

TEST 9

CHAPTER 1: RATE OF REACTION

NAME :

CLASS:

1. Table A shows the data from Experiment I and Experiment II that were carried out to investigate the rate of reaction of magnesium with two types of acids, A and B.

Experiment	Reactants	Products	Observation
I	0.72 g of magnesium and 50 cm ³ of acid A 2.0 mol dm ⁻³	Magnesium chloride and hydrogen gas	The temperature of the mixture increases
II	0.72 g of magnesium and 50 cm ³ of acid B 2.0 mol dm ⁻³	Magnesium sulphate and hydrogen gas	The temperature of the mixture increases

Table A

(i) By choosing either Experiment I or Experiment II, name the acid used. Write the chemical equation for the reaction of this acid with magnesium.

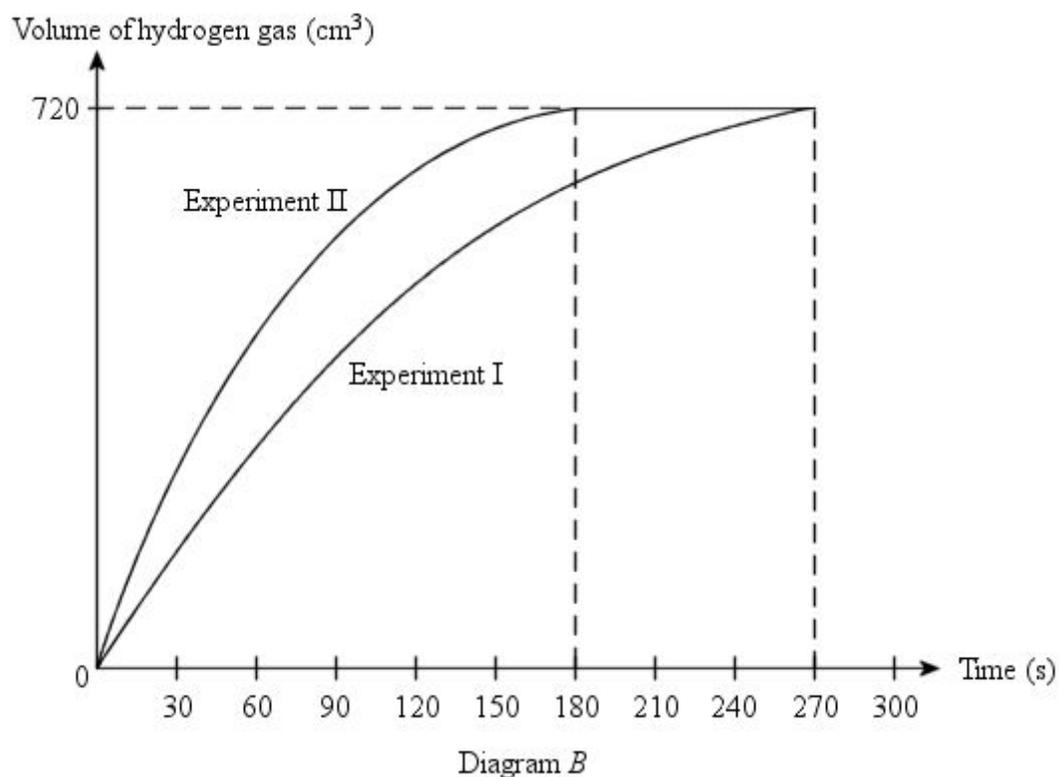
[2 marks]

(ii) Draw an energy profile diagram for the reaction in (a)(i) and indicate the followings:

1. Heat reaction, ΔH
 2. Activation energy without a catalyst, E_a
 3. Activation energy with a catalyst, E_a
- Explain the energy profile diagram.

[10 marks]

(b) The graph in Diagram B shows the results of Experiment I and Experiment II.



Based on the graph:

(i) calculate the average rate of reaction for either Experiment I or Experiment II.

[2 marks]

(ii) Explain the difference in the rate of reaction between Experiment I and Experiment II before 180 s, using the Collision Theory.

[6 marks]

2. Four experiments were carried out to investigate the rate of reaction between magnesium ribbon and a few types of acid. The table below shows the time taken to dissolve the 10-cm magnesium ribbon in each experiment.

Experiment	Mixture of reactants in experiment	Temperature ($^{\circ}\text{C}$)	Time (s)
<i>P</i>	30 cm ³ of 0.9 mol dm ⁻³ ethanoic acid + 19 cm magnesium ribbon	29	154
<i>Q</i>	30 cm ³ of 0.9 mol dm ⁻³ hydrochloric acid + 19 cm magnesium ribbon	29	68
<i>R</i>	30 cm ³ of 0.9 mol dm ⁻³ sulphuric acid + 19 cm magnesium ribbon	29	34
<i>S</i>	30 cm ³ of 0.9 mol dm ⁻³ hydrochloric acid + 19 cm magnesium ribbon + 5 drops of copper(II) sulphate	29	44

- (a) Write an ionic equation for the reaction between acid and the magnesium ribbon.

_____ [1 mark]

- (b) Based on the theory of collision, explain

- (i) why the reaction time for Experiment *Q* is shorter than Experiment *P*, although the concentrations for both ethanoic acid and hydrochloric acid are the same.

 _____ [2 marks]

- (ii) why the reaction time for Experiment *R* is shorter than Experiment *Q*.

 _____ [2 marks]

- (iii) why the time of reaction for Experiment *S* is shorter than Experiment *Q*.

 _____ [2 marks]

- (c) Explain what will happen to the reaction time if Experiment *R* is repeated at a higher temperature of 39 $^{\circ}\text{C}$.

 _____ [3 marks]

3. Two different experiments were carried out using hydrogen peroxide solution and manganese(IV) oxide powder as shown below.

Experiment	Reactants
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I	10 cm ³ of 2-volume hydrogen peroxide solution + 3 g manganese(IV) oxide powder.
II	10 cm ³ of 4-volume hydrogen peroxide solution + 3 g manganese(IV) oxide powder.

The volume of gas liberated was recorded at regular time intervals.

- (a) Draw a diagram of the set-up of apparatus used to carry out these experiments.

[2 marks]

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

_____ [1 mark]

- (c) Sketch a graph of volume of gas liberated against time for Experiments I and II on the same axes.

[2 marks]

- (d) (i) Which of the two experiments have a higher rate of reaction?

_____ [1 mark]

- (ii) State a reason for your answer in (d)(i).

_____ [1 mark]

- (e) Manganese(IV) oxide acts as a catalyst in Experiments I and II. Using the collision theory, explain the role of manganese(IV) oxide which helps to increase the rate of liberation of the gas in the experiments.

_____ [3 marks]

4. Table A shows the data from Experiment I and Experiment II that were carried out to investigate

the rate of reaction of magnesium with two types of acids, *A* and *B*.

Experiment	Reactants	Products	Observation
I	0.72 g of magnesium and 50 cm ³ of acid <i>A</i> 2.0 mol dm ⁻³	Magnesium chloride and hydrogen gas	The temperature of the mixture increases
II	0.72 g of magnesium and 50 cm ³ of acid <i>B</i> 2.0 mol dm ⁻³	Magnesium sulphate and hydrogen gas	The temperature of the mixture increases

Table A

(i) By choosing either Experiment I or Experiment II, name the acid used. Write the chemical equation for the reaction of this acid with magnesium.

[2 marks]

(ii) Draw an energy profile diagram for the reaction in (a)(i) and indicate the followings:

1. Heat reaction, ΔH
2. Activation energy without a catalyst, E_a
3. Activation energy with a catalyst, E_a

Explain the energy profile diagram.

[10 marks]

(b) The graph in Diagram *B* shows the results of Experiment I and Experiment II.

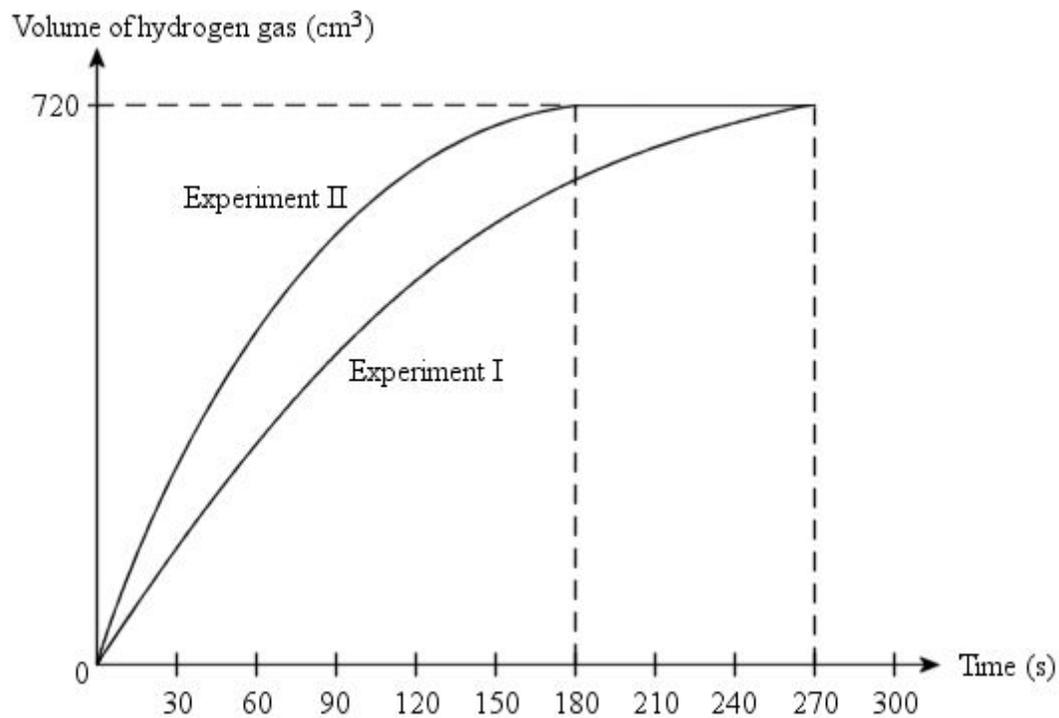


Diagram B

Based on the graph:

(i) calculate the average rate of reaction for either Experiment I or Experiment II.

[2 marks]

(ii) Explain the difference in the rate of reaction between Experiment I and Experiment II before 180 s, using the Collision Theory.

[6 marks]

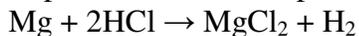
Answers:

1.

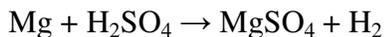
(a)(i) Experiment I: A is hydrochloric acid

or

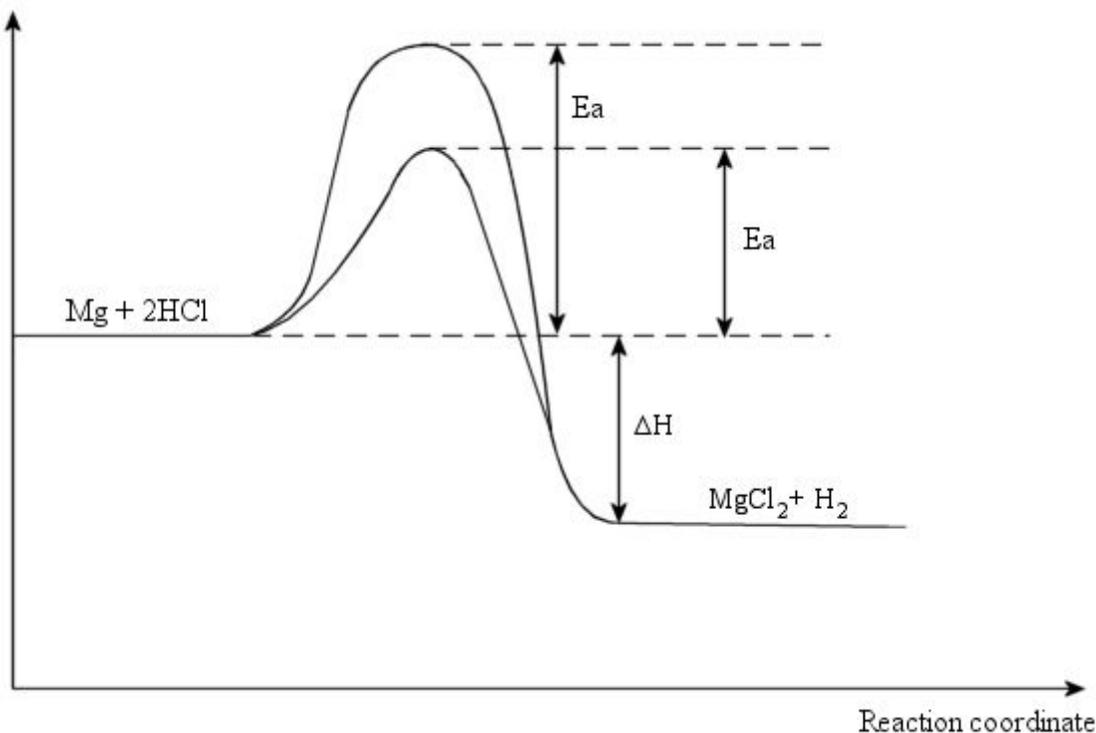
Experiment II: B is sulphuric acid



or



(ii) Energy



- Reaction of Mg with HCl is exothermic
- The reactions contain more energy than the products
- Activation energy must be overcome in order for the reaction to take place
- ΔH is the energy difference between the reactants and products
- A catalyst reduces the activation energy

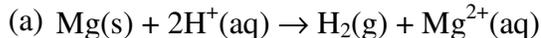
(b)(i) Experiment I: $\frac{720}{270} = 2.67 \text{ cm}^3 \text{ s}^{-1}$

Experiment II: $\frac{720}{180} = 4 \text{ cm}^3 \text{ s}^{-1}$

- (ii)- The slope of graph in Experiment II is steeper than slope of graph in Experiment I
- The rate of reaction for Experiment II is higher than Experiment I
 - Experiment II used H₂SO₄ - a diprotic acid while Experiment I used HCl - a monobasic acid
 - H₂SO₄ has higher concentration of H⁺
 - Frequency of collision between H⁺ ion and magnesium in Experiment II is higher than in Experiment I

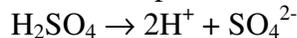
- Frequency of effective collision in Experiment II is higher than in Experiment I

2.

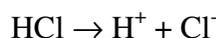


(b) (i) HCl ionises completely in water to produce high concentration of H^+ ions while CH_3COOH ionises partially in water to produce low concentration of H^+ ions. Thus the number of particles per unit volume increases in the case of HCl. So the frequency of collision between H^+ ions and Mg atoms increases, followed by the frequency of effective collision increases, resulting in a shorter time in Experiment Q.

(ii) Sulphuric acid is a strong diprotic acid. 1 mole of sulphuric acid dissociates completely in water to produce 2 moles of hydrogen ions:



1 mole of hydrochloric acid dissociates completely in water to produce 1 mole of H^+ ions:



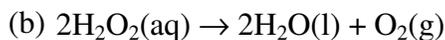
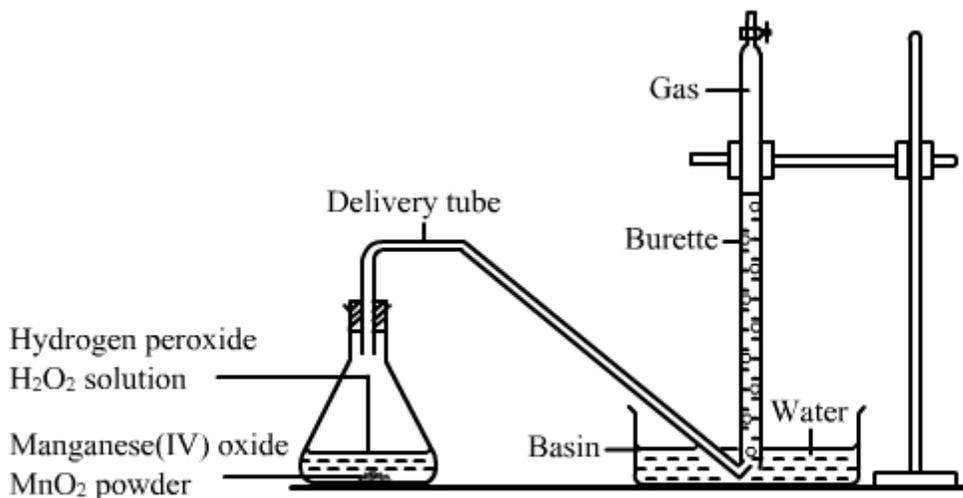
Thus, the concentration of H^+ ions in sulphuric acid is higher.

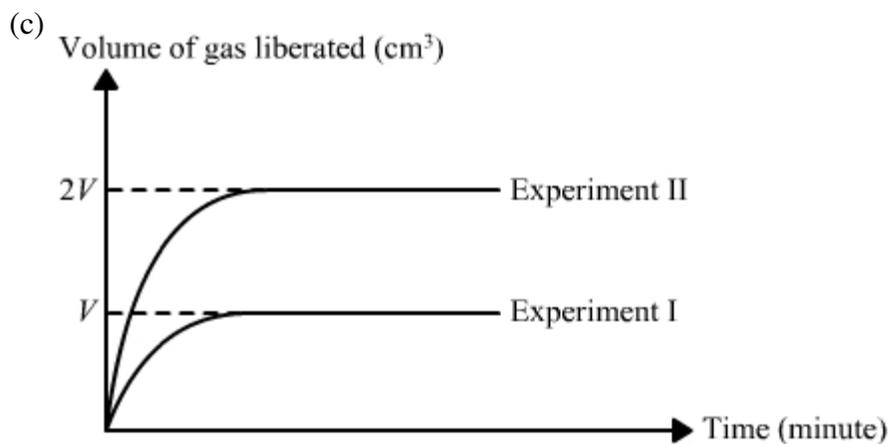
(iii) Copper(II) sulphate catalyses the reaction between hydrochloric acid and magnesium ribbon, reducing its activation energy and hence increases the frequency of effective collisions between the particles.

(c) The time to dissolve the magnesium ribbon will become shorter because at higher temperature, the kinetic energy of H^+ ions increases. There are more particles obtaining energy higher than the activation energy. So the frequency of effective collision increases and the rate of reaction increases.

3.

(a)





(d) (i) Experiment II

(ii) This is because the concentration of hydrogen peroxide solution in experiment II is higher than that of experiment I.

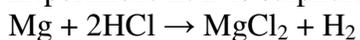
(e) In the presence of manganese(IV) oxide, the reaction takes place through an alternative path that requires a lower activation energy. A larger number of particles colliding against one another can easily overcome this lower activation energy. Hence, the frequency of effective collision increases which results in a higher rate of reaction.

4.

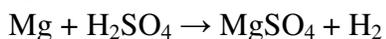
(a)(i) Experiment I: *A* is hydrochloric acid

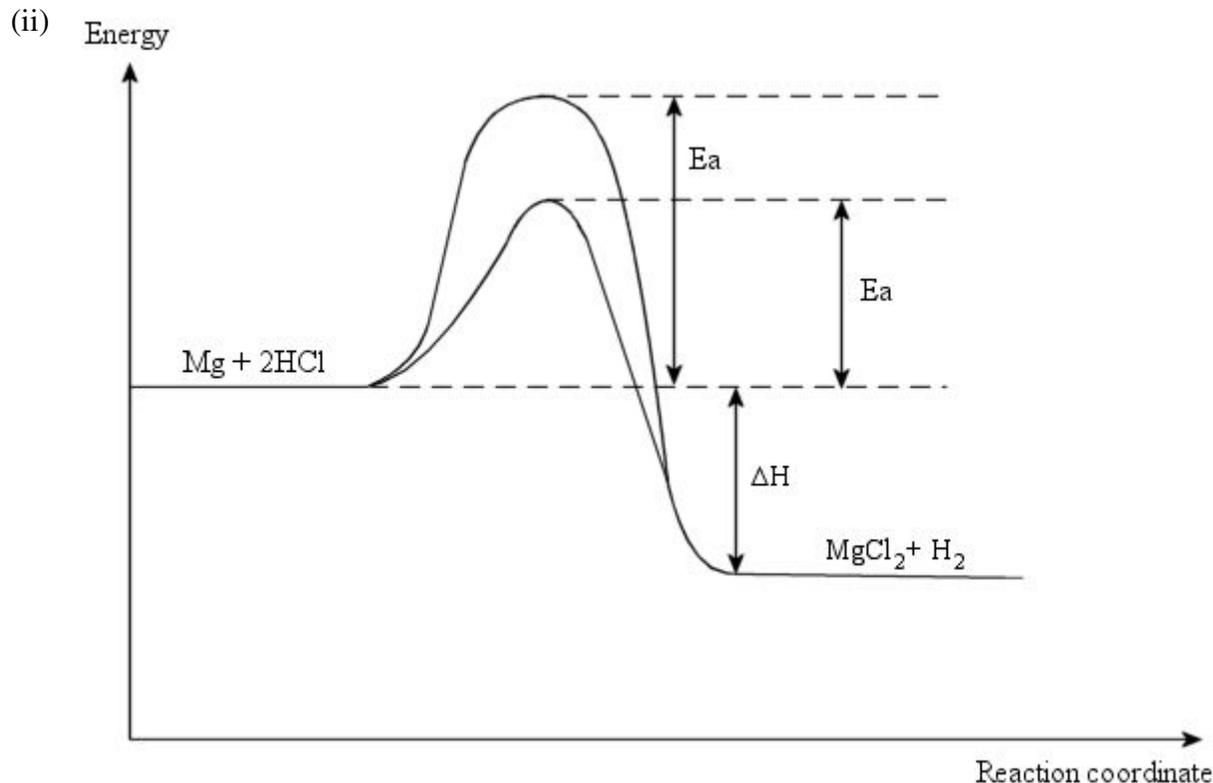
or

Experiment II: *B* is sulphuric acid



or





- Reaction of Mg with HCl is exothermic
- The reactions contain more energy than the products
- Activation energy must be overcome in order for the reaction to take place
- ΔH is the energy difference between the reactants and products
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(b)(i) Experiment I: $\frac{720}{270} = 2.67 \text{ cm}^3 \text{ s}^{-1}$

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 - H₂SO₄ has higher concentration of H⁺
 - Frequency of collision between H⁺ ion and magnesium in Experiment II is higher than in Experiment I
 - Frequency of effective collision in Experiment II is higher than in Experiment I