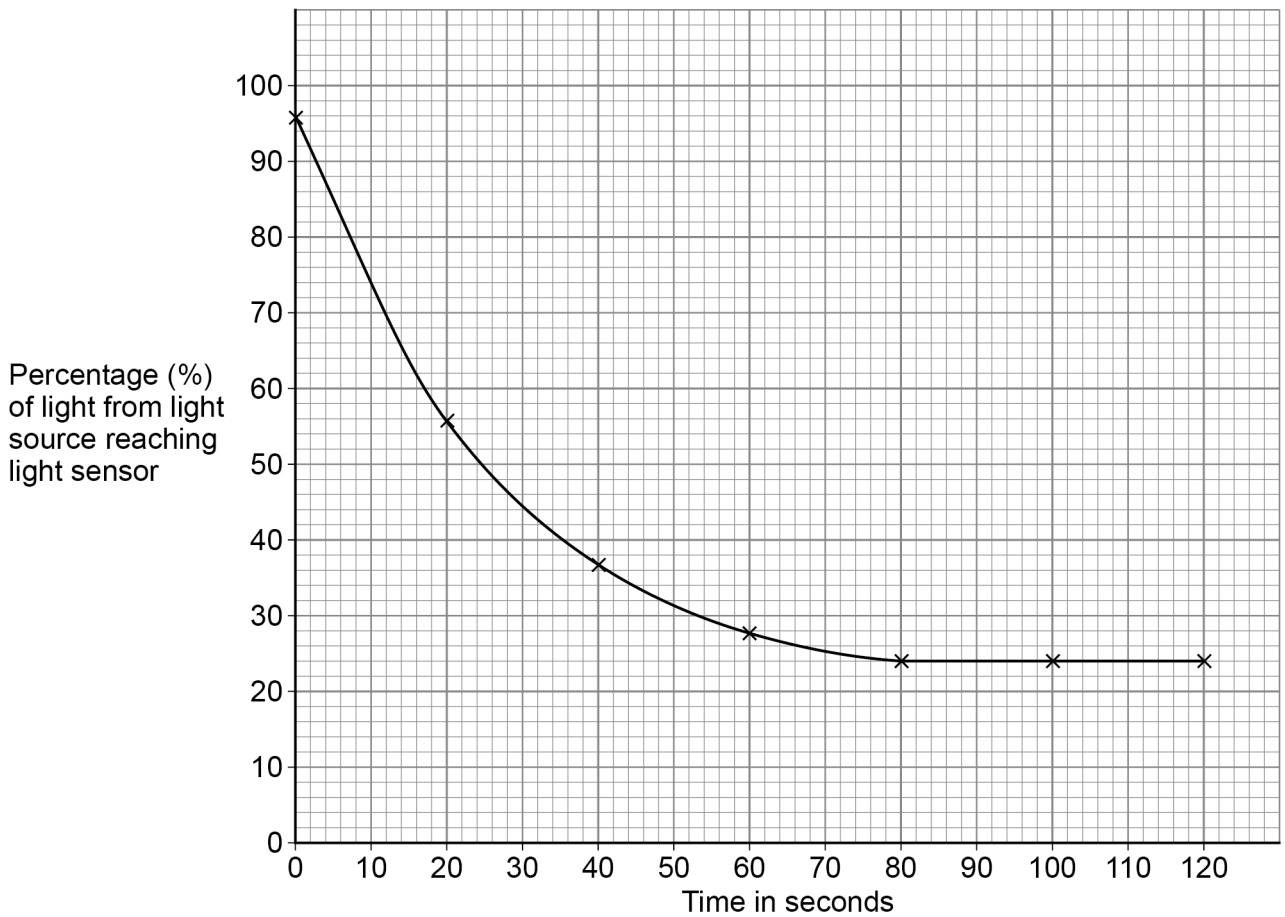
Question 6 continues on the next page

4.6.1.2 Factors which affect the rates of chemical reactions

Question 20 · continued

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. ☐

4.6.1.2 Factors which affect the rates of chemical reactions

Question 20 · continued

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. ☐

Question 6 continues on the next page

4.6.1.2 Factors which affect the rates of chemical reactions

Question 20 · continued

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. ☐

8

4.6.1.2 Factors which affect the rates of chemical reactions

Question 21

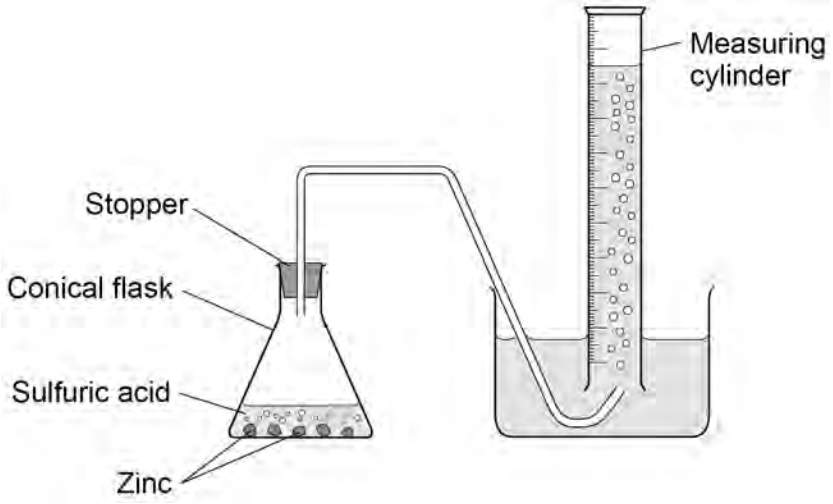
June 2023 | 8462/2F | Original Q8

0 8 A student investigated the rate of the reaction between zinc and sulfuric acid.

Hydrogen gas is produced during this reaction.

Figure 7 shows the apparatus.

Figure 7



This is the method used.

1. Add 50 cm^3 of sulfuric acid to a conical flask.

2. Add 2.0 g of zinc to the conical flask.

3. Quickly put a stopper in the conical flask and start a timer.

4. Measure the time taken to collect 20 cm^3 of gas.

5. Repeat steps 1 to 4 three more times.

0 8 . 1 Suggest why the stopper must be put in the conical flask as quickly as possible in **step 3**.

[1 mark]

Question 21 · continued

0 8 . 2 The student calculated the rate of the reaction for each trial.

Table 7 shows the results of the calculations.

Table 7

	Trial 1	Trial 2	Trial 3	Trial 4
Rate of reaction in cm^3/s	0.78	0.81	0.68	0.81

Determine the mean time taken to collect 20 cm^3 of gas.

Do **not** include any anomalous results.

Use the equation:

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

[5 marks]

Mean time taken = _____ s

Question 8 continues on the next page

4.6.1.2 Factors which affect the rates of chemical reactions

Question 21 · continued June 2023 | 8462/2F | Original Q8

0 8 . 3 The student changed the investigation so that the mean time taken to collect 20 cm^3 of gas was greater.

Which **two** changes would increase the mean time taken to collect 20 cm^3 of gas?

[2 marks]

Tick (✓) **two** boxes.

- Use a catalyst ☐
- Use a larger conical flask ☐
- Use a lower temperature ☐
- Use smaller pieces of zinc ☐
- Use sulfuric acid of a lower concentration ☐

0 8 . 4 Hydrogen gas is produced during this reaction.

Describe the test for hydrogen gas.

Give the result of the test.

[2 marks]

Test _____

_____

Result _____

_____

10

4.6.1.2 Factors which affect the rates of chemical reactions

Question 22

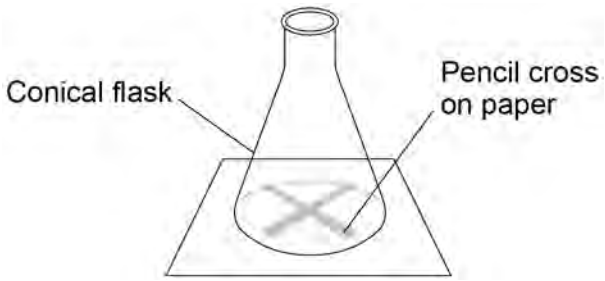
June 2024 | 8462/2F | Original Q5

0 5 A student investigated the rate of the reaction of sodium thiosulfate solution with hydrochloric acid.

When sodium thiosulfate solution reacts with hydrochloric acid, the mixture becomes cloudy.

Figure 6 shows the apparatus.

Figure 6



This is the method used.

1. Put 75 cm^3 of sodium thiosulfate solution in a conical flask.
2. Draw a pencil cross on paper.
3. Put the conical flask on the pencil cross.
4. Add 15 cm^3 of hydrochloric acid to the contents of the conical flask.
5. Swirl the conical flask to mix the contents and immediately start a timer.
6. Stop the timer when the pencil cross is no longer visible through the reaction mixture.
7. Repeat steps 1 to 6 using different concentrations of sodium thiosulfate solution.

0 5 . 1 Explain why a 50 cm^3 conical flask is unsuitable to use in this method.

[2 marks]

4.6.1.2 Factors which affect the rates of chemical reactions

Question 22 · continued

0 5 . 2 Name a piece of equipment suitable for measuring the volume of sodium thiosulfate solution.

[1 mark]

0 5 . 3 The student measured the time taken for the pencil cross to be no longer visible for different concentrations of sodium thiosulfate solution.

Draw **one** line from each type of variable to the variable in this investigation.

[2 marks]

Type of variable	Variable in this investigation
	Concentration of sodium thiosulfate solution
	Size of conical flask
Dependent variable	
	Temperature of sodium thiosulfate solution
Independent variable	
	Time for pencil cross to become no longer visible
	Volume of hydrochloric acid

Question 5 continues on the next page

Question 22 · continued

0 5 . 4 What effect will using a darker pencil cross have on the time taken for the cross to be no longer visible?

[1 mark]

Tick (✓) **one** box.

The time taken will decrease. ☐

The time taken will be the same. ☐

The time taken will increase. ☐

0 5 . 5 **Table 2** shows the results.

Table 2

Concentration of sodium thiosulfate solution in g/dm^3	Time for cross to become no longer visible in seconds
8	120
16	60
24	40
32	30

Which concentration of sodium thiosulfate solution had the highest rate of reaction?

[1 mark]

Tick (✓) **one** box.

8 g/dm^3 ☐ 16 g/dm^3 ☐ 24 g/dm^3 ☐ 32 g/dm^3 ☐

4.6.1.2 Factors which affect the rates of chemical reactions

Question 22 · continued

0 5 . 6 Increasing the concentration of sodium thiosulfate solution changes the rate of the reaction with hydrochloric acid.

Which **two** statements explain the effect of increasing the concentration?

[2 marks]

Tick (✓) **two** boxes.

- The particles are closer together. ☐
- The particles are further apart. ☐
- The particles collide less frequently. ☐
- The particles collide more frequently. ☐
- The particles move faster. ☐
- The particles move slower. ☐

0 5 . 7 The effect on the time taken for the cross to disappear can also be investigated by:

- changing the temperature of the hydrochloric acid
- changing the concentration of the hydrochloric acid.

Complete the sentences.

Choose the answers from the box.

[2 marks]

decreases	**stays the same**	**increases**

If the temperature of the hydrochloric acid is **increased**, the time taken for the cross to disappear _____.

If the concentration of the hydrochloric acid is **decreased**, the time taken for the cross to disappear _____.

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4.6.1.2 Factors which affect the rates of chemical reactions

Question 23

June 2025 | 8462/2F | Original Q2

0 2 Alkanes and alkenes are hydrocarbons.

Hydrocarbon molecules are made up of hydrogen and carbon atoms only.

An alkene has the formula C_3H_6

0 2 . 1 Which alkene has the formula C_3H_6?

[1 mark]

Tick (✓) **one** box.

Butene ☐

Ethene ☐

Propene ☐

0 2 . 2 How many atoms are there in a molecule of C_3H_6?

[1 mark]

Tick (✓) **one** box.

2 ☐ 3 ☐ 6 ☐ 9 ☐

0 2 . 3 Which is a use of C_3H_6?

[1 mark]

Tick (✓) **one** box.

Making a polymer ☐

Making ammonia ☐

Making glass ☐

Question 23 · continued

0 2 . 4 The percentage (%) by mass of each element in a molecule of C_3H_6 is:

- hydrogen 14%
- carbon 86%.

Figure 1 shows the percentage by mass of hydrogen in a molecule of C_3H_6

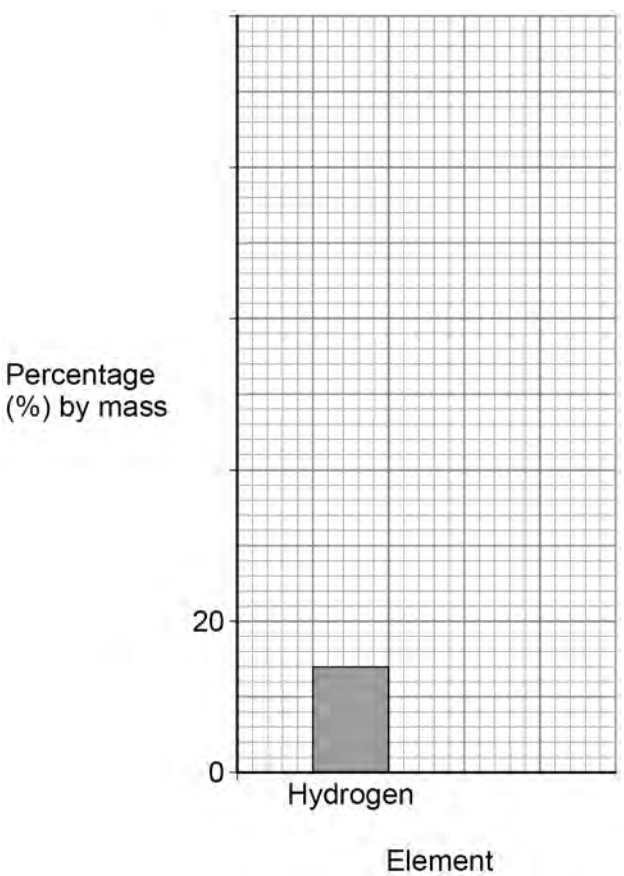
Complete **Figure 1**.

You should:

- complete the *y*-axis scale
- plot the percentage by mass of carbon as a bar
- label the bar plotted for carbon.

[3 marks]

Figure 1



4.6.1.2 Factors which affect the rates of chemical reactions

Question 23 · continued June 2025 | 8462/2F | Original Q2

Alkanes can be cracked to produce alkenes and smaller alkane molecules.

0 2 . 5 Describe a test for alkenes.

Give the result of the test.

[2 marks]

Test _____

_____

Result _____

_____

0 2 . 6 $C_{10}H_{22}$ can be cracked to produce C_3H_6 and an alkane.

Complete the equation for the reaction.

[1 mark]

$$C_{10}H_{22} \longrightarrow C_3H_6 + C___H_{16}$$

0 2 . 7 Complete the sentence.

Choose the answer from the box.

[1 mark]

ceramics	**fertilisers**	**fuels**

Smaller alkanes from cracking are useful as _____.

4.6.1.2 Factors which affect the rates of chemical reactions

Question 23 · continued

High temperatures between 450 °C and 750 °C are used in cracking reactions.

0 2 . 8 Which statement describes the molecules at 750 °C compared with the molecules at 450 °C?

[1 mark]

Tick (✓) **one** box.

The molecules collide more frequently at 750 °C. ☐

The molecules have less energy at 750 °C. ☐

The molecules move more slowly at 750 °C. ☐

0 2 . 9 How does the rate of reaction at 750 °C compare with the rate of reaction at 450 °C?

[1 mark]

_____

_____

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