

Name: \_\_\_\_\_

# Rates & Equilibrium part 2 AQA Triple Chemistry

Class: \_\_\_\_\_

Date: \_\_\_\_\_

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Time: **73 minutes**

Marks: **68 marks**

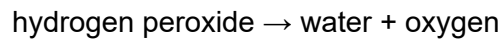
Comments:

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1.

Some students investigated the rate of decomposition of hydrogen peroxide.

The equation for the reaction is:



(a) Complete the sentence.

Choose an answer from the box.

<b>a burning splint</b>	<b>a glowing splint</b>
<b>damp litmus paper</b>	<b>limewater</b>

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

The students used \_\_\_\_\_.

(1)

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<sup>3</sup> 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.

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

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

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<sup>3</sup> hydrogen peroxide.

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

(1)

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

(c) How could student **B** improve the accuracy of these results?

Tick (✓) **one** box.

Calculate a mean but do not include any anomalous results.

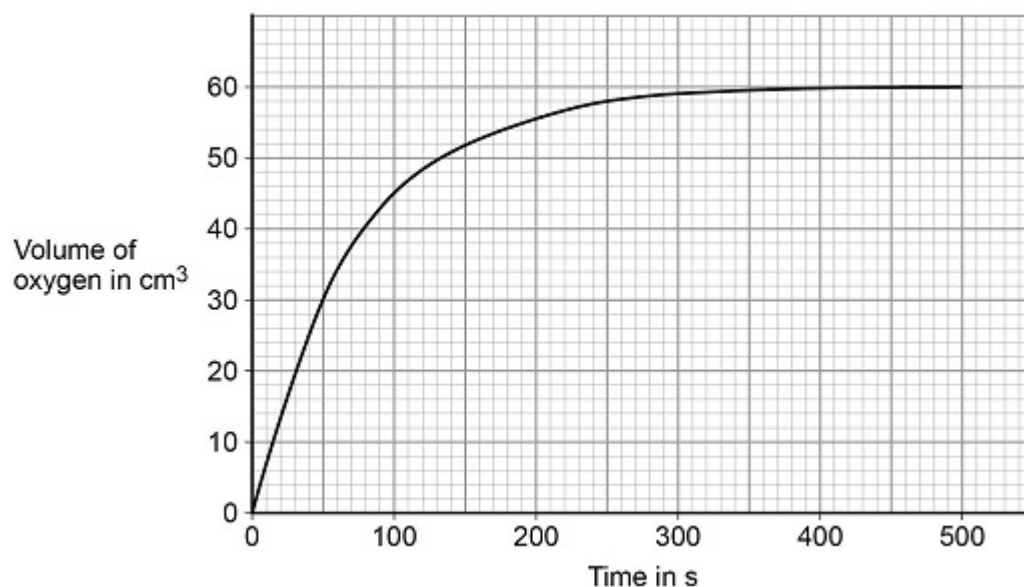
Calculate a mean but do not include the first set of results.

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.

**(1)**

The figure below shows student **B**'s results for coarse manganese dioxide lumps.



- (d) Calculate the mean rate of reaction between 30 and 250 seconds for coarse manganese dioxide lumps.

Use the figure and the equation:

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

Give your answer to 3 significant figures.

Volume of oxygen formed \_\_\_\_\_

Time taken \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Mean rate of reaction = \_\_\_\_\_ cm<sup>3</sup>/s

(4)

- (e) Fine manganese dioxide powder produces a higher rate of reaction than coarse manganese dioxide lumps.

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

(2)

- (f) 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?

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.

(1)

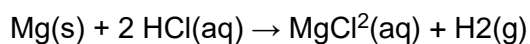
(Total 10 marks)

2.

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:



- (a) Which state symbol in the equation for the reaction does not represent one of the three states of matter?

\_\_\_\_\_

(1)

The student determined the rate of production of hydrogen gas.

- (b) What **two** pieces of measuring apparatus could the student use to find the rate of production of hydrogen gas?

1 \_\_\_\_\_

2 \_\_\_\_\_

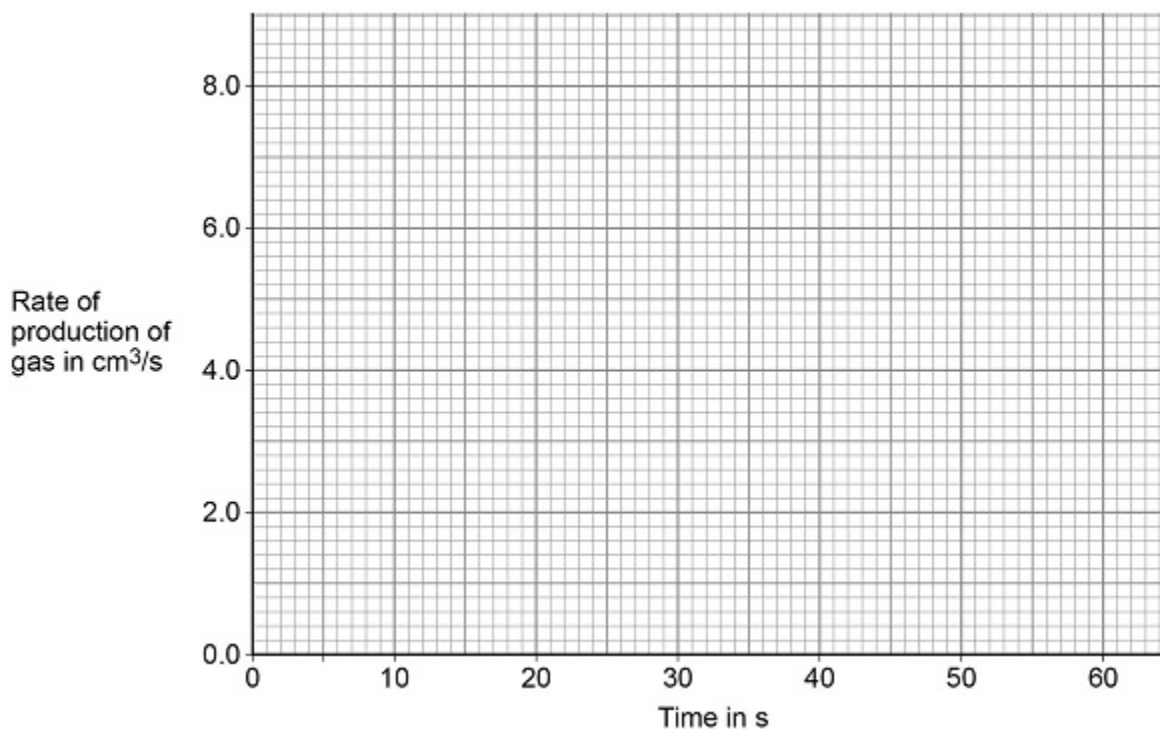
(2)

The following table shows the results of the investigation.

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

(c) Plot the data from the table on the graph below.

You should draw a line of best fit.



(3)

- (d) Give **three** conclusions that can be drawn about the rate of reaction between magnesium and dilute hydrochloric acid in this investigation.

Use data from the graph and the table above.

1 \_\_\_\_\_

\_\_\_\_\_

2 \_\_\_\_\_

\_\_\_\_\_

3 \_\_\_\_\_

\_\_\_\_\_

**(3)**

- (e) 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?

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.

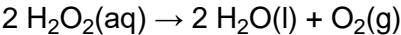
**(2)**

**(Total 11 marks)**

3.

Some students investigated the rate of decomposition of hydrogen peroxide, H<sub>2</sub>O<sub>2</sub>

The equation for the reaction is:



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<sup>3</sup> of 0.3 mol/dm<sup>3</sup> 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.

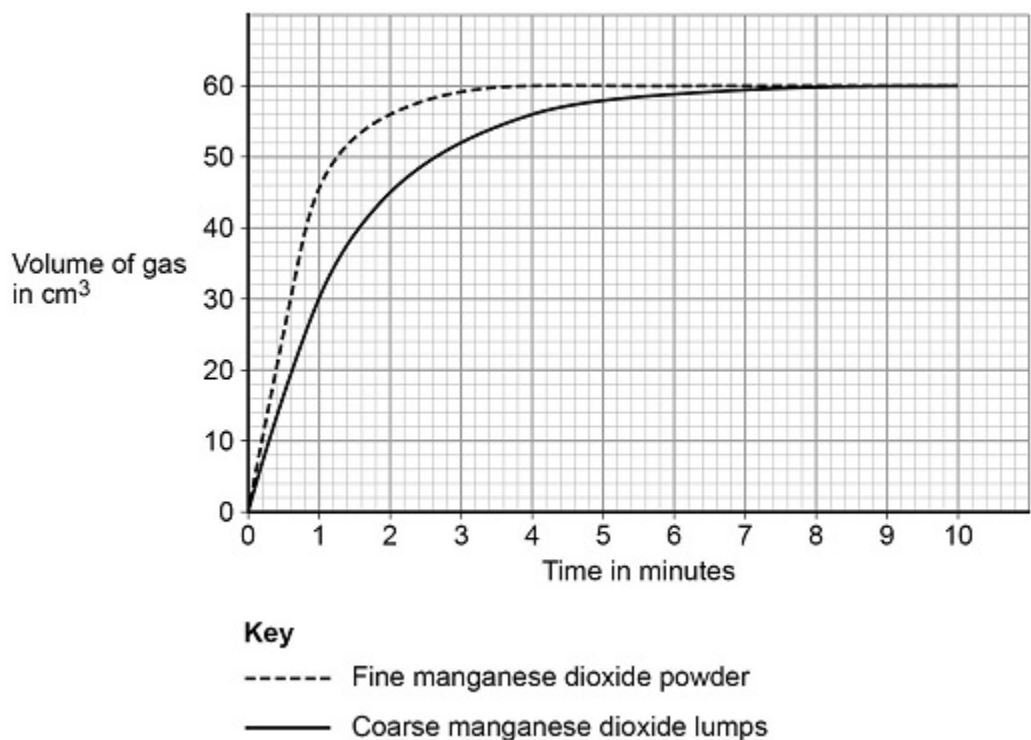
Use 0.05 mol/dm<sup>3</sup> hydrogen peroxide solution.

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<sup>3</sup>/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<sup>3</sup>/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  $0.2 \text{ mol/dm}^3$  hydrogen peroxide instead of  $0.3 \text{ mol/dm}^3$  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.

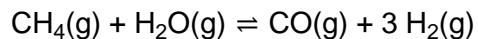
This question is about reversible reactions and equilibrium.

Hydrogen is used to produce ammonia in the Haber process.

The hydrogen is made in two stages.

**Stage 1** is the reaction of methane and steam to produce carbon monoxide and hydrogen.

The equation for the reaction is:



(a) Calculate the atom economy for the formation of hydrogen in **stage 1**.

Relative atomic masses ( $A_r$ ): H = 1 C = 12 O = 16

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Atom economy = \_\_\_\_\_%

(2)

(b) Explain why a low pressure is used in **stage 1**.

Give your answer in terms of equilibrium.

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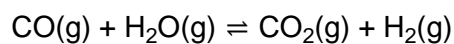
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(2)

(c) **Stage 2** uses the carbon monoxide produced in **stage 1**.

The carbon monoxide is reacted with more steam to produce carbon dioxide and more hydrogen.

The equation for the reaction in **stage 2** is:



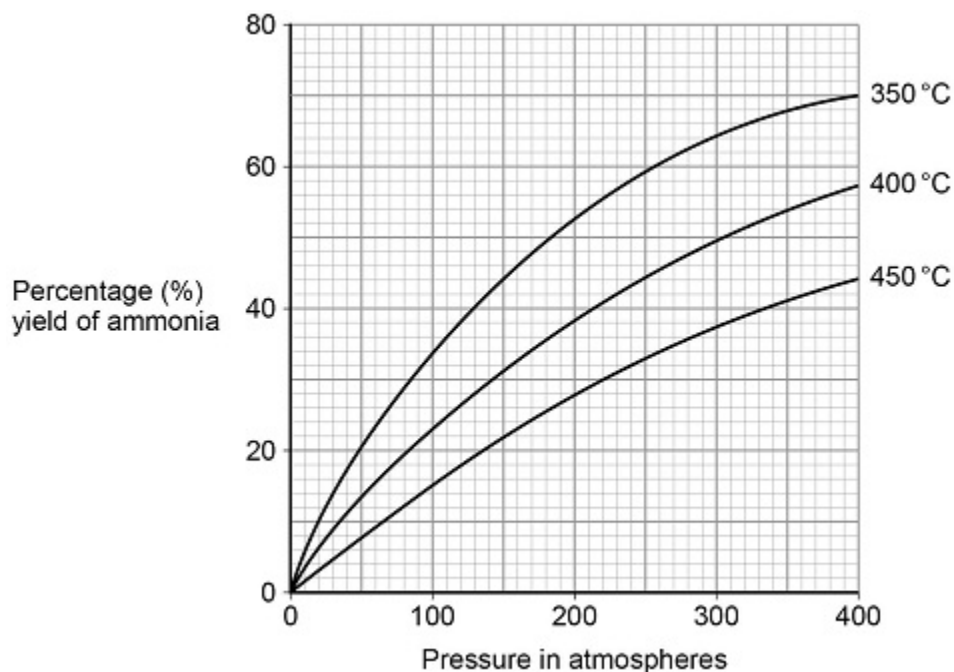
What is the effect of increasing the pressure on the equilibrium yield of hydrogen in **stage 2**?

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(1)

The graph below shows the percentage yield of ammonia produced at different temperatures and pressures in the Haber process.



A temperature of 450 °C and a pressure of 200 atmospheres are used in the Haber process.

- (d) A student suggested that a temperature of 350 °C and a pressure of 285 atmospheres could be used instead of those used in the Haber process.

Determine how many times greater the percentage yield of ammonia obtained would be.

Use the graph.

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Percentage yield = \_\_\_\_\_ times greater

(3)

- (e) A pressure of 285 atmospheres is **not** used in the Haber process instead of 200 atmospheres.

Give **one** reason why.

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(1)

- (f) How does the graph above show that the forward reaction in the Haber process is exothermic?

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(1)

- (g) World production of ammonia is now about 30 times greater than it was in 1950.

Suggest why the demand for ammonia has increased.

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(2)

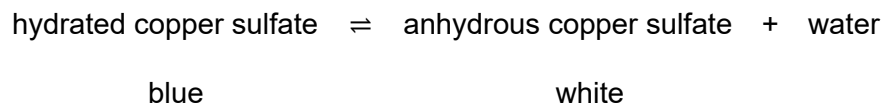
(Total 12 marks)

5.

This question is about copper sulfate.

Blue copper sulfate turns white when it is heated.

The word equation for the reaction is:



(a) What name is given to hydrated copper sulfate in this reaction?

Tick **one** box.

Catalyst

Element

Product

Reactant

(1)

(b) What does the symbol  $\rightleftharpoons$  mean?

Tick **one** box.

Endothermic

Exothermic

Reversible

Polymerisation

(1)

(c) Complete the sentence.

The colour change when the water is added to anhydrous copper sulfate is white to \_\_\_\_\_ .

(1)

A student heats 2.5 g of hydrate copper sulfate in a test tube.

0.9 g of water is given off.

The remaining solid is anhydrous copper sulfate.

(d) Calculate the mass of anhydrous copper sulfate produced.

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Mass of anhydrous copper sulfate = \_\_\_\_\_ g

(2)

(e) Calculate the percentage of water contained in 2.5 g of hydrated copper sulfate.

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Percentage of water = \_\_\_\_\_ %

(2)

(f) Draw **one** line from each compound to the formula for the compound.

Compound	Formula for the compound
	CuO
Copper sulfate	CuS
	CuSO <sub>4</sub>
Water	H <sub>2</sub> O
	H <sub>2</sub> SO <sub>4</sub>

(2)

(Total 8 marks)

6.

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

The equation for the reaction is:



(a) Why does the solution become cloudy?

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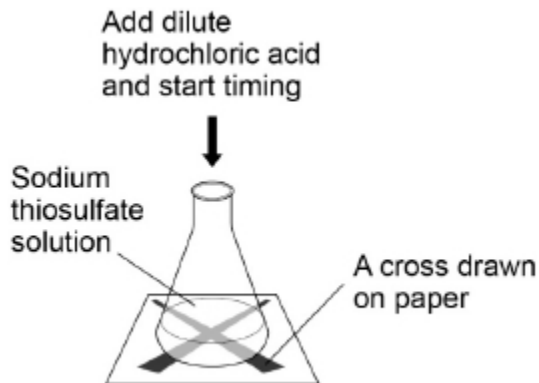
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(2)

Some students used this reaction to investigate the effect of concentration on rate of reaction.

The diagram shows the apparatus used.



This is the method used.

1. Measure 25 cm<sup>3</sup> sodium thiosulfate solution into a conical flask.
2. Stand the conical flask on a cross drawn on paper.
3. Add 10 cm<sup>3</sup> of dilute hydrochloric acid.
4. Time how long it takes the cross to become no longer visible.
5. Repeat steps 1–4 with sodium thiosulfate solutions of different concentrations.

(b) The students used a measuring cylinder to measure 25 cm<sup>3</sup> of sodium thiosulfate solution.

Suggest a more accurate way of measuring 25 cm<sup>3</sup> of sodium thiosulfate solution.

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(1)

(c) Name one control variable the students should use in this investigation.

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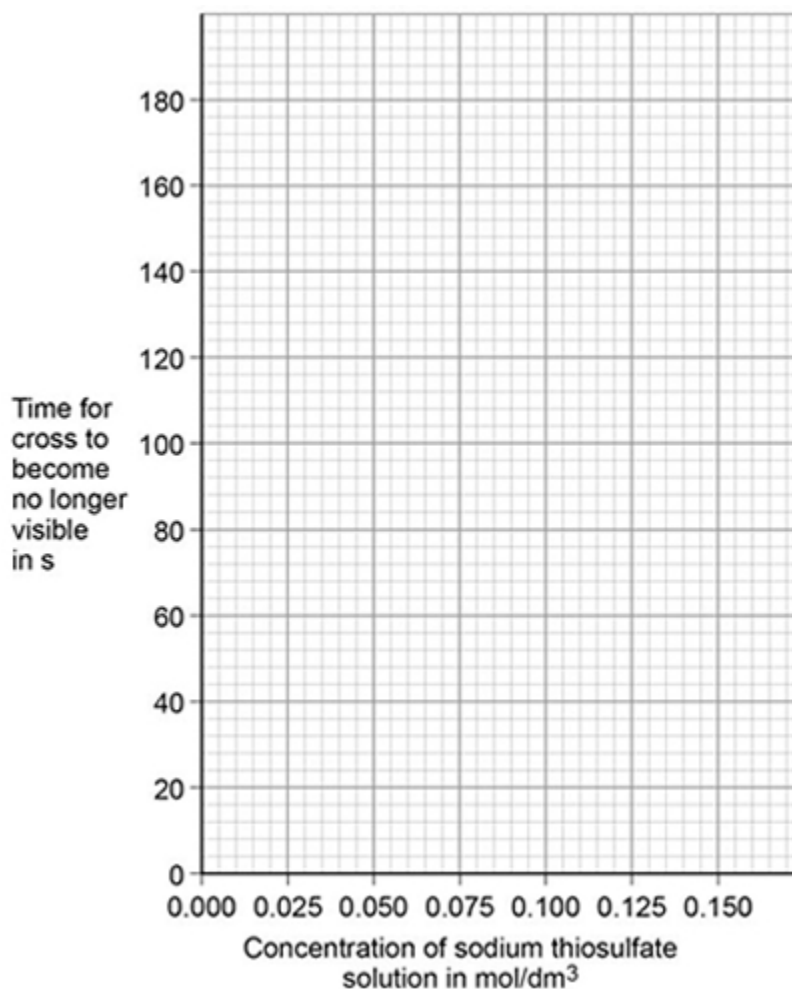
(1)

The table shows the students' results.

Concentration of sodium thiosulfate solution in mol / dm <sup>3</sup>	Time for cross to become no longer visible in s
0.020	170
0.040	90
0.060	82
0.080	42
0.100	34
0.120	30
0.140	28

(d) Plot the data from the table above on the graph below.

Draw a line of best fit.



(3)

The students repeated the investigation two more times.

They obtained similar results each time.

- (e) What word describes an investigation by the same students which gives similar results each time?

\_\_\_\_\_

(1)

- (f) Describe how the students can use their results to improve the accuracy of the investigation.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(2)

- (g) The students analysed their results to give a conclusion and an explanation for their investigation.

**Conclusion:** 'The higher the concentration, the lower the rate of reaction.'

**Explanation:** 'At higher concentrations, the particles have more energy, so they are moving faster. Therefore the collisions are more energetic.'

The students are not correct.

Give a **correct** conclusion **and** explanation for the results of the investigation.

Conclusion \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Explanation \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(3)

- (h) A solution containing 0.18 g of sodium thiosulfate reacts with dilute hydrochloric acid in 2 minutes.

Calculate the mean rate of reaction in g / s.

Give your answer in standard form.

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Mean rate of reaction = \_\_\_\_\_ g / s

**(3)**

**(Total 16 marks)**

## Mark schemes

- 1.** (a) a glowing splint 1
- (b) student **A** should measure the mass of manganese dioxide. 1
- (c) calculate a mean but do not include any anomalous results. 1
- (d) *an answer of 0.173 (cm<sup>3</sup>/s) scores 4 marks*
- (volume of oxygen formed =)  
(58 - 20 =) 38 (cm<sup>3</sup>)  
*allow values between 36 (cm<sup>3</sup>) and 40 (cm<sup>3</sup>) inclusive* 1
- (time taken = 250 - 30 =) 220 (s) 1
- $\frac{38}{220}$  **or** 0.1727 (cm<sup>3</sup>/s)  
*allow a correct calculation using an incorrectly determined value for volume and / or time* 1
- = 0.173 (cm<sup>3</sup>/s)  
*allow a correctly calculated answer given to 3 significant figures from an incorrect attempt at the rate equation* 1
- (e) line starts at the origin **and** steeper than existing line 1
- final volume same as existing line  
*allow a tolerance of  $\pm \frac{1}{2}$  a small square* 1
- (f) fine manganese dioxide powder has a larger surface area 1
- [10]
- 2.** (a) (aq) *allow aqueous / aq* 1
- (b) (gas) syringe  
*allow measuring cylinder (and water trough)*  
*allow balance* 1
- stopclock / stopwatch  
*allow timer / clock / watch* 1

- (c) all points plotted correctly  
*allow a tolerance of  $\pm \frac{1}{2}$  a small square*  
*allow at least 3 points plotted correctly for 1 mark.* 2
- line of best fit  
*allow correctly drawn line of best fit for incorrectly plotted points* 1
- (d) (rate) decreases  
*allow slows down* 1
- (rate decreases) more slowly as time increases  
*allow (rate decreases) at a non-linear rate* 1
- (rate) becomes zero at 60 s  
*allow the reaction stops at 60 s*  
*allow ecf from part (c)* 1
- (e) more bubbles were produced in the first 10 seconds 1
- the magnesium was used up more quickly 1
- [11]
- 3.** (a) glowing splint  
*do **not** accept burning splint* 1
- (which) relights  
*dependent on correct test in MP1*  
*ignore with a pop* 1
- (b) place the conical flask in a water bath at constant temperature. 1
- use a mass of 1 g manganese dioxide each time. 1

(c)

*an answer of 0.092 (cm<sup>3</sup>/s) scores 3 marks*

*allow an answer of 0.091666 (cm<sup>3</sup>/s) correctly rounded to at least 2 significant figures for 2 marks*

*allow an answer of 0.033 (cm<sup>3</sup>/s) for 2 marks*

*allow an answer of 0.033333 (cm<sup>3</sup>/s) for 1 mark*

11 (cm<sup>3</sup>) **and** 120 (seconds)

1

(mean rate of reaction =  $\frac{11}{120}$  )

= 0.09167

*allow a correct calculation using incorrectly determined value(s) for difference in volume and / or time*

1

= 0.092 (cm<sup>3</sup>/s)

*allow a correctly calculated answer given to 2 significant figures from an incorrect attempt at the rate equation*

1

(d) line starts at origin **and** less steep than solid line

1

line levelling off at 40 (cm<sup>3</sup>)

*allow a tolerance of  $\pm \frac{1}{2}$  a small square*

1

(e) (because) surface area (of fine manganese dioxide powder) greater

*allow converse for coarse lumps*

1

(so) more collisions (with hydrogen peroxide molecules / particles) per unit time

*do **not** accept references to changes in kinetic energy or speed (of molecules / particles)*

*ignore references to activation energy.*

1

[11]

4.

(a)

*an answer of 17.6470588 (%) correctly rounded to at least 2 significant figures scores 2 marks*

$\frac{6}{34} \times 100$

1

= 17.6 (%)

*allow 17.6470588 (%) correctly rounded to at least 2 significant figures*

1

(b)

*allow converse arguments in terms of higher pressure  
ignore references to rate*

higher yield (of hydrogen or carbon monoxide or product)  
*allow more hydrogen or more carbon monoxide or more product  
allow equilibrium moves to the right  
allow equilibrium moves in the forward direction*

1

(because) fewer moles / molecules / particles on left hand side

**or**

(because) more moles / molecules / particles on right hand side  
*allow (because) the reverse reaction produces fewer moles / molecules / particles  
**or**  
allow (because) the forward reaction produces more moles / molecules / particles  
do **not** accept fewer / more atoms*

1

(c) no effect (on yield of hydrogen)

*allow position of equilibrium unaffected by pressure  
ignore references to rate of reaction*

1

(d)

*an answer of 2.25 scores **3** marks*

350 (°C) and 285 (atmospheres) = 63 (%)

**and**

450 (°C) and 200 (atmospheres) = 28 (%)

*allow a value between 62 (%) and 64 (%) inclusive*

1

$\frac{63}{28}$

*allow a correct expression using incorrectly determined value(s) for percentage yield*

1

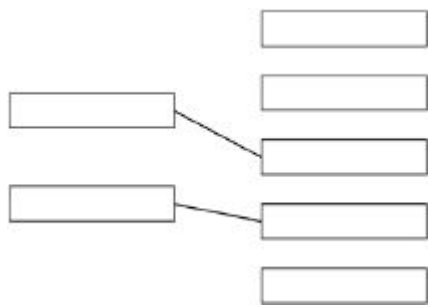
= 2.25 (times greater)

*allow a correct calculation using incorrectly determined value(s) for percentage yield correctly evaluated and rounded to at least 2 significant figures*

1

- (e) *allow converse arguments in terms of low(er) pressure*  
 any **one** from:
- the energy costs would be high(er)  
*ignore energy / cost unqualified*
  - the equipment would need to be strong(er)  
*allow the equipment would be (more) expensive (to build / maintain)*
  - high(er) pressures are (more) dangerous  
*allow (more) dangerous because (greater) risk of explosion*
- 1
- (f) higher temperatures produce a lower (percentage) yield (of ammonia)  
*allow converse*  
*allow correct reference to shift in equilibrium*  
*ignore references to pressure*
- 1
- (g) world population has increased
- 1
- any **one** from:
- demand for fertiliser has increased  
*allow more food needed*
  - increased demand for other specified ammonia-based products e.g. nitric acid, drugs, dyes, explosives
- 1
- [12]**
- 5.** (a) reactant
- 1
- (b) reversible
- 1
- (c) blue  
*allow shades of blue, e.g. pale blue*
- 1
- (d) 1.6 (g)
- 1
- (e)  $\frac{0.9}{2.5} \times 100$
- 1
- = 36 (%)
- 1
- an answer of 36 (%) scores 2 marks*

(f)



*copper sulfate – CuSO<sub>4</sub>*

*water – H<sub>2</sub>O*

1

1

[8]

6.

(a) sulfur

1

precipitate

*allow solid*

1

(b) any **one** from:

- (volumetric) pipette
- burette

1

(c) any **one** from:

- concentration of hydrochloric acid
- volume of hydrochloric acid
- volume of sodium thiosulfate solution
- temperature (of solution)
- darkness of cross

*allow same cross*

- same stirring / swirling

1

(d) 7 points plotted correctly

*allow tolerance of ± half a small square*

*allow 5 or 6 points plotted correctly for 1 mark*

2

line of best fit

*must avoid anomalous point*

1

(e) repeatable

*do not accept reproducible*

1

- (f) discard any anomalous results 1
- calculate a mean 1
- (g) **conclusion:**  
the higher the concentration, the higher the rate of reaction 1
- explanation:**  
(at higher concentrations) there are more particles in a fixed volume 1
- (therefore the) collisions are more frequent 1
- allow converse*
- (h) 120 (s) 1
- 0.18 / 120 1
- allow 0.0015*
- =  $1.5 \times 10^{-3}$  (g / s)
- an answer of  $9 \times 10^{-2}$  scores 2 marks*
- allow an answer of 0.09 for 1 mark* 1
- an answer of  $1.5 \times 10^{-3}$  (g / s) scores 3 marks*

[16]