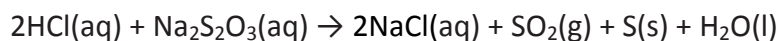


**NCEA COLLATED QUESTIONS ON RATES OF REACTION**

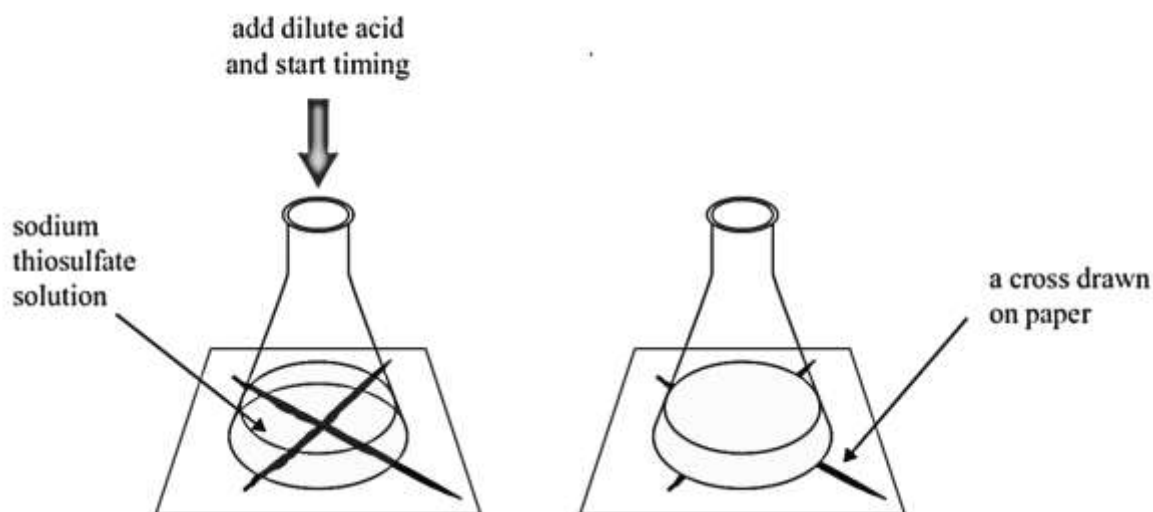
Previously part of expired AS 90301, now part of 91166, Demonstrate understanding of chemical reactivity

**2012** (91166 exam)

When dilute hydrochloric acid, HCl(aq), is added to sodium thiosulfate, Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>(aq), in a conical flask, the following reaction occurs:



A pale yellow solid of sulfur, S(s), forms during the reaction. Over time, a cross on a piece of paper under the conical flask gradually disappears when viewed from above.



- (a) List TWO ways that the rate of this reaction could be decreased.
- (b) The following experiments were carried out, and the times taken for the cross to disappear recorded. The HCl(aq) was in excess in all of the experiments.

Experiment	Concentration of 50.0 mL Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> / mol L <sup>-1</sup>	Concentration of 10.0 mL HCl / mol L <sup>-1</sup>	Temperature / °C	Time taken for cross to disappear / s
1	0.0500	1.00	25	127
2	0.0250	1.00	25	206
3	0.0500	1.00	45	34

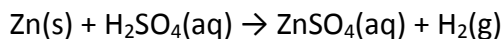
Analyse how the results of **Experiment 2 and Experiment 3 compare to Experiment 1.**

In your answer you should:

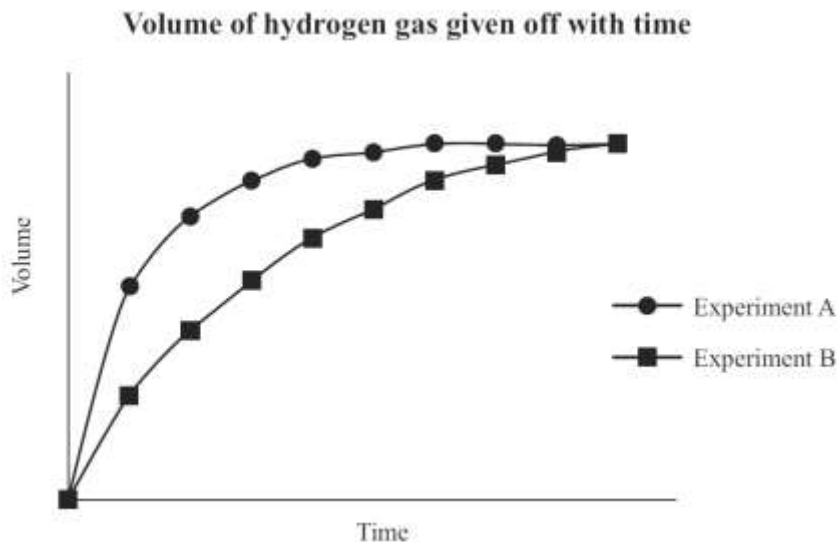
- identify the factor being changed and the effect it has on the reaction rate
- explain how the rate of reaction was affected, with reference to the collision of particles, and activation energy where appropriate.

**2011**

(a) Zinc foil reacts with dilute sulfuric acid to produce zinc sulfate and hydrogen gas.



Two experiments were carried out using the same mass of zinc foil and excess sulfuric acid of concentrations  $0.500 \text{ mol L}^{-1}$  and  $1.00 \text{ mol L}^{-1}$ . The reactions were carried out at  $25^\circ\text{C}$ . A graph showing the results of the two experiments is shown below.



- (i) Circle the letter of the experiment which was carried out using the  $1.00 \text{ mol L}^{-1}$  sulfuric acid.  
Experiment: A B Justify your answer in terms of the collision of particles.
- (ii) Experiment A was repeated, using the same mass of zinc granules instead of zinc foil.  
The rate of reaction increased. Explain this effect on the reaction rate, in terms of the factor investigated and the collision of particles.
- (iii) Experiment A was repeated again; this time the reaction was carried out at a temperature of  $15^\circ\text{C}$ .  
Discuss the effect of this temperature change. Your answer must include reference to:
- reaction rate
  - collision of particles
  - activation energy.

**2010**

(a) An experiment to investigate the rate of reaction between a 5 cm strip of magnesium ribbon and 20 mL of  $1.00 \text{ mol L}^{-1}$  hydrochloric acid was carried out at  $25^\circ\text{C}$ . The hydrochloric acid was in excess. The experiment was repeated under different conditions as given below.

Complete the table below for EACH change, by:

- stating the factor being investigated
- describing how the reaction rate would be affected by using the word 'increase' or 'decrease' in your answer.

		Factor being investigated	Effect on reaction rate
Change One	The magnesium ribbon was added to a mixture containing 10 mL of $1.00 \text{ mol L}^{-1}$ hydrochloric acid and 10 mL of water.		

● CHEMISTRY

Change Two	The reaction was carried out at 40°C.		
Change Three	One side of the strip of magnesium ribbon was coated with nail varnish. This made one surface of the magnesium ribbon unreactive. The magnesium ribbon was then added to the 1.00 mol L <sup>-1</sup> hydrochloric acid.		

- (b) Discuss the effect on the reaction rate for **Change One** above, in terms of the factor investigated and the collision of particles.

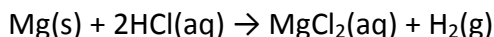
**2009**

- (a) An experiment was carried out by reacting calcium carbonate with dilute hydrochloric acid. The equation for this reaction can be represented by:

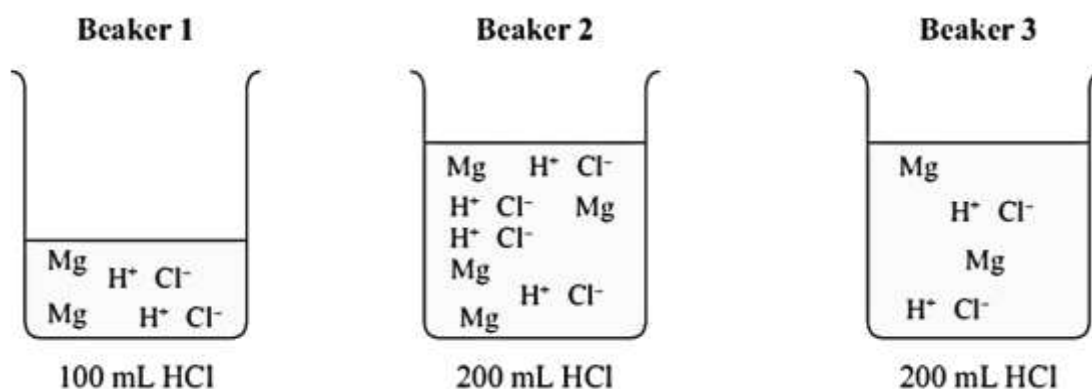


State THREE ways to increase the rate of this reaction.

- (b) Three experiments were carried out by reacting magnesium metal with hydrochloric acid. The equation for this reaction can be represented by:



The beakers show particle representations of magnesium metal and hydrochloric acid just before the reaction is about to begin.

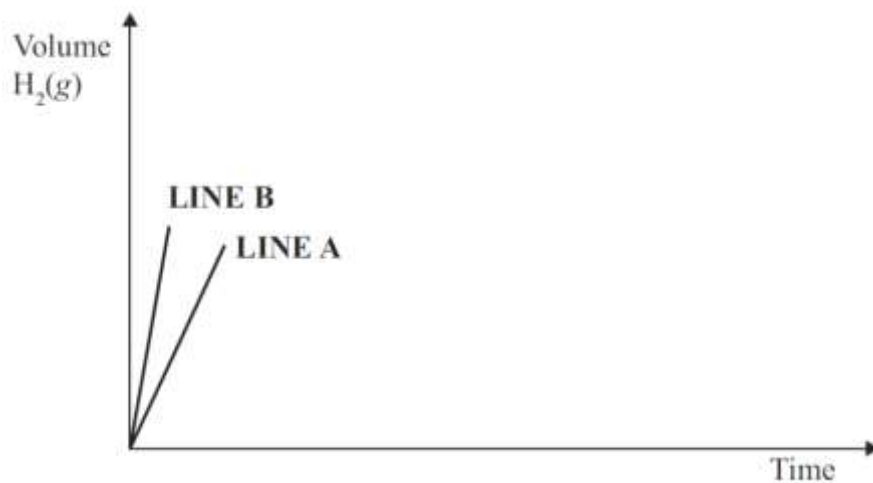


Mg = particles of magnesium metal

H<sup>+</sup> Cl<sup>-</sup> = particles of hydrochloric acid

The rate of reaction can be followed by recording the volume of hydrogen, H<sub>2</sub>, produced. The graph below shows the volume of hydrogen produced during the **initial** part of the reaction.

● CHEMISTRY

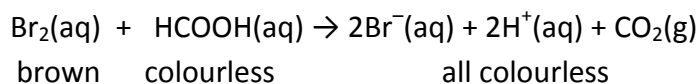


Which beaker(s) corresponds to: LINE A of the graph      LINE B of the graph

Explain your answers in terms of

- particle collision
- concentration of the particles present.

- (c) An experiment was carried out by reacting bromine, Br<sub>2</sub>, and methanoic acid, HCOOH, in a beaker. The equation for this reaction can be represented by:



The rate of reaction can be followed by measuring the time taken for the solution to go colourless. A series of reactions were carried out and the time taken for the solution to go colourless was recorded. The results are shown below.

Temperature of solution/ °C	10	20	30	40	50
Time to go colourless / s	34	28	21	15	7

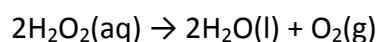
- (i) Describe the trend shown by these results.  
 (ii) Discuss the reasons for this trend.

Your answer must include reference to

- particle collision
- reaction rate
- activation energy.

**2008**

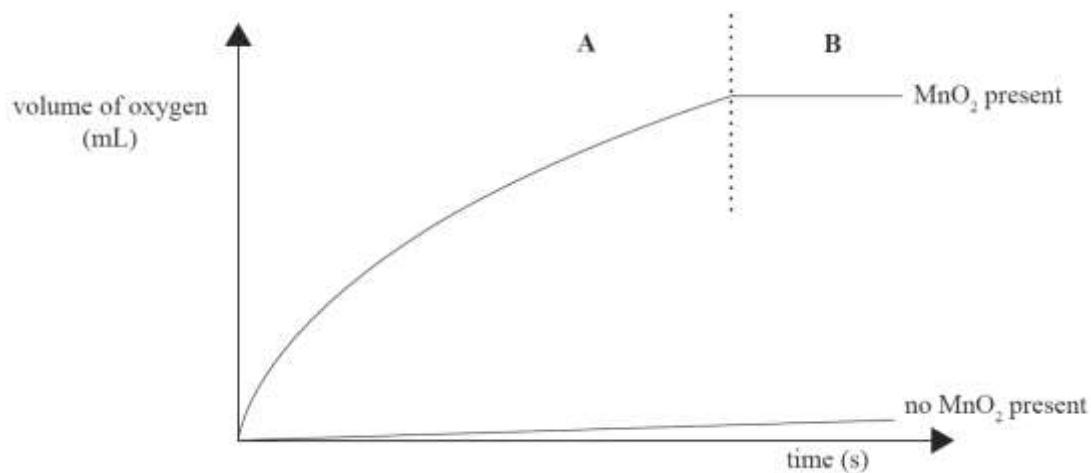
Hydrogen peroxide decomposes to form water and oxygen gas.



The rate of decomposition is changed with the addition of manganese dioxide, MnO<sub>2</sub>.

The rate of the reaction can be followed by recording the volume of oxygen produced. The graph below shows the volume of oxygen produced with, and without, manganese dioxide.

● CHEMISTRY



- (a) Describe what happens to the rate of decomposition of hydrogen peroxide when manganese dioxide is added.
- (b) A student suggested that manganese dioxide is a catalyst for the decomposition reaction. Explain the role of a catalyst in changing the rate of a reaction. Your answer must include reference to:
- particle collision
  - activation energy.
- (c) One line on the graph is divided into two time periods, A and B. Discuss the change in reaction rate in terms of particle collisions during these two time periods, A and B.

Answers to collated questions

**2012**

- (a) Decrease concentration of a reactant.  
Decrease temperature.

**(b) Experiment 2 and 1**

Concentration of a reactant has decreased, which decreased the rate of reaction.

This means there are fewer reactant particles per unit volume so the collision rate decreases (less collisions per time).

**Experiment 3 and 1**

Temperature is increased, so the rate of reaction increases.

This means:

The particles have more average kinetic energy and are moving faster. There will be an increase in the frequency of collisions between particles.

Particles also collide more effectively as the particles have more energy to overcome the activation energy for the reaction.

**2011**

- (a)(i) A: It has higher concentration. It has more particles in a given volume. It has more frequent collisions. It has a higher rate of reaction.
- (ii) Granules have greater surface area. Thus more Zn atoms are exposed. Thus more frequent collisions occur.
- (iii) The change causes a lower rate of reaction. It lowers kinetic energy. It causes less frequent collisions. Thus fewer particles have EA. Thus fewer collisions are successful.

**2010**

- (a)

	<b>Factor</b>	<b>Effect</b>
<b>Change One</b>	concentration	decrease
<b>Change Two</b>	temperature	increase
<b>Change Three</b>	surface area	decrease

- (b) The concentration of hydrochloric acid has decreased, so there are fewer particles per unit volume of acid to react at any one time. Lower concentration means that there is a decrease in the frequency of collisions, so the frequency of effective collisions decreases. Hence the reaction occurs more slowly.

**2009**

- (a) Rate of reaction can be increased by
- increasing the temperature (heat the reaction)
  - increasing the surface area of the calcium carbonate (use powdered calcium carbonate)
  - increasing the concentration of hydrochloric acid. (not reactants).
- (b) Line A – Beaker 3    Line B – Beakers 1 and 2  
Beakers 1 and 2 have the same concentration of HCl and Beaker 3 has a lower concentration of HCl.

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Line B corresponds to beakers 1 and 2 because it is steeper showing a faster rate of reaction. In Beakers 1 and 2, there are more reactant particles per unit volume compared to Beaker 3, so the concentration is greater. As the concentration of reactants is increased, the collision rate of reactant particles increases, so there are more successful / effective collisions and the reaction rate is increased. Hence a steeper line on the graph.

Line A corresponds to beaker 3 because it is less steep and shows a slower rate of reaction. In beaker 3 there are fewer reactant particles per unit volume compared to beakers 1 and 2, so the concentration is lower. As the concentration of the reactants is decreased, the collision rate of the reactant particles decreases, so there are fewer successful / effective collisions and the rate of the reaction is decreased.

- (c)(i) States that as temperature increases the rate of reaction increases / time taken for the solution to decolourise decreases.
- (c)(ii) This is because as temperature increases, the molecules have more kinetic energy / higher energy and moving faster. There will be an increase in the frequency of collisions between particles. Particles also collide more effectively when they actually do collide. There are more effective / successful collisions because more particles have enough kinetic energy to overcome the activation energy for the reaction. Leading to an increased rate of reaction.

**2008**

- (a) The reaction rate is increased when manganese dioxide is added.
- (b) The catalyst increases the reaction rate by providing an alternative pathway of lower activation energy. Therefore a greater proportion of collisions (in a given time) have the required activation energy and are successful.
- (c) Time period A: Initially the reaction rate is high, as the concentration of reactants in the solution is high. As the reaction proceeds, the reaction rate decreases because the concentration of reactants is decreased; the collision rate of reactant particles is decreased.
- Time period B: The reaction has stopped / zero reaction rate. There are no more (or few)  $\text{H}_2\text{O}_2$  particles left to collide, so no more oxygen is being produced.