Name:	Target Grade:	Actual Grade:

BRIGHT CULTURE

RATE OF REACTION
MCQ and STRUCTURED QUESTIONS

READ THESE INSTRUCTIONS FIRST

INSTRUCTIONS TO CANDIDATES

1. Find a quiet, comfortable spot free place from distractions.

2. Spend one minute on each mark.

3. Time yourself for every single question.

4. Every chapter has their own question types. Ensure that you know the different question type for each chapter.

5. Make a conscientious effort to remember your mistakes, especially in terms of answering techniques. E.g Take a picture for the mistakes that you made, keep it in a photo album, and revise it over and over again.

6. Highlight question types that you tend to keep making mistakes and review them nearing exams.

7. Always review the common questions and question type that you tend to make mistakes nearing exams.

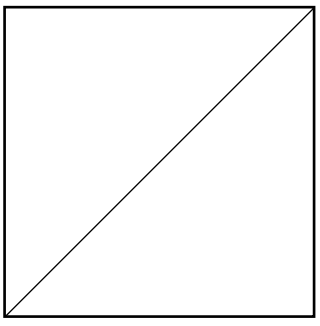
8. During exams, classify the question type and recall what you have learnt, how you need to analyse the questions for the different question type, what you need to take note of and answer with the correct answering techniques!

✨ **Wishing you all the best for this test!**

You've got this!

💡 **With lots of love,**
Bright Culture 💛

MARKS



If you are struggling in this paper, means you need to work harder!

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RATE OF REACTION MCQ

Paper 1

1 In which reaction is the pressure **not** likely to affect the rate of reaction?

A $3H_2\ (g) + N_2\ (g) \rightarrow 2NH_3\ (g)$
B $CuO\ (s) + H_2\ (g) \rightarrow Cu\ (s) + H_2O\ (l)$
C $Fe_2O_3\ (s) + 3CO\ (g) \rightarrow 2Fe\ (s) + 3CO_2\ (g)$
D $H_2SO_4\ (aq) + 2NaOH\ (aq) \rightarrow Na_2SO_4\ (aq) + 2H_2O\ (l)$

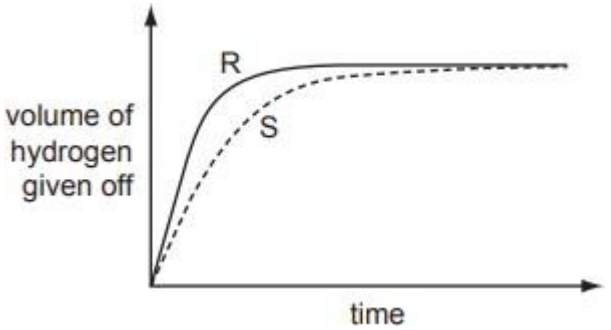
2 Methane gas reacts extremely slowly with air at room temperature. If a piece of warm platinum is held in a methane-air mixture, methane ignites. Which of the following statements correctly describes the reaction with platinum?

I The activation energy is low.
II The energy change is greater.
III The energy of the reactants is lower than expected.
IV The rate of reaction is faster.

A **I** and **II**
B **I** and **IV**
C **I**, **II** and **IV**
D **I**, **II**, **III** and **IV**

3 A student investigates the rate of reaction between magnesium and excess sulfuric acid. The volume of hydrogen given off in the reaction is measured over time.

The graph shows the results of two experiments, **R** and **S**.



Which change in conditions would cause the difference between **R** and **S**?

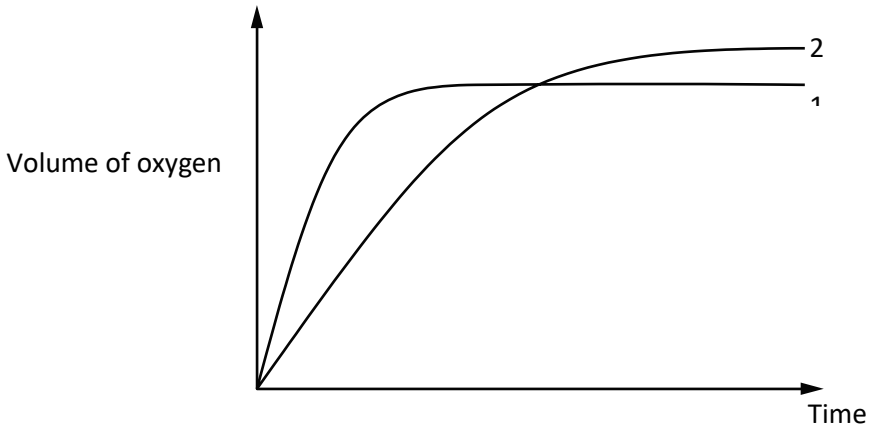
A Catalyst is added into **S**.
B The acid is more concentrated in **R** than in **S**.
C The magnesium is less finely powdered in **R** than in **S**.
D The temperature in **R** is lower than in **S**.

4 Zinc reacts with acids to form salts. Which of the following solutions would give the slowest rate of reaction when reacted with zinc?

A 0.0500 mol sulfuric acid in 500 cm^3 of water.
B 0.0250 mol sulfuric acid in 100 cm^3 of water.
C 0.0500 mol hydrochloric acid in 200 cm^3 of water.
D 0.0250 mol hydrochloric acid in 75 cm^3 of water.

5 In the graph, curve 1 was obtained by observing the decomposition of 100 cm^3 of 1.0 mol/dm^3 hydrogen peroxide solution, catalysed by manganese(IV) oxide.

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



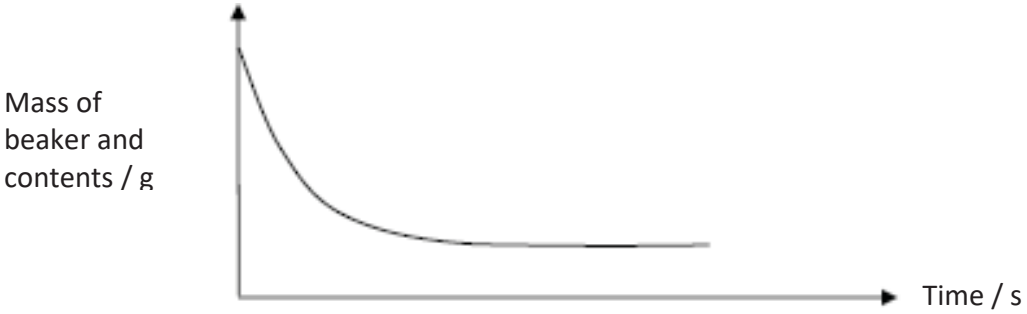
Which alteration to the original experimental conditions would produce curve 2?

A adding some 0.1 mol / dm^3 hydrogen peroxide solution
B lowering the temperature
C using a different catalyst
D using less manganese(IV) oxide

6 In which reaction is the pressure least likely to affect the speed of reaction?

A $C(s) + CO_2(g) \rightarrow 2CO(g)$
B $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
C $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$
D $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

7 Two solutions were mixed in a beaker and the mass of the beaker and contents was then recorded at various times. The graph shows the results.



What could the two solutions be?

A aqueous ammonia and aqueous iron(II) nitrate
B dilute hydrochloric acid and aqueous potassium hydroxide
C dilute nitric acid and solid copper(II) carbonate
D dilute sulfuric acid and aqueous barium nitrate

8 A sample of hydrogen peroxide is decomposed by a metal oxide catalyst.

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

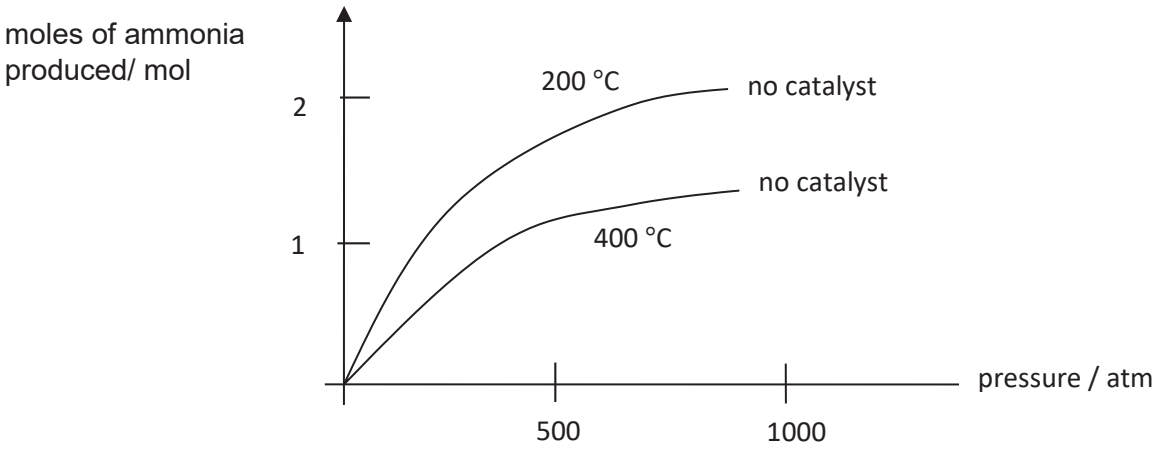
What will become larger if the experiment is repeated using a better catalyst?

A The total volume of gas produced at the end of the reaction.
B The amount of hydrogen peroxide left over at the end of the reaction.
C The initial gradient of a graph of total volume of gas produced against time.
D The time needed to produce a particular volume of gas.

9 When heated, nitrogen and hydrogen react according to the equation:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

The graph below shows the number of moles of ammonia produced from 1 mole of nitrogen at different temperatures and pressures.



Which one of the following statements may be deduced from this information?

1	At 500 atm pressure, the number of moles of ammonia produced is greater at 200 °C than at 400 °C.
2	An increase of pressure increases the number of moles of ammonia produced both at 200 °C and at 400 °C.
3	At 500 atm pressure and 300 °C, the number of moles of ammonia produced is likely to be greater than one.

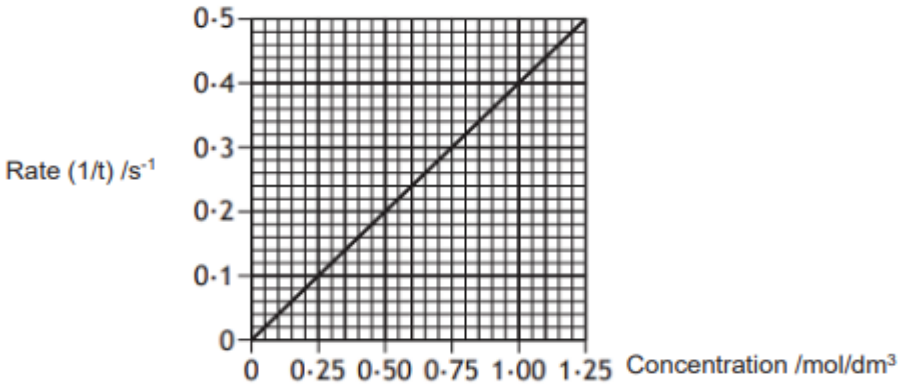
A 1, 2, and 3 are correct
B 2 and 3 only are correct
C 1 and 2 only are correct
D 1 only is correct

10 A student carries out a single experiment to determine the speed of reaction between calcium carbonate and an excess of hydrochloric acid.

Which of the following does **not** change during the course of the reaction?

A concentration of the hydrochloric acid solution
B mass of the calcium carbonate
C volume of carbon dioxide evolved
D volume of hydrochloric acid solution

11 The graph shows how the rate of a reaction varies with the concentration of one of the reactants.



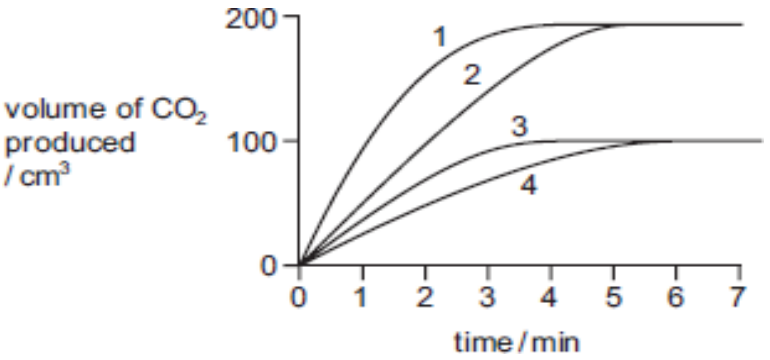
What is the reaction time, in seconds, when the concentration of the reactant was 0.50 mol/dm^3?

A 0.2
B 0.5
C 2.0
D 5.0

12 In four separate experiments, 1, 2, 3 and 4, nitric acid was added to excess marble chips and the volume of carbon dioxide formed was measured.

In all four experiments the same volume of nitric acid was used.

Its concentration, or temperature, or both concentration and temperature, were changed. The results of the experiments are shown on the graph.



Which statement is correct?

A A lower concentration of acid was used in experiment 3 than in experiment 1.
B Experiment 4 was faster than experiment 3.
C The acid used in experiment 2 was of a lower concentration than in experiment 1.
D The temperature of the acid was the same in experiments 1 and 2.

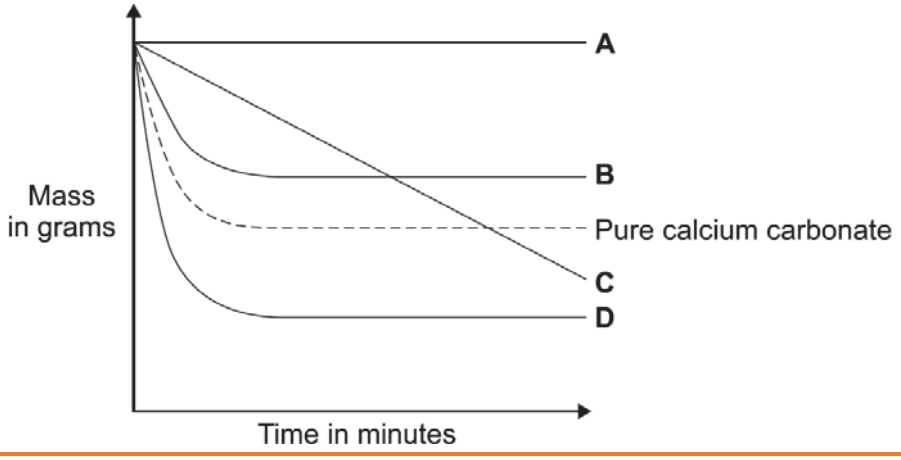
13 The following changes could be made to the conditions in the reaction between zinc and hydrochloric acid.

1 increase in concentration of the acid
2 increase in particle size of the zinc
3 increase in pressure on the system
4 increase in temperature of the system

Which pair of changes will increase the rate of reaction?

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

14 Limestone usually contains impurities.
The diagram below shows the change in mass when pure calcium carbonate is heated.
Which graph, **A**, **B**, **C** or **D**, shows a sample of limestone, of the same mass, containing impurities that do not thermally decompose?

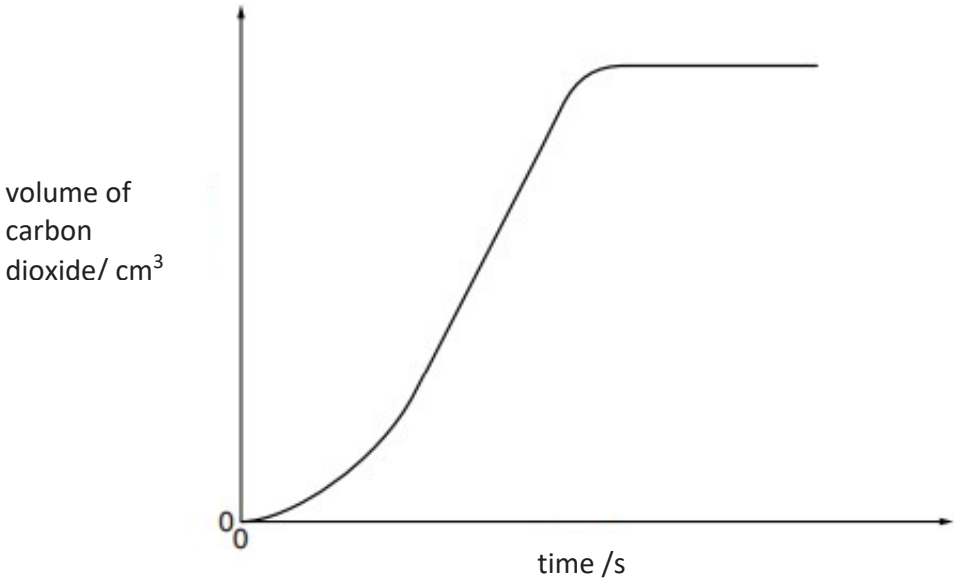


RATE OF REACTION STRUCTURED QUESTIONS

Paper 2 Section A

1 In **Experiment I**, a sample of magnesium carbonate is heated in a test-tube using a hot plate at 300 °C. The total volume of carbon dioxide formed is measured every 10 seconds.

The graph shows his results.



(a) Suggest why there is **no significant** increase in the volume of carbon dioxide when magnesium carbonate is first heated.

……

…… [1]

(b) In **Experiment II**, the same mass of magnesium carbonate is heated in a test-tube using a hot plate at a **higher temperature** of 500 °C.

Sketch a curve on the graph above to show the results for this experiment.

Explain your answer.

……

……

……

…… [3]

(c) Ron wishes to investigate
how the thermal stability of metal carbonates is related to the position of their metal in the reactivity series.

To ensure a fair experiment, he repeated **Experiment I** using different metal carbonates, while keeping all other variables constant.

The table below shows the results of the experiment after the first 60 seconds.

metal carbonate	total volume of gas collected/ cm^3
$\mathbf{X}_2CO_3$	0
$\mathbf{Y}CO_3$	0
$CaCO_3$	2
$FeCO_3$	7
$ZnCO_3$	5

(i) Write a balanced equation, with state symbols, for the thermal decomposition of $FeCO_3$.

……..…. [2]

(ii) Explain why $\mathbf{X}_2CO_3$ and $\mathbf{Y}CO_3$ do **not** decompose.

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……..….

……..…. [2]

(iii) A solution containing 0.002 mol of sulfuric acid is titrated with a solution containing 9.2 g/dm^3 of $\mathbf{X}_2CO_3$. The volume of $\mathbf{X}_2CO_3$ solution needed to exactly neutralise the acid is 23.2 cm^3.

1 mole of sulfuric acid reacts with 1 mole of $\mathbf{X}_2CO_3$.

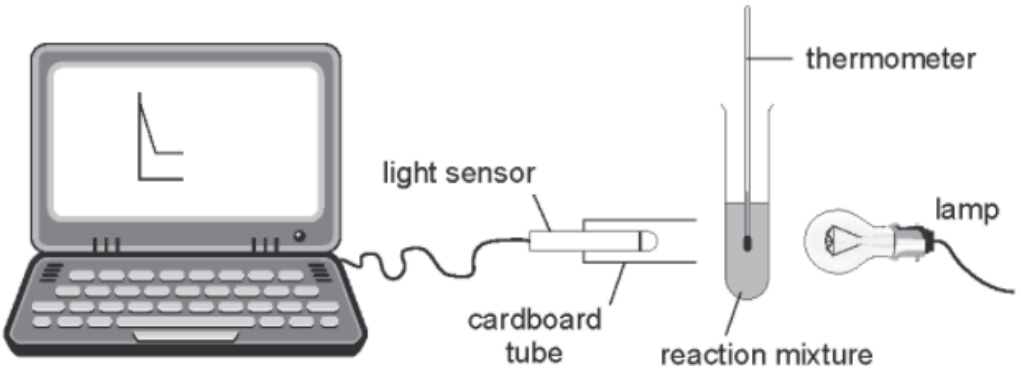
Calculate the relative atomic mass, *A*r, of **X** and suggest its identity.

A_r of **X** = ...

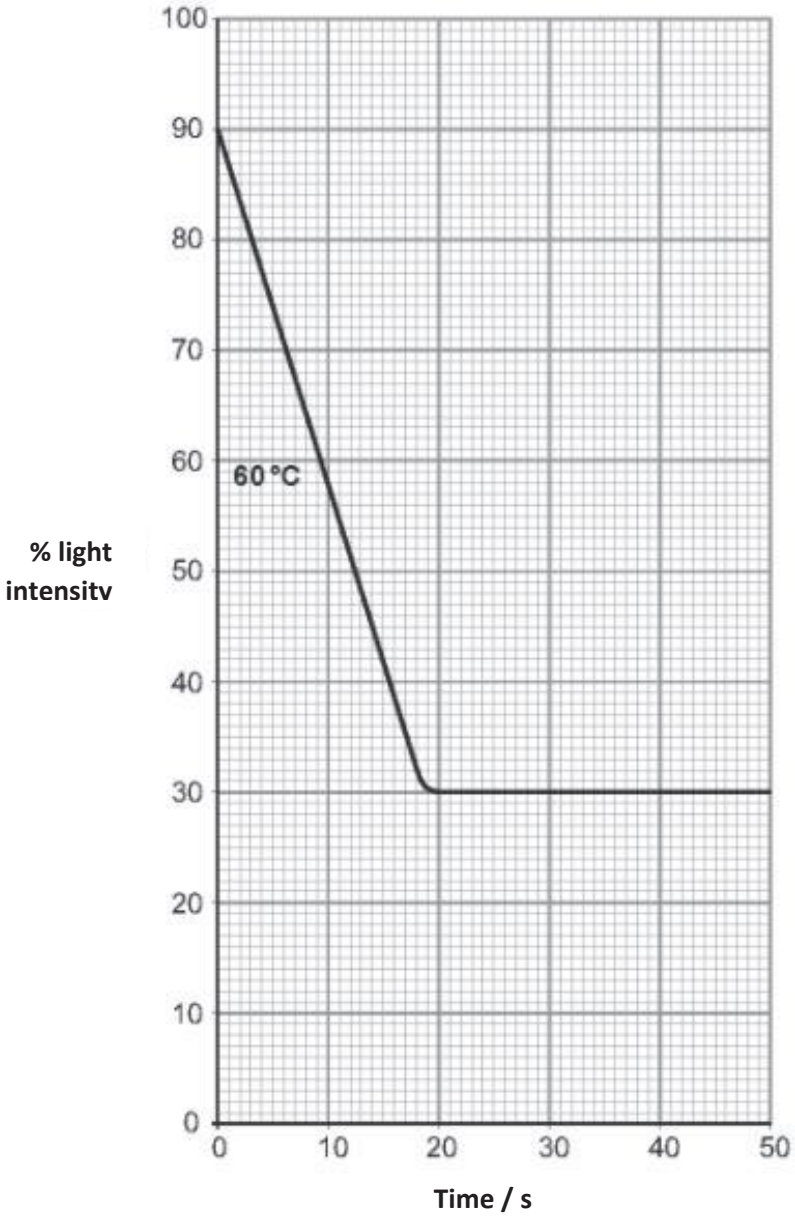
identity of **X** .....[3]

[Total:11]

2 Sodium thiosulfate solution reacts with dilute hydrochloric acid forming a yellow precipitate. This reaction was investigated using the equipment below.



5 cm^3 of dilute hydrochloric acid was added to 10 cm^3 of sodium thiosulfate solution at 60 °C and the light intensity was measured over time. The results are shown on the grid below.



(a) Explain why the light intensity decreases as the reaction takes place.

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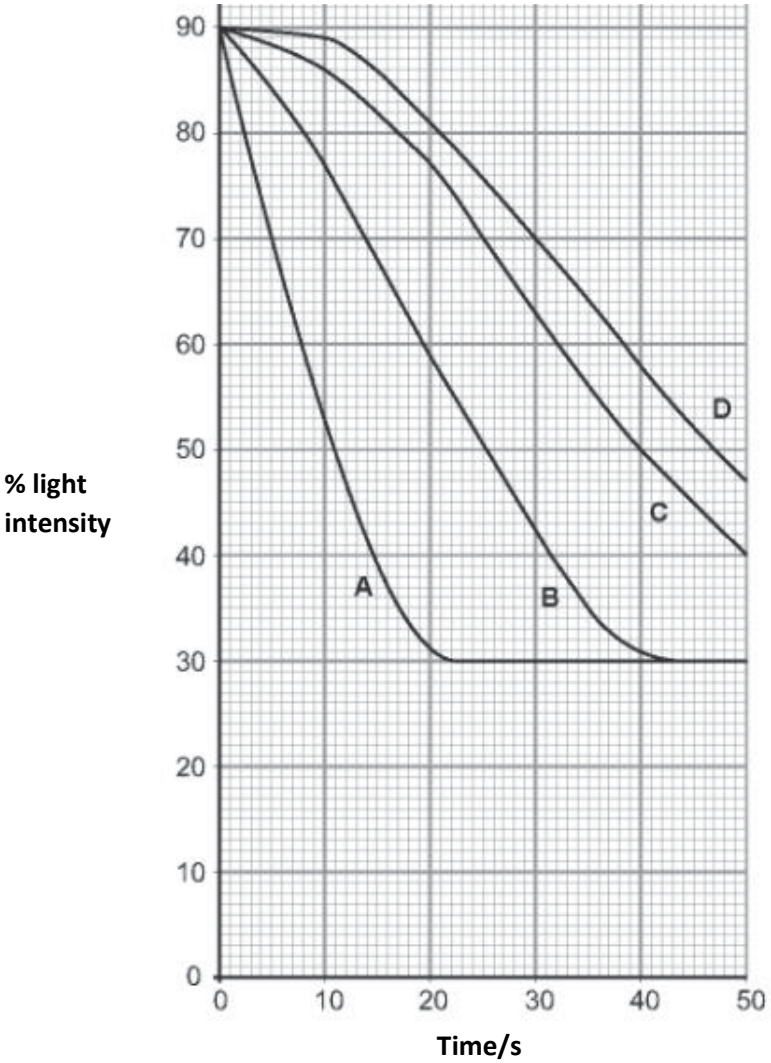
……[2]

(b) Suggest one possible reason why the light intensity does not fall to 0%.

……[1]

(c) In a separate experiment, 5 cm^3 of dilute hydrochloric acid was added separately to 10 cm^3 of sodium thiosulfate solution at four different temperatures. All other factors were kept the same. The results are shown on the grid below.



(i) Provide the letter **A**, **B**, **C** or **D** from the graph shown that represents the reaction carried out at the highest temperature. Explain your choice.

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……[1]

(ii) The rate of reaction can be calculated using the formula:

Rate = 1 / time

The reaction is considered to be complete when the percentage light intensity reaches 30%. Calculate the mean rate for experiment **B**. [1]

(iii) Using collision theory, provide a conclusion you can draw from the above investigation.

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…… [3]

(d) A chemist carried out an experiment to find out the reactivity of the metals. Below shows the time taken for limewater to form white precipitate for each metal carbonate.

Metal carbonate	Time taken to form white precipitate / s
Copper carbonate	10
Magnesium carbonate	40
Zinc carbonate	24

Explain these results in terms of reactivity of the metals.

……

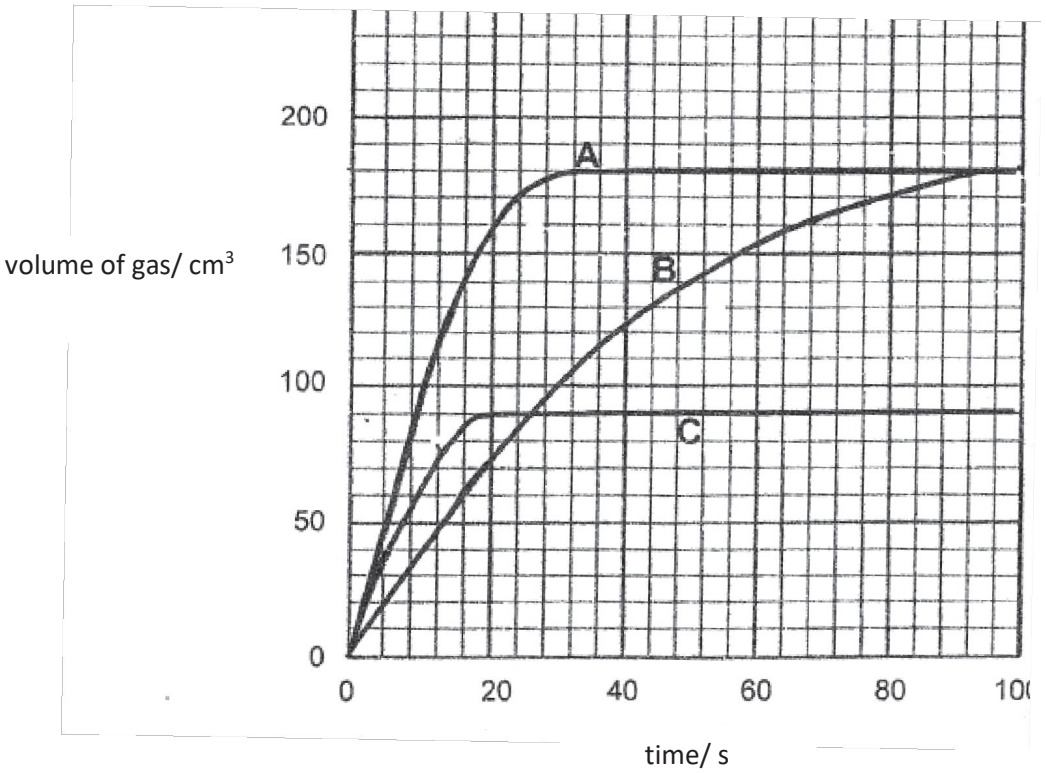
……

……[2]

[Total: 10]

3 An experiment was carried out involving two separate reactions between 0.18 g of magnesium and two acids, hydrochloric acid and sulfuric acid. The volume and concentration of both acids used were 20.0 cm^3 and 2.00 mol/dm^3. The results of reactions A and B are shown on Fig. 10.1.

A third reaction C was carried out using 20.0 cm^3 and 2.00 mol/dm^3 of an acid and a unknown amount of magnesium ribbon.



(a) With relevant equations and calculations, explain why the same volume of gas was produced for reactions A and B.

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…… [3]

4 **(b)** Determine which reaction, A or B, used sulfuric acid.

Explain your choice.

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……. [3]

(c) In reaction C, identify the acid and calculate the mass of magnesium ribbon that was used.

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…….[2]

(d) When calcium was used in place of magnesium to react with the 2.00 mol/dm^3 sulfuric acid, the reaction stopped very quickly and also produced less gas.

Give reasons for this observation.

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…….[2]

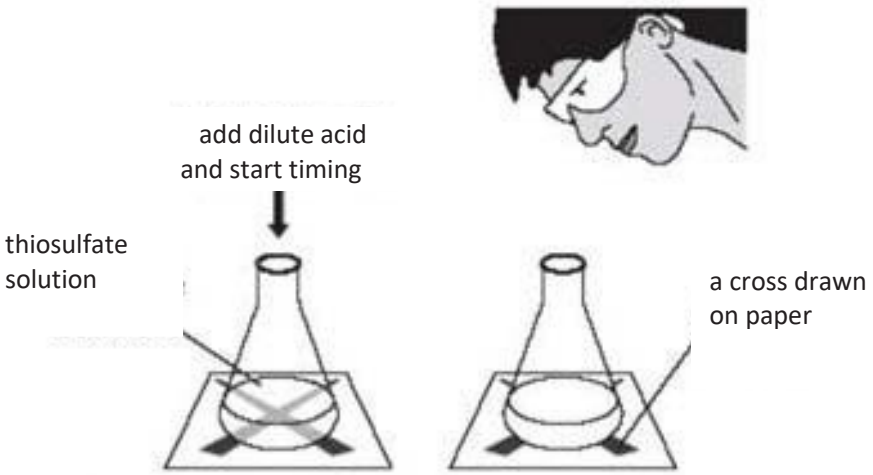
[Total: 10]

Paper 2 Section B

1 Aqueous sodium thiosulfate, $Na_2S_2O_3$, reacts with dilute hydrochloric acid. The reaction was used in an experiment to determine the effects of varying concentration and temperature on the speed of the reaction.

The equation for the reaction is:

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



A cloudy suspension of sulfur forms and covers the cross (X) slowly. When the cross completely disappears from top view, the time taken is recorded.

The table below shows the results obtained in different experiments using 10 cm^3 of acid and 10 cm^3 of 1 mol/dm^3 aqueous sodium thiosulfate.

experiment	concentration of acid / mol/dm^3	temperature / °C	time taken / s	1/time / s^{-1}
A	0.15	20	65	
B	0.10	30	45	
C	0.10	20	85	
D	0.05	30	55	
E	0.05	20	105	

(a) **(i)** Complete the table by calculating the values of 1/time for each experiment. Leave your answers to 3 significant figures. [1]

(ii) Explain the significance of 1/time. [2]

……

……

……

(b) Which of the experiments (**A** to **E**) are suitable to be used to show the effect of concentration on the speed of the reaction? Explain your answer. [2]

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……

……

(c) Explain, using the collision theory, the effect of concentration on the speed of the reaction. [2]

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……

(d) In trying to explain the effect of temperature on the speed of the reaction, a student said, "The higher the temperature, the faster is the speed of the reaction. This is because at a higher temperature, the activation energy of the reaction is lowered. Thus, more effective collisions can occur."

(e)

Is the student correct? Justify your answer.

……

……

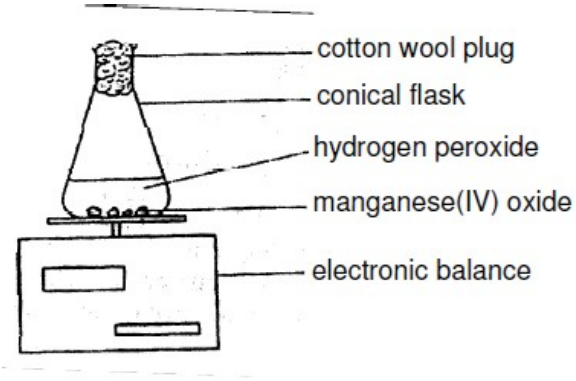
……

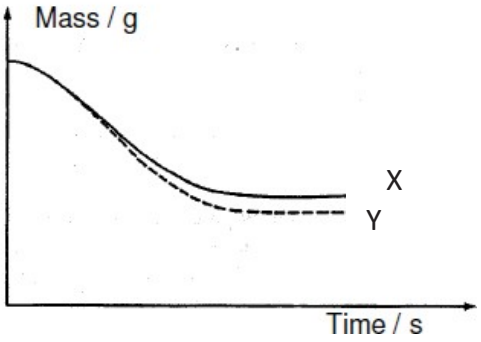
……

……

[Total: 10]

2 The following experiment was carried out to investigate the rate of decomposition of hydrogen peroxide. A catalyst, manganese(IV) oxide, was added to a conical flask containing 50 cm^3 of aqueous solution of hydrogen peroxide. The mass of the flask was measured by an electronic balance as shown. The results were recorded and the graph obtained was labelled X.





(a) Write the chemical equation for the decomposition of hydrogen peroxide.

…… [1]

(b) Suggest the use of the cotton wool.

…… [1]

(c) Curve Y shows the results that is expected to be obtained.
Explain the difference between the actual curve X and theoretical curve Y.

……

……[1]

(d) State one other way in which the rate of decomposition of aqueous hydrogen peroxide can be increased.

……[1]

(e) Describe what you would do to show that manganese(IV) oxide is acting as a catalyst in this decomposition.

……

……

……

……[3]

[Total: 7]

3 The rate of reaction of iron with aqueous bromine is determined by using the apparatus shown below.

The iron is removed at regular intervals. It is washed, dried and then weighed. The iron is then replaced in the solution.
The experiment is repeated twice, each time with a different concentration of aqueous bromine at room temperature, 25 ^{o}C. The results are shown in the table below.

Experiment	concentration of aqueous bromine mol/dm_3	speed of reaction mg iron reacted/min
1	0.050	9.2
2	0.10	18.1
3	0.15	27.2

(a) Describe how and explain why the speed of this reaction changes with concentration of bromine.

……

……

……...[2]

(b) **(i)** Experiment 1 is repeated after aqueous bromine has been cooled in an ice bath to 15^{o}C. Predict the speed of reaction, with appropriate unit

……...[1]

(ii) Using collision theory, explain your answer in **(b)(i)**

……

……..

……..

…… [2]

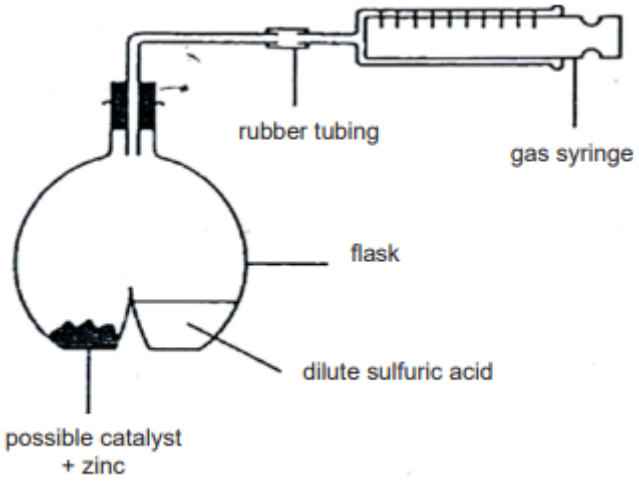
(c) Suggest another method for measuring the speed of this reaction.

……...[1]

[Total: 6]

4 The apparatus shown in the diagram was used to study the catalytic effect of certain substances on the exothermic reaction between zinc and dilute sulfuric acid.

Several experiments were carried out. In each experiment, 50 cm^3 of 1.0 mol/dm^3 sulfuric acid, 1.0 g of zinc powder and 0.1g of a possible catalyst were used.



To start the reaction, the flask was shaken. The time taken to collect 50 cm^3 of hydrogen was recorded. Other observations are shown in the table.

Possible catalyst added	**Time to collect 50 cm^3 of hydrogen/s**	**Other observations**
No added catalyst	65	-
0.1 g of copper(II) sulfate	10	colourless solution obtained and a brown solid coated the zinc
0.1 g of copper(II) chloride	15	colourless solution obtained and a brown solid coated the zinc
0.1 g of copper powder	19	pink solid remained
0.1g of copper lumps	56	pink solid remained
0.1g of sodium chloride	65	colourless solution formed

(a) **(i)** Write the chemical equation for the reaction between zinc and dilute sulfuric acid.

_____[1]

(ii) Calculate the maximum volume of hydrogen gas that can be produced at room temperature and pressure in the reaction.

[3]

(a) Which of the added substances behaved as a catalyst? Explain your answer using information from the table.

[2]

(b) Explain, in terms of activation energy, how a catalyst speeds up a reaction.

[2]

(c) Suggest whether the time taken to collect 50 cm^3 of hydrogen would be longer or shorter than 65 s when 1.0 g of zinc lumps was used in the absence of a catalyst.

Explain your answer in terms of colliding particles.

[2]

[Total: 10]

ANSWERS FOR RATE OF REACTION MCQ

Paper 1

1 In which reaction is the pressure **not** likely to affect the rate of reaction?

A $3H_2\ (g) + N_2\ (g) \rightarrow 2NH_3\ (g)$
B $CuO\ (s) + H_2\ (g) \rightarrow Cu\ (s) + H_2O\ (l)$
C $Fe_2O_3\ (s) + 3CO\ (g) \rightarrow 2Fe\ (s) + 3CO_2\ (g)$
D $H_2SO_4\ (aq) + 2NaOH\ (aq) \rightarrow Na_2SO_4\ (aq) + 2H_2O\ (l)$

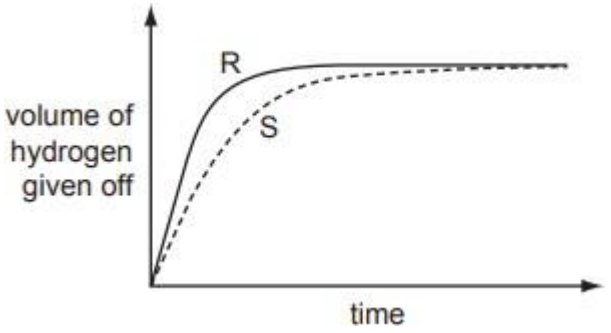
2 Methane gas reacts extremely slowly with air at room temperature. If a piece of warm platinum is held in a methane-air mixture, methane ignites. Which of the following statements correctly describes the reaction with platinum?

I The activation energy is low.
II The energy change is greater.
III The energy of the reactants is lower than expected.
IV The rate of reaction is faster.

A **I** and **II**
B **I** and **IV**
C **I**, **II** and **IV**
D **I**, **II**, **III** and **IV**

3 A student investigates the rate of reaction between magnesium and excess sulfuric acid. The volume of hydrogen given off in the reaction is measured over time.

The graph shows the results of two experiments, **R** and **S**.



Which change in conditions would cause the difference between **R** and **S**?

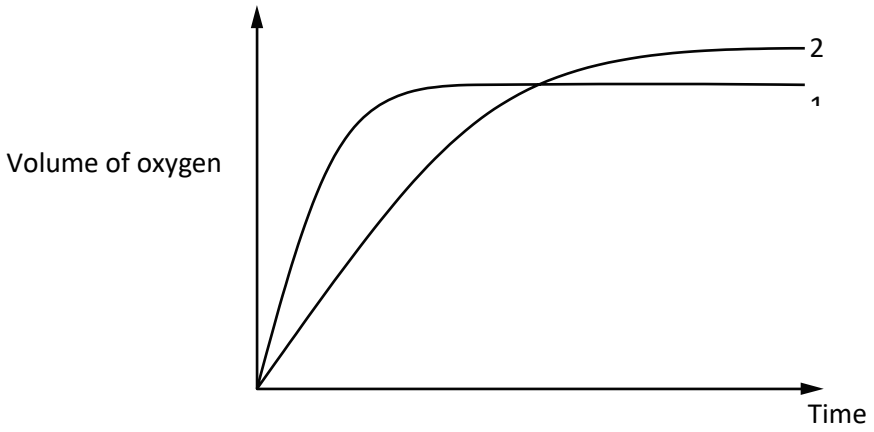
A Catalyst is added into **S**.
B The acid is more concentrated in **R** than in **S**.
C The magnesium is less finely powdered in **R** than in **S**.
D The temperature in **R** is lower than in **S**.

4 Zinc reacts with acids to form salts. Which of the following solutions would give the slowest rate of reaction when reacted with zinc?

A 0.0500 mol sulfuric acid in 500 cm^3 of water.
B 0.0250 mol sulfuric acid in 100 cm^3 of water.
C 0.0500 mol hydrochloric acid in 200 cm^3 of water.
D 0.0250 mol hydrochloric acid in 75 cm^3 of water.

5 In the graph, curve 1 was obtained by observing the decomposition of 100 cm^3 of 1.0 mol/dm^3 hydrogen peroxide solution, catalysed by manganese(IV) oxide.

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



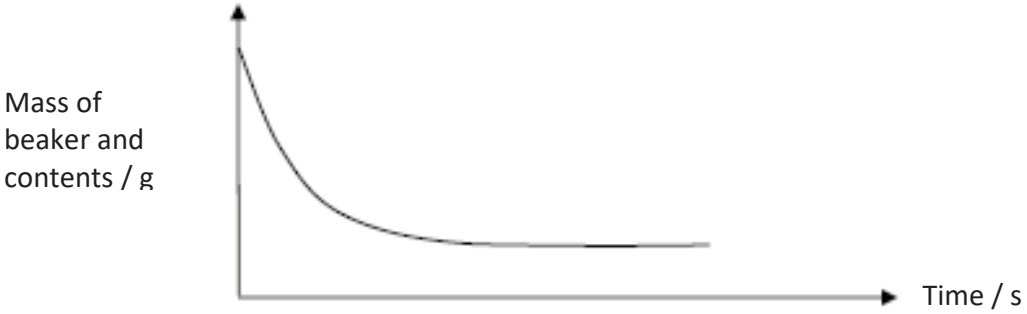
Which alteration to the original experimental conditions would produce curve 2?

A adding some 0.1 mol / dm^3 hydrogen peroxide solution
B lowering the temperature
C using a different catalyst
D using less manganese(IV) oxide

6 In which reaction is the pressure least likely to affect the speed of reaction?

A $C(s) + CO_2(g) \rightarrow 2CO(g)$
B $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
C $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$
D $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

7 Two solutions were mixed in a beaker and the mass of the beaker and contents was then recorded at various times. The graph shows the results.



What could the two solutions be?

A aqueous ammonia and aqueous iron(II) nitrate
B dilute hydrochloric acid and aqueous potassium hydroxide
C dilute nitric acid and solid copper(II) carbonate
D dilute sulfuric acid and aqueous barium nitrate

8 A sample of hydrogen peroxide is decomposed by a metal oxide catalyst.

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

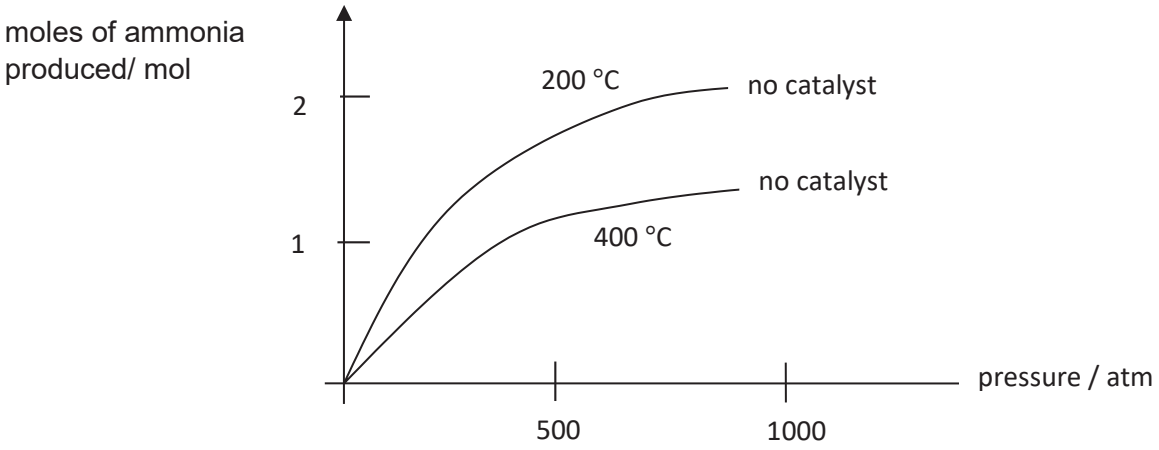
What will become larger if the experiment is repeated using a better catalyst?

A The total volume of gas produced at the end of the reaction.
B The amount of hydrogen peroxide left over at the end of the reaction.
C The initial gradient of a graph of total volume of gas produced against time.
D The time needed to produce a particular volume of gas.

9 When heated, nitrogen and hydrogen react according to the equation:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

The graph below shows the number of moles of ammonia produced from 1 mole of nitrogen at different temperatures and pressures.



Which one of the following statements may be deduced from this information?

1	At 500 atm pressure, the number of moles of ammonia produced is greater at 200 °C than at 400 °C.
2	An increase of pressure increases the number of moles of ammonia produced both at 200 °C and at 400 °C.
3	At 500 atm pressure and 300 °C, the number of moles of ammonia produced is likely to be greater than one.

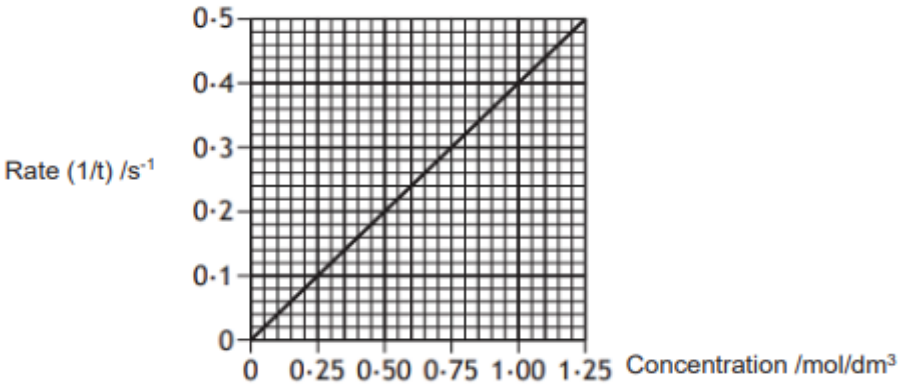
A 1, 2, and 3 are correct
B 2 and 3 only are correct
C 1 and 2 only are correct
D 1 only is correct

10 A student carries out a single experiment to determine the speed of reaction between calcium carbonate and an excess of hydrochloric acid.

Which of the following does **not** change during the course of the reaction?

A concentration of the hydrochloric acid solution
B mass of the calcium carbonate
C volume of carbon dioxide evolved
D volume of hydrochloric acid solution

11 The graph shows how the rate of a reaction varies with the concentration of one of the reactants.



What is the reaction time, in seconds, when the concentration of the reactant was 0.50 mol/dm^3?

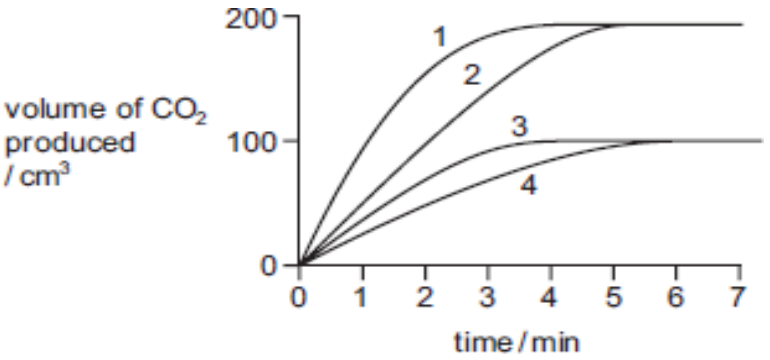
A 0.2
B 0.5
C 2.0
D 5.0

12 In four separate experiments, 1, 2, 3 and 4, nitric acid was added to excess marble chips and the volume of carbon dioxide formed was measured.

In all four experiments the same volume of nitric acid was used.

Its concentration, or temperature, or both concentration and temperature, were changed.

The results of the experiments are shown on the graph.



Which statement is correct?

A A lower concentration of acid was used in experiment 3 than in experiment 1.
B Experiment 4 was faster than experiment 3.
C The acid used in experiment 2 was of a lower concentration than in experiment 1.
D The temperature of the acid was the same in experiments 1 and 2.

13 The following changes could be made to the conditions in the reaction between zinc and hydrochloric acid.

1 increase in concentration of the acid
2 increase in particle size of the zinc
3 increase in pressure on the system
4 increase in temperature of the system

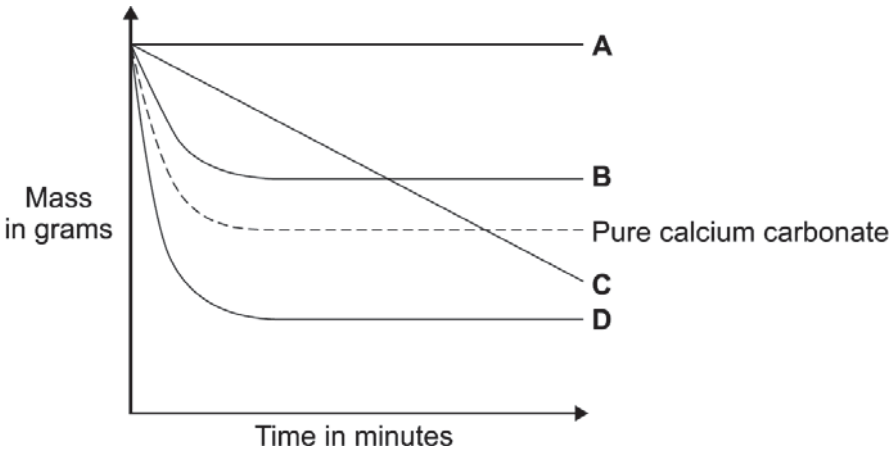
Which pair of changes will increase the rate of reaction?

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

14 Limestone usually contains impurities.

The diagram below shows the change in mass when pure calcium carbonate is heated.

Which graph, **A**, **B**, **C** or **D**, shows a sample of limestone, of the same mass, containing impurities that do not thermally decompose? Answer : B

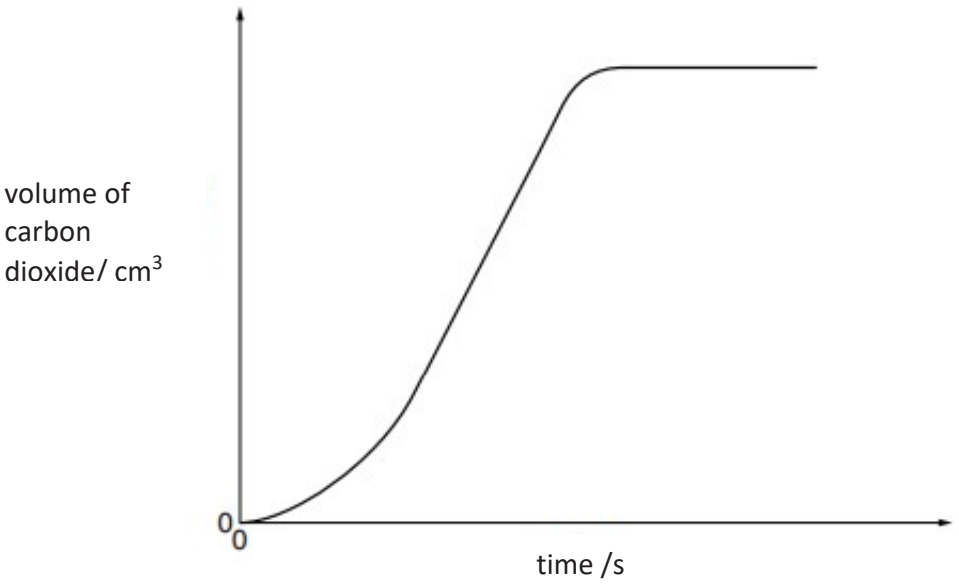


RATE OF REACTION STRUCTURED QUESTIONS

Paper 2 Section A

1 In **Experiment I**, a sample of magnesium carbonate is heated in a test-tube using a hot plate at 300 °C. The total volume of carbon dioxide formed is measured every 10 seconds.

The graph shows his results.



(a) Suggest why there is **no significant** increase in the volume of carbon dioxide when magnesium carbonate is first heated.

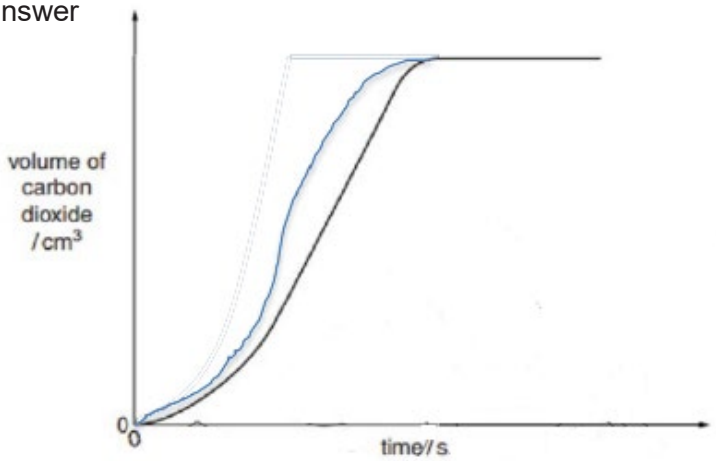
Not much magnesium carbonate has achieved activation energy required. [1]

Accept:
The flame is not hot enough to decompose much magnesium carbonate. [1]

(b) In **Experiment II**, the same mass of magnesium carbonate is heated in a test-tube using a hot plate at a **higher temperature** of 500 °C.

Sketch a curve on the graph above to show the results for this experiment.

Explain your answer



Correct graph [1]
At higher temperature, rate of reaction increases because more zinc carbonate particles ha sufficient energy to overcome the activation energy. [1]

Volume of carbon dioxide stays constant as it is dependent on the number of moles/ mass of zinc carbonate which did not change. [1]

[3]

(c) Ron wishes to investigate how the thermal stability of metal carbonates is related to the position of their metal in the reactivity series.

To ensure a fair experiment, he repeated **Experiment I** using different metal carbonates, while keeping all other variables constant.

The table below shows the results of the experiment after the first 60 seconds.

metal carbonate	total volume of gas collected/ cm^3
$\mathbf{X}_2CO_3$	0
$\mathbf{Y}CO_3$	0
$CaCO_3$	2
$FeCO_3$	7
$ZnCO_3$	5

(i) Write a balanced equation, with state symbols, for the thermal decomposition of $FeCO_3$.

$FeCO_3$ (s) → FeO (s) + CO_2(g)

Correct state symbols – 1M Correct formula – 1M [2] [2]

(ii) Explain why $\mathbf{X}_2CO_3$ and $\mathbf{Y}CO_3$ do **not** decompose.

X and Y are highly reactive metal [1], thus forming highly stable metal carbonates [1] that do not decompose on heating [2]

(iii) A solution containing 0.002 mol of sulfuric acid is titrated with a solution containing 9.2 g/dm^3 of $\mathbf{X}_2CO_3$. The volume of $\mathbf{X}_2CO_3$ solution needed to exactly neutralise the acid is 23.2 cm^3.

1 mole of sulfuric acid reacts with 1 mole of $\mathbf{X}_2CO_3$.
Calculate the relative atomic mass, *A*r, of **X** and suggest its identity.

Mass of X_2CO_3 used = 9.2 x 0.0232 = 0.2134 g [1] M_r of X_2CO_3 = 0.2134/0.002 =106.72

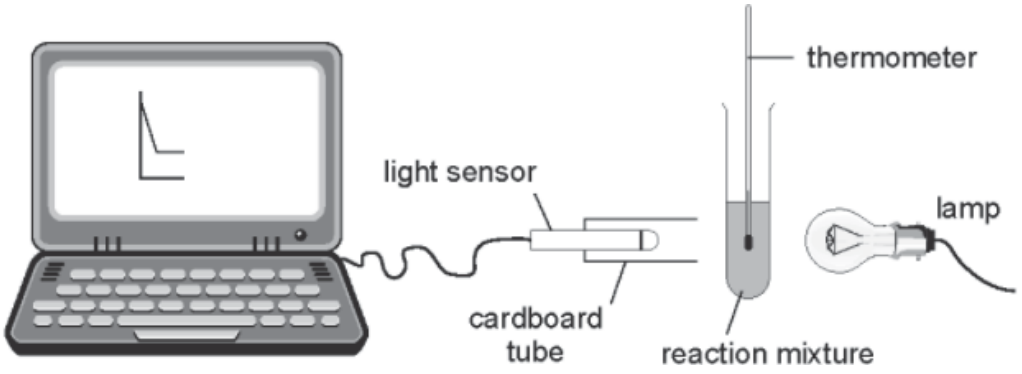
A_r of X = (106.72 – 12 – 16 x 3)/2 = 23.4 [1] (3 s.f.)
A_r of X = 23.4
identity of X sodium [1]

A_r of **X** = ...

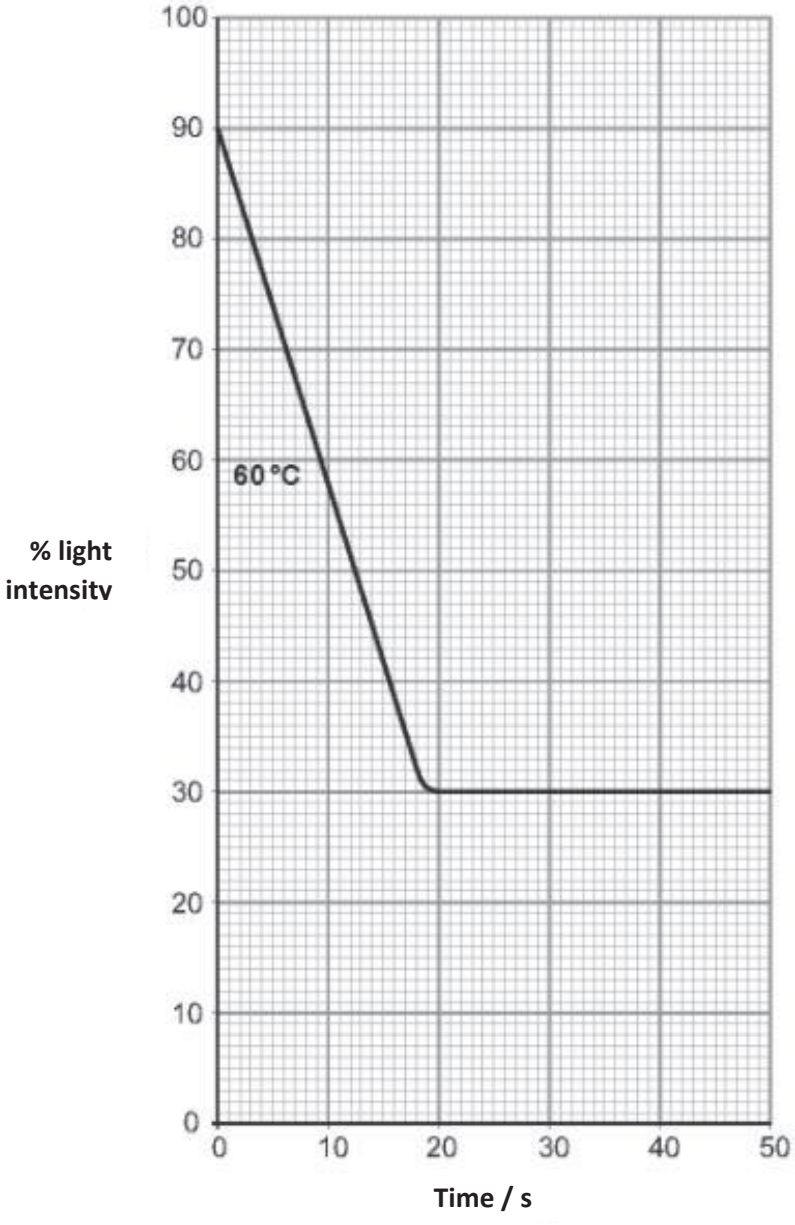
identity of **X** .....[3]

[Total:11]

2 Sodium thiosulfate solution reacts with dilute hydrochloric acid forming a yellow precipitate. This reaction was investigated using the equipment below.



5 cm^3 of dilute hydrochloric acid was added to 10 cm^3 of sodium thiosulfate solution at 60 °C and the light intensity was measured over time. The results are shown on the grid below.



(a) Explain why the light intensity decreases as the reaction takes place.

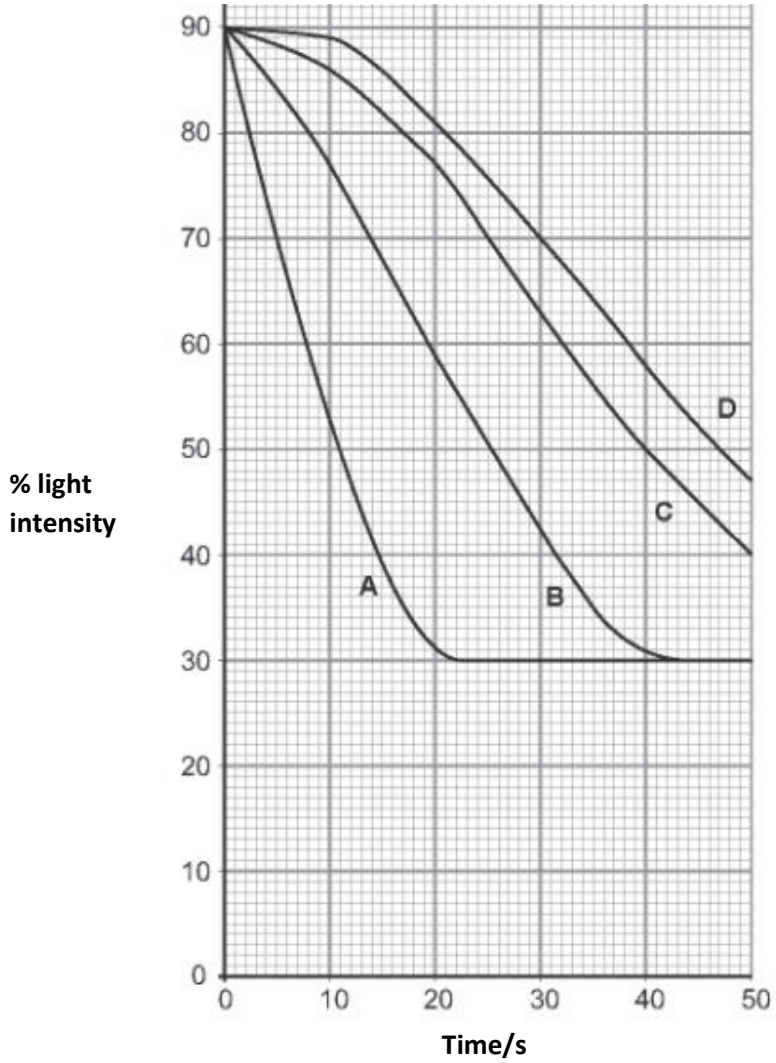
Insoluble substance / precipitate formed [1]

Hence, light cannot travel through / stops light / block light [1] [2]

(b) Suggest one possible reason why the light intensity does not fall to 0%.

Precipitate formed is not dense enough / thick enough / does not block all light / settled to the bottom of the tube. [1]

(c) In a separate experiment, 5 cm^3 of dilute hydrochloric acid was added separately to 10 cm^3 of sodium thiosulfate solution at four different temperatures. All other factors were kept the same. The results are shown on the grid below.



(i) Provide the letter **A**, **B**, **C** or **D** from the graph shown that represents the reaction carried out at the highest temperature. Explain your choice.

A. It is t steepest graph, indicating fastest rate of reaction / finish in the sh test time [1]

(ii) The rate of reaction can be calculated using the formula:

Rate = 1 / time

The reaction is considered to be complete when the percentage light intensity reaches 30%. Calculate the mean rate for experiment **B**. [1]

Time = 42s Rate = 1/42
0.024 s^{-1} [1, with units]
NO FRACTIONS ALLOWED IN CALCULATION

(iii) Using collision theory, provide a conclusion you can draw from the above investigation.

As temperature increases, particles gain heat with more kinetic energy and will move faster at a higher temperature and collide more frequently. [1]
More particles possess energy greater or equal than the activation energy [1]
Therefore, there is a higher frequency of effective collision, increasing the rate of reaction [1]

[3]

(d) A chemist carried out an experiment to find out the reactivity of the metals. Below shows the time taken for limewater to form white precipitate for each metal carbonate.

Metal carbonate	Time taken to form white precipitate / s
Copper carbonate	10
Magnesium carbonate	40
Zinc carbonate	24

Explain these results in terms of reactivity of the metals.

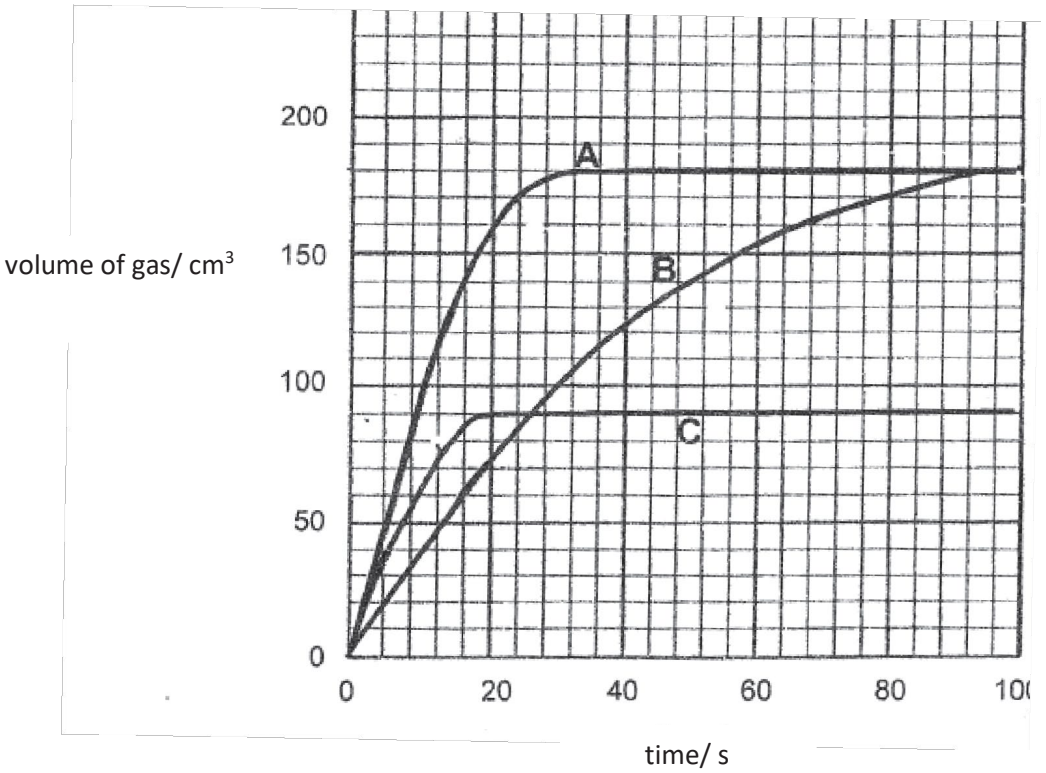
A more reactive metal will form a more stable metal carbonate [1]
which takes a longer time to decompose to produce carbon dioxide gas [1]
where white precipitate is formed in the limewater

Note: Metal carbonate → Meta oxide → carbon dioxide gas [2]

[Total: 10]

3 An experiment was carried out involving two separate reactions between 0.18 g of magnesium and two acids, hydrochloric acid and sulfuric acid. The volume and concentration of both acids used were
20.0 cm^3 and 2.00 mol/dm^3. The results of reactions A and B are shown on Fig. 10.1.

A third reaction C was carried out using 20.0 cm^3 and 2.00 mol/dm^3 of an acid and a unknown amount of magnesium ribbon.



(a) With relevant equations and calculations, explain why the same volume of gas was produced for reactions A and B.

No. of moles of Mg = 0.18 / 24 = **0.0075**
No. of moles of hydrochloric acid = No. of moles of sulfuric acid
= 0.02 x 2.00 = **0.04**
$Mg + 2\ HCl \rightarrow MgCl_2 + H_2$
mole of Mg reacts with 2 moles of HCl,

hence, magnesium is the limiting reactant and hydrochloric acid is in excess.
$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$
1 mole of Mg reacts with 1 mole of H_2SO_4

hence, magnesium is the limiting reactant and sulfuric acid is in excess.
Since magnesium is the **limiting reactant for both reactions**, the same volume of hydrogen is produced. [3]

4 **(b)** Determine which reaction, A or B, used sulfuric acid.

Explain your choice.

Curve A.
This is because curve A has a **steeper gradient** showing that its reaction is faster. Reaction between magnesium and sulfuric acid is faster than its reaction with hydrochloric acid because there are **more hydrogen ions per unit volume /**
higher concentration of hydrogen ions in sulfuric acid. [3]

(c) In reaction C, identify the acid and calculate the mass of magnesium ribbon that was used.

The acid used is **sulfuric acid** because it has the same initial rate of reaction.
Volume of hydrogen = 90 cm^3 .
No. of moles of hydrogen = 0.09 / 24 = 0.003750 No. of moles of magnesium = 0.003750 Therefore, mass of magnesium = 0.003750 x 24 = **0.09 g**
OR
Volume of hydrogen is half that of curve A and magnesium is the limiting reactant. Hence mass of magnesium = 0.18 / 2 = **0.09 g**

[2]

(d) When calcium was used in place of magnesium to react with the 2.00 mol/dm^3 sulfuric acid, the reaction stopped very quickly and also produced less gas.

Give reasons for this observation.

The reaction stopped very quickly because when calcium reacts with sulfuric acid, **a layer of insoluble calcium sulfate coats over the calcium**.
Hence, **some calcium remains unreacted**, resulting in less hydrogen produced

[2]

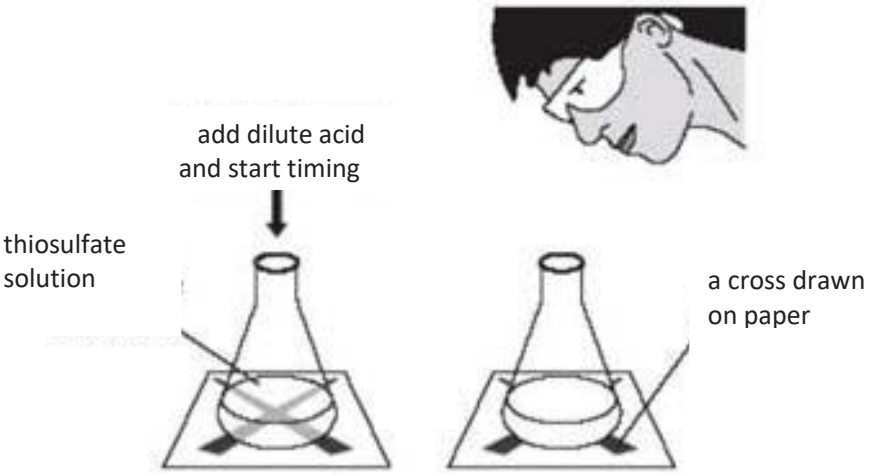
[Total: 10]

Paper 2 Section B

1 Aqueous sodium thiosulfate, $Na_2S_2O_3$, reacts with dilute hydrochloric acid. The reaction was used in an experiment to determine the effects of varying concentration and temperature on the speed of the reaction.

The equation for the reaction is:

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



A cloudy suspension of sulfur forms and covers the cross (X) slowly. When the cross completely disappears from top view, the time taken is recorded.

The table below shows the results obtained in different experiments using 10 cm^3 of acid and 10 cm^3 of 1 mol/dm^3 aqueous sodium thiosulfate.

experiment	concentration of acid / mol/dm^3	temperature / °C	time taken / s	1/time / s^{-1}
A	0.15	20	65	0.0154
B	0.10	30	45	0.0222
C	0.10	20	85	0.0118
D	0.05	30	55	0.0182
E	0.05	20	105	0.00952

(a) **(i)** Complete the table by calculating the values of 1/time for each experiment. Leave your answers to 3 significant figures. [1]

(ii) Explain the significance of 1/time. [2]

1/ time provides information about the speed of reaction. [1]

The longer the time taken, the slower is the speed of the reaction. / The shorter the time taken, the faster is the speed of the reaction.

(b) Which of the experiments (**A** to **E**) are suitable to be used to show the effect of concentration on the speed of the reaction? Explain your answer. [2]

The results of experiments A, C and E can be used. / The results of experiments B and D can be used. [1]

These experiments were conducted using different concentrations of acid but temperature was kept constant.

(c) Explain, using the collision theory, the effect of concentration on the speed of the reaction. [2]

The higher the concentration, the faster is the speed of the rea No marks awarded.

With a higher concentration, there are more reactant particles i a unit volume. [1]
Thus, there are more collisions between reactant particles. Th s results n higher frequency of effective collisions occurring.

(d) In trying to explain the effect of temperature on the speed of the reaction, a student said, "The higher the temperature, the faster is the speed of the reaction. This is because at a higher temperature, the activation energy of the reaction is lowered. Thus, more effective collisions can occur."

Is the student correct? Justify your answer.

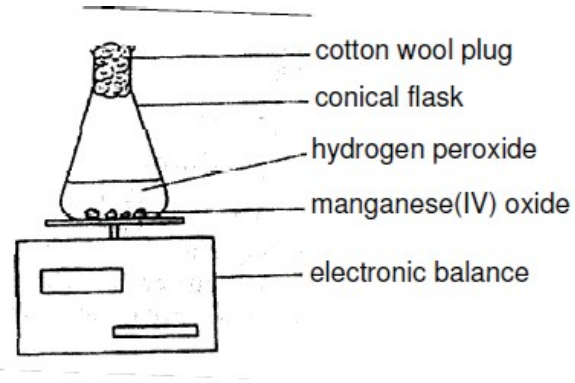
The student is not correct. The activation energy of the react on is not lowered with higher temperature. [1]

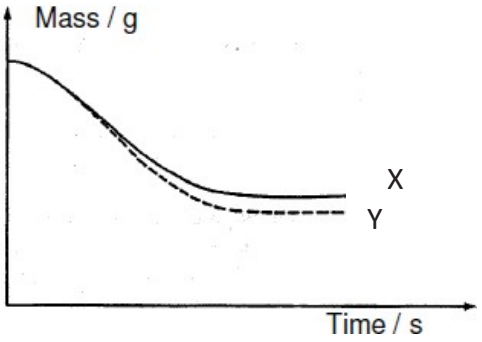
Must mention what is wrong with the student's explanation.

At higher temperatures, reactant particles possess greater amount of kinetic energy. Thus, they are able move more quickly [1] and collide into one another more frequently.
This results in a higher frequency of effective collisions occurring.

[Total: 10]

2 The following experiment was carried out to investigate the rate of decomposition of hydrogen peroxide. A catalyst, manganese(IV) oxide, was added to a conical flask containing 50 cm^3 of aqueous solution of hydrogen peroxide. The mass of the flask was measured by an electronic balance as shown. The results were recorded and the graph obtained was labelled X.





(a) Write the chemical equation for the decomposition of hydrogen peroxide.

…… [1]

(b) Suggest the use of the cotton wool.

…….... [1]

(c) Curve Y shows the results that is expected to be obtained.
Explain the difference between the actual curve X and theoretical curve Y.

…….

……....[1]

(d) State one other way in which the rate of decomposition of aqueous hydrogen peroxide can be increased.

……[1]

(e) Describe what you would do to show that manganese(IV) oxide is acting as a catalyst in this decomposition.

…….

…….

…….

……..……[3]

[Total: 7]

Answers:

2	**(a)**	$2H_2O_2$ (l) → $2H_2O$ (l) + O_2 (g)	1	There are students who do not know the products of the decomposition of hydrogen peroxide. Weak students do not even know the formula of hydrogen peroxide
	(b)	To prevent acid spray	1	Well-answered
	(c)	Curve Y shows a slightly lower mass obtained/ greater mass lost. The actual mass lost is smaller due to a small amount of oxygen dissolving in the solution	1	Many students do not know that oxygen is soluble in water
	(d)	Heating up hydrogen peroxide solution/ using smaller pieces of manganese(IV) oxide	1	A small number of very weak students could not even recall the factors that affect the speed of reaction
	(e)	Weigh a fixed mass of manganese(IV) oxide and add to asolution of hydrogen peroxide. Monitor the mass loss. Once the mass loss reached a constant (the end of reaction), filter and measure the mass of manganese(IV) oxide at the end of the reaction. It would be noted that the mass of manganese(IV) oxide remains the same	1 1 1	Badly answered. Students did not read the question carefully that it is asking with respect to this decomposition reaction. Hence there is only 1 experiment involved. Many wrote the experiment as conducting 1 without MnO_2 and 1 experiment with MnO_2

3 The rate of reaction of iron with aqueous bromine is determined by using the apparatus shown below.

The iron is removed at regular intervals. It is washed, dried and then weighed. The iron is then replaced in the solution.
The experiment is repeated twice, each time with a different concentration of aqueous bromine at room temperature, 25 ^{o}C. The results are shown in the table below.

Experiment	concentration of aqueous bromine mol/dm_3	speed of reaction mg iron reacted/min
1	0.050	9.2
2	0.10	18.1
3	0.15	27.2

(a) Describe how and explain why the speed of this reaction changes with concentration of bromine.

As concentration increases, the speed of this reaction increases. When concentration increases, there is greater number of particles in the same volume

Particles are closer to each other frequency of effective collision increases...[2]

(b) (i) Experiment 1 is repeated after aqueous bromine has been cooled in an ice bath to 15°C. Predict the speed of reaction, with appropriate unit

4.5 – 5 0 mg iron reacted/min (units needed) [1]

(ii) Using collision theory, explain your answer in **(b)(i)**

As temperature drops, particles loses energy, move slower.

Number of particles with energy equal to or greater than activate energy drops. Frequency of effective collision decreases [2]

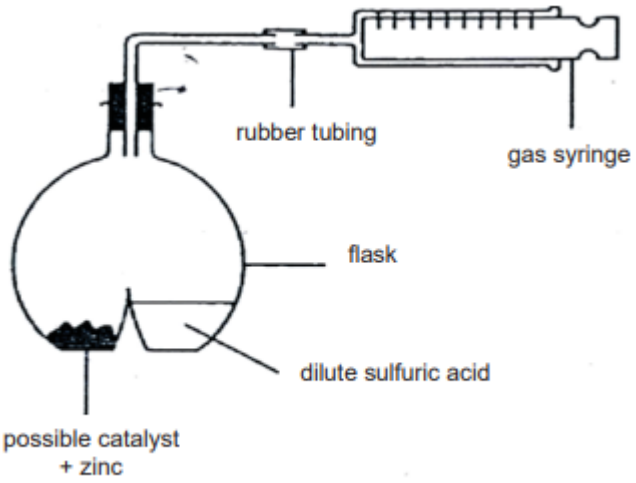
(c) Suggest another method for measuring the speed of this reaction.

measure the colour intensity of aqueous bromine. [1]

[Total: 6]

4 The apparatus shown in the diagram was used to study the catalytic effect of certain substances on the exothermic reaction between zinc and dilute sulfuric acid.

Several experiments were carried out. In each experiment, 50 cm^3 of 1.0 mol/dm^3 sulfuric acid, 1.0 g of zinc powder and 0.1g of a possible catalyst were used.



To start the reaction, the flask was shaken. The time taken to collect 50 cm^3 of hydrogen was recorded. Other observations are shown in the table.

Possible catalyst added	**Time to collect 50 cm^3 of hydrogen/s**	**Other observations**
No added catalyst	65	-
0.1 g of copper(II) sulfate	10	colourless solution obtained and a brown solid coated the zinc
0.1 g of copper(II) chloride	15	colourless solution obtained and a brown solid coated the zinc
0.1 g of copper powder	19	pink solid remained
0.1g of copper lumps	56	pink solid remained
0.1g of sodium chloride	65	colourless solution formed

(a) (i) Write the chemical equation for the reaction between zinc and dilute sulfuric acid.

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ [1]

(ii) Calculate the maximum volume of hydrogen gas that can be produced at room temperature and pressure in the reaction.

Number of moles of Zn = 1/65 = 0.015385 mol

Number of moles of H_2SO_4 = 50/1000 x 1 = 0.0500 mol

Zinc is the limiting reactant

Number of moles of H_2 = 0.015385 mol;

Volume of H_2 = 0.015385 x 24 = 0.369 dm^3

[3]

(a) Which of the added substances behaved as a catalyst? Explain your answer using information from the table.

Copper powder. As it speeds up the rate of reaction with itself remains chemically unchanged at the end of the reaction. [2]

(b) Explain, in terms of activation energy, how a catalyst speeds up a reaction.

Copper metal/powder/lumps. It speeds up the rate of reaction; while remains chemically unchanged at the end of the reaction; [2]

(c) Suggest whether the time taken to collect 50 cm^3 of hydrogen would be longer or shorter than 65 s when 1.0 g of zinc lumps was used in the absence of a catalyst.

Explain your answer in terms of colliding particles.

A catalyst provides an alternative pathway with a lower activation energy; more particles would have sufficient energy to overcome the activation energy;

Longer. Lumps of zinc have less total surface area compared to powdered zinc; So the frequency of effective collisions decreases and speed of reaction decreases; [2]

[Total: 10]