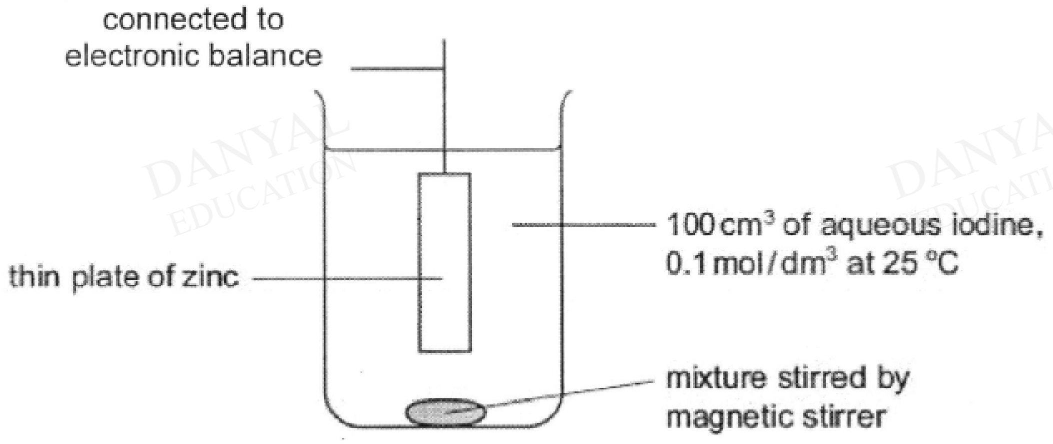
O Level Pure Chemistry Structured

Speed of Reaction Test 1.0

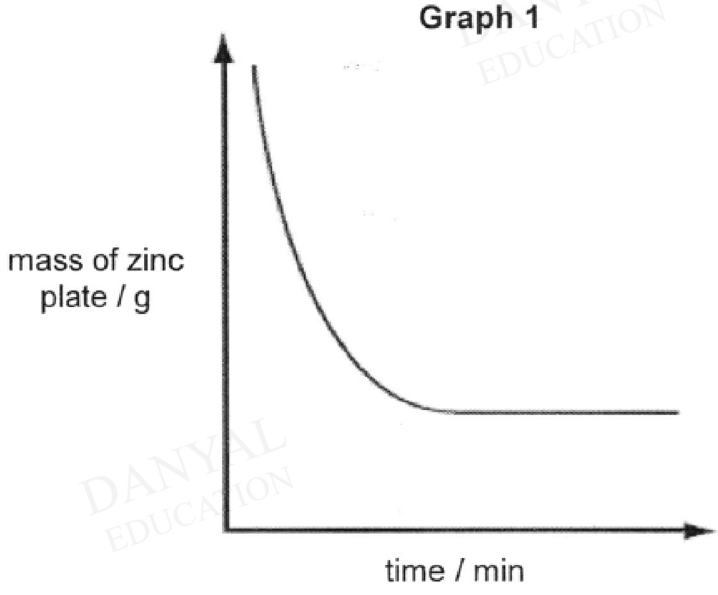
Q1

Zinc reacts with aqueous iodine to form zinc iodide. The following apparatus was used to measure the rate of the reaction between zinc and aqueous iodine at 25°C.



The mass of the zinc plate was measured every minute until the reaction was complete.
Graph 1 shows the results obtained.

Graph 1



(a) Identify the reagent that was used in excess.

....[1]

(b) (i) The experiment was repeated with 100 cm^3 of 0.05 mol/dm^3 aqueous iodine and keeping all other conditions the same. On the same axes as **Graph 1** above, sketch the curve that would be obtained and label it '**Y**'. [1]

(ii) Explain the shape of the graph obtained in **(b)(i)**.

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....[2]

(c) Explain, in terms of collisions between reacting particles, the effect on the speed of reaction if the experiment was repeated at 15°C with all other conditions kept constant.

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....[2]

(d) Describe and explain what would be observed if aqueous chlorine was bubbled into the resulting zinc iodide solution.

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....[2]

[Total: 8]

Q2

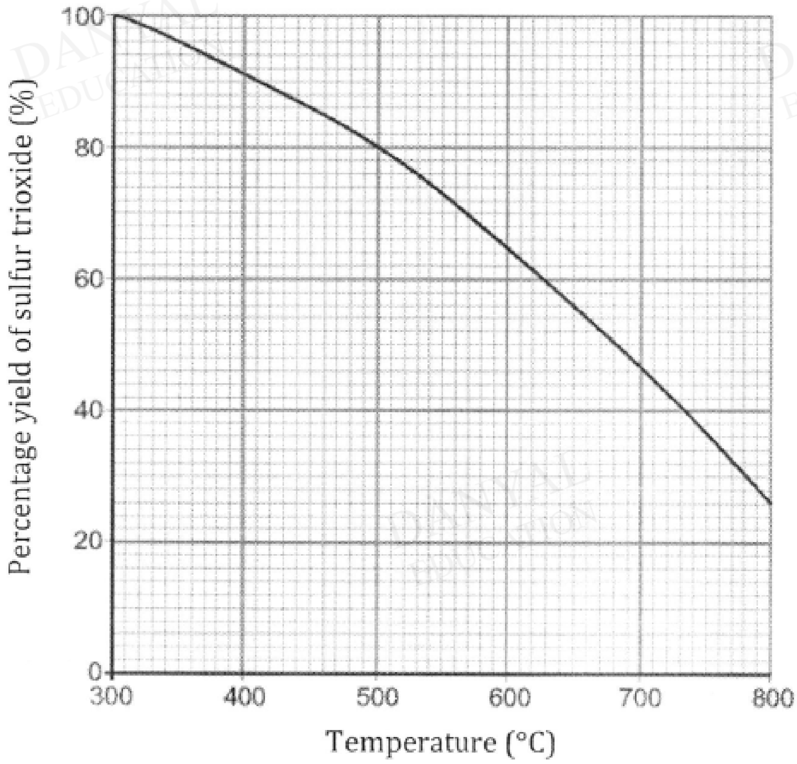
A4 One of the main stages in the manufacture of sulfuric acid is the reaction between sulfur dioxide and oxygen to produce sulfur trioxide, SO_3. The reaction is reversible.

(a) Write a balanced chemical equation for this reaction.

.... [2]

(b) The percentage yield of sulfur trioxide against temperature is shown in Graph 4.1.

Graph 4.1



(i) Using information from the graph, describe how the percentage **yield** of sulfur trioxide changes with temperature.

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.... [1]

(ii) Using ideas about collisions between particles, explain how the **rate** of sulfur trioxide production changes with temperature.

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.... [3]

Q3

Three experiments were carried out to study the speed of reaction between dilute acid and granulated zinc.

The table below shows the amount of acid, mass of zinc used, drops of copper(II) sulfate used and the time taken to collect 50 cm^3 of hydrogen gas for each experiment.

experiment	amount of dilute acid used	mass of granulated zinc used /g	drops of aqueous copper (II) sulfate used	time taken /s
I	25.0 cm^3, 1.0 mol/dm^3 sulfuric acid	2.5	0	28.0
II	25.0 cm^3, 1.0 mol/dm^3 hydrochloric acid	2.5	0	52.0
III	25.0 cm^3, 1.0 mol/dm^3 sulfuric acid	2.5	`5	17.0

(a) Explain, in terms of collision theory, why the time taken for Experiment **I** is shorter than Experiment **II**.

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.... [4]

(b) Using the information from the table, explain the role of aqueous copper (II) sulfate in Experiment **III**.

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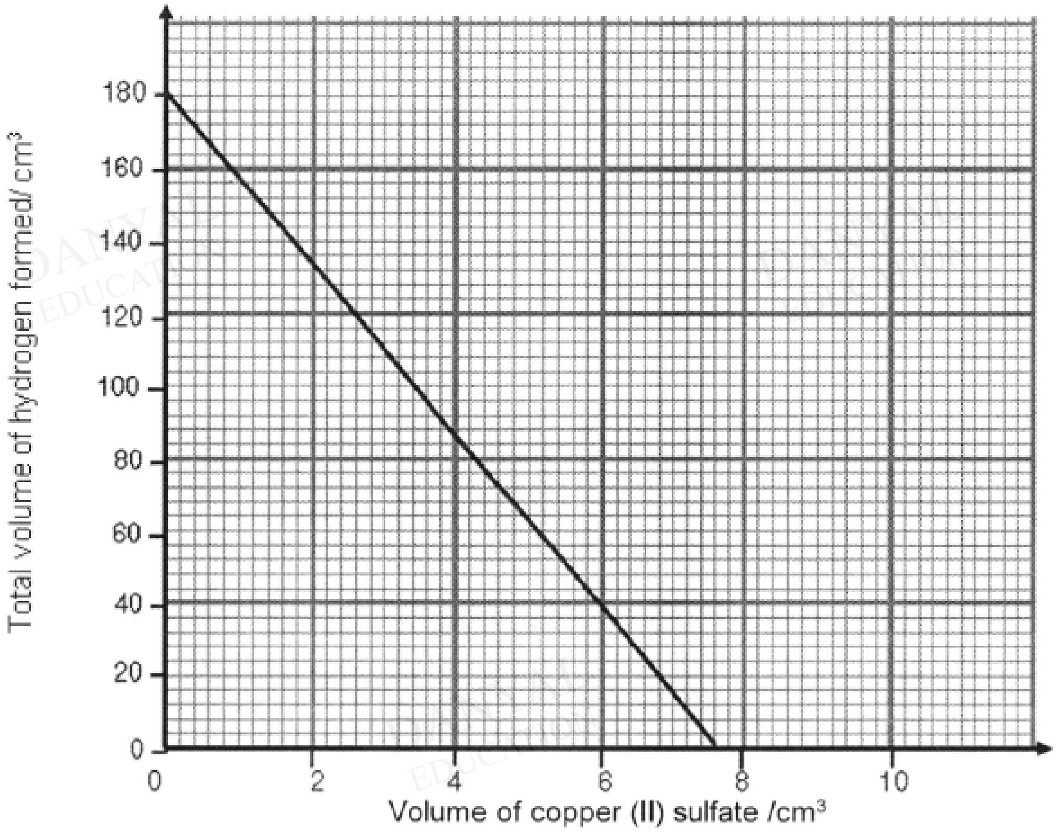
.... [2]

Further experiments of the reaction between zinc and sulfuric acid were carried out. In these experiments, various volumes of aqueous copper(II) sulfate were added to the sulfuric acid.

The graph below shows the volume of hydrogen gas collected when various volumes of aqueous copper (II) sulfate (1.0 mol/dm^3) were added to excess sulfuric acid and a fixed mass of zinc. The volume of hydrogen was measured at room temperature and pressure.



(c) Explain why the volume of hydrogen formed decreases as the volume of aqueous copper(II) sulfate added increases.

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.... [2]

(d) Predict the change in the volume of hydrogen gas produced when aqueous magnesium sulfate is used in place of aqueous copper (II) sulfate. Explain your answer.

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.... [2]

[Total: 10]

Q4

The table below shows the time taken for the same mass of zinc to react completely with sulfuric acid of various concentrations at room temperature and pressure.

concentration (mol/dm^3)	0.5	1.0	2.0	4.0
time taken (s)	450	45	22	5

(a) Explain, using collision theory, how the rate of reaction change when the concentration of sulfuric acid used increases from 0.5 mol/dm^3 to 4.0 mol/dm^3.

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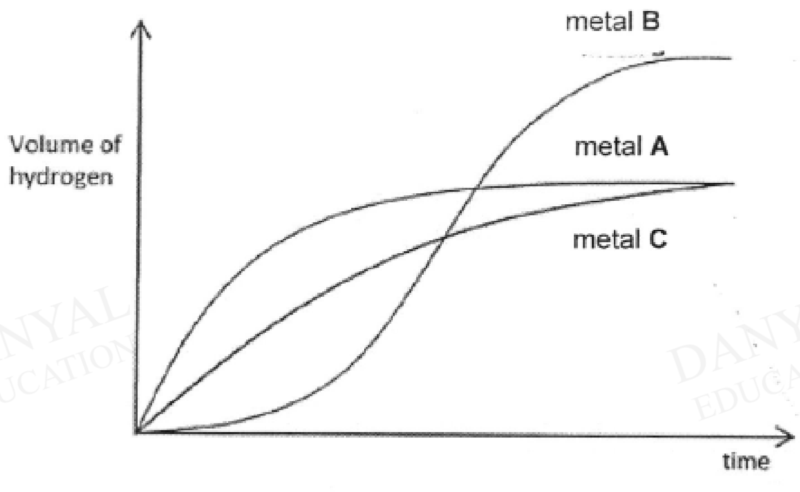
.... [2]

Q5

Excess sulfuric acid is added to powdered zinc. The hydrogen evolved is collected and its volume measured every 20 seconds. The experiment is repeated at the same temperature using the same number of moles of powdered magnesium and aluminium.

The graph below shows the volume of hydrogen produced from each metal against time.



(a) Identify metal **B** and account for the shape of its graph.

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.... [3]

(b) Identify metals **A** and **C**.

.... [1]

(c) Using the concept of moles, explain why metals **A** and **C** form the same volume of hydrogen but metal **B** forms a larger volume of hydrogen.

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.... [2]

(d) On the graph above, sketch the curve obtained when excess sulfuric acid is added to powdered calcium of the same mass.
Label this curve as "Ca" and explain the shape of the curve.

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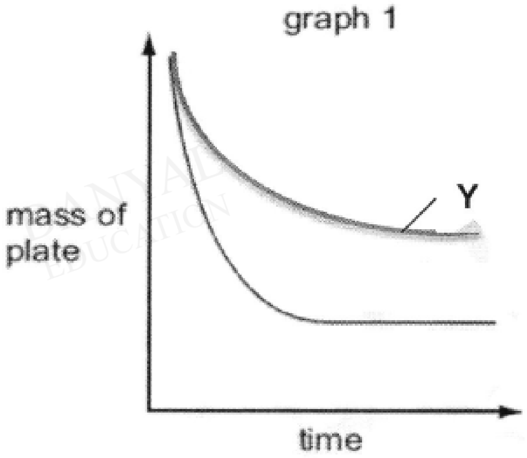
.... [2]

[Total: 8 marks]

Answers

Speed of Reaction Test 1.0

Q1

B8a	zinc	1
b(i)		1
(ii)	Gradient is less steep as the concentration of iodine is halved, resulting in a slower speed of reaction. Half the mass of zinc reacted since only half the number of mole of the limiting reagent, iodine is present.	1 1
c	At 15 °C, the zinc atoms and iodine molecules have lower kinetic energy. Hence, less particles have energy greater or equal to the activation energy. The frequency of effective collisions between the zinc atoms and iodine molecules decreases. Hence, speed of reaction decreases.	1 1
d	The colourless zinc iodide solution will turn brown. Chlorine displaces the iodine from zinc iodide solution as chlorine is more reactive than iodine.	1 1

Q2

(a) $2SO_2 + O_2 \rightleftharpoons 2SO_3$ [2]

Award 1m for all correct symbols and balanced equation.
Award 1m for the '$\rightleftharpoons$' reversible arrow.

(b) (i) Percentage yield decreases as temperature increases. [1]
Accept any answers to the same effect.

(ii) Reacting particles have more energy and move faster /
More reacting particles have energy to overcome the activation energy [1]
Particles collide more frequently / Frequency of collision increases [1]
Rate of reaction increases / Reaction goes faster [1] [3]

Q3

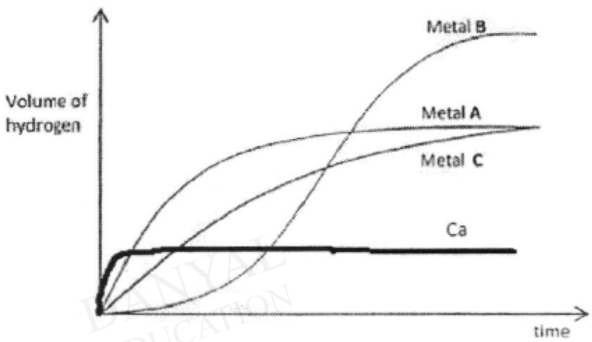
(a)	Sulfuric acid used in Experiment I is dibasic. **Every mole of sulfuric acid ionise completely to form 2 moles of hydrogen ions.**	[1]
	Hydrochloric acid in Experiment II is monobasic. **Every mole of hydrochloric acid ionize completely to form 1 mole of hydrogen ions.**	[1]
	In Experiment I, there is a **twice the concentration of hydrogen ions per unit volume than in Experiment II.**	[1]
	Hence, there is a **higher frequency of effective collision** in Experiment I than in Experiment II.	[1]
	As a result, there is a **higher rate of reaction** in Experiment I than in Experiment II.	
(b)	**Copper(II) sulfate acts as a catalyst**	[1]
	It **increases the speed of reaction** by **reducing the time taken to collect 50 cm^3 of hydrogen gas. Experiment I takes 28s while experiment III takes only 17s.** *(must support with data readings)*	[1]
(c)	When aqueous copper (II) sulfate is added, a side reaction occurs. **Zinc displaces copper from copper (II) sulfate**	[1]
	Less zinc is available to reacts with sulfuric acid to produce less hydrogen.	[1]
	Hence, the greater the volume of aqueous copper (II) sulfate added, the lower the volume of hydrogen produced.	

(d)	No (no marks) **Zinc, being less reactive than magnesium is unable to displace magnesium from magnesium sulfate.**	[1]
	Hence, **mass of zinc reacting with sulfuric acid remains the same.**	[1]

Q4

As the concentration increases, there are more H^+ ions in the same volume of solution.	1
This increases the frequency of the successful collisions between the reacting particles and hence increases the rate of the reaction	1

Q5

A2(a)	B is aluminium. Reaction is slow at start, because of the oxide layer reacting with acid. Reaction is fast when the oxide layer is removed, exposing the aluminium which reacts with the acid.	**1** **1** **1**
(b)	Metal A – magnesium Metal C – Zinc	**½** **½**
(c)	$2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$ $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$ For both magnesium and zince, 1 mol of metal produces 1 mol of H_2, therefore same volume of hydrogen produced. For aluminium, 1 mol of metal produces 1.5 mol of H_2, therefore higher volume of hydrogen produced.	 **1** **1**
(d)	 Graph must show that initial reaction is fast. Initial reaction is fast as Ca is very reactive. However, reaction stops due to the formation of a **layer of insoluble calcium sulfate**. This **prevents further reaction** between calcium and acid, therefore no more hydrogen is produced.	**1** **1**