ScienceCube

Reaction Rate Based on Surface Area

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1. **Explain the effect of surface area on the reaction rate.**
2. **Understand the definition of reaction rate and measure the reaction rate through the change in gas production.**

Fundamental Concept

1. Reaction Rate

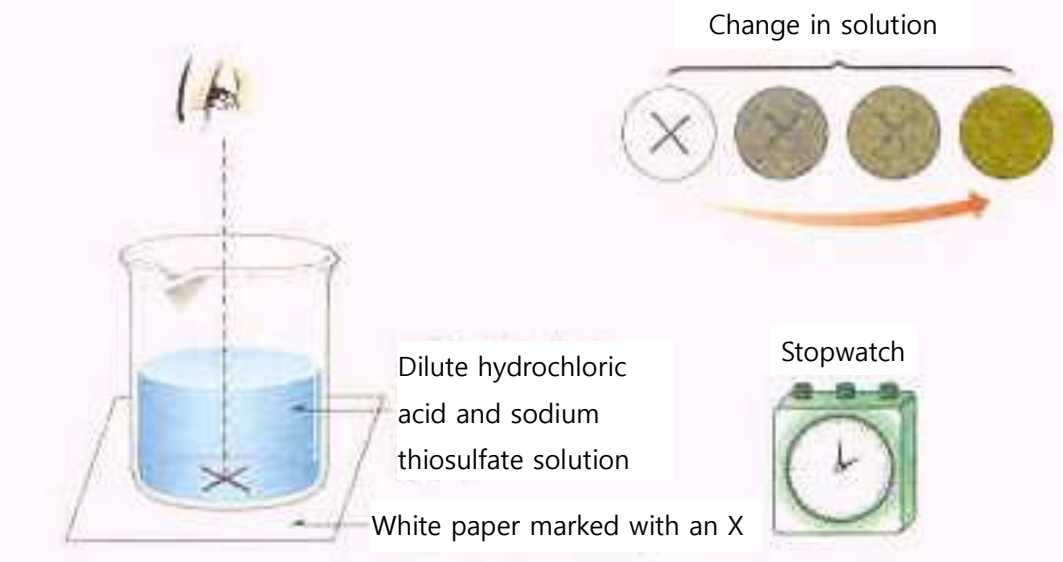
The change in the concentration of reactants consumed (or products formed) per unit time.

$$V = \frac{\text{Decrease in reactants}}{\text{Reaction time}} = \frac{\text{Increase in products}}{\text{Reaction time}}$$

2. Various Methods to Measure Reaction Rate

(1) Generally, the rate of decrease in the concentration of reactants or the rate of increase in the concentration of products is investigated.

(2) Precipitate Formation: The time taken for a certain amount of precipitate to form is measured. The rate is inversely proportional to the time taken.

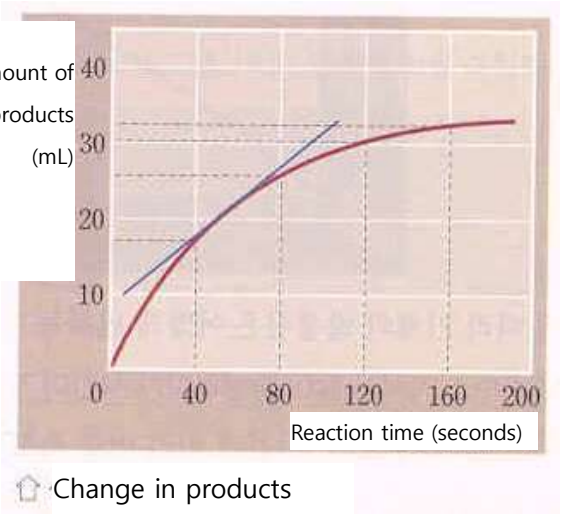


(3) Gas Production

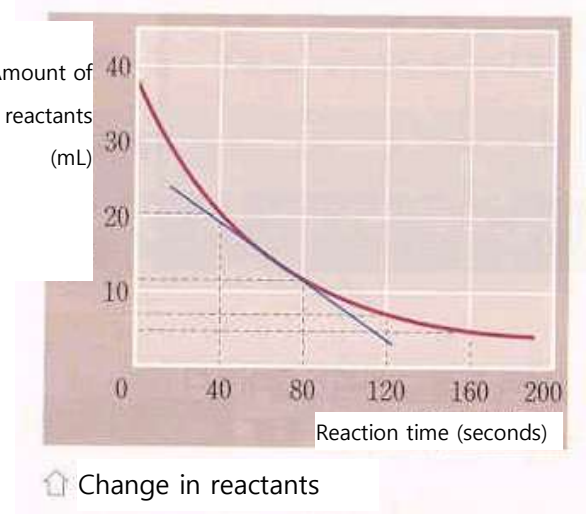
- Mass Measurement Method: If the produced gas escapes, the mass decreases as the reaction progresses, and the reaction rate is measured by the decrease in mass per unit time (using an electronic balance).
- Volume Measurement Method: The volume of gas produced per unit time is measured..

3. Reaction Rate Graph

- The slope of the graph represents the change in concentration over a certain period.
- A steeper slope indicates a faster reaction rate.
- A gentler slope indicates a slower reaction rate..



Change in products



Change in reactants

4. Factors Affecting Reaction Rate

(1) Concentration and Reaction Rate

- Increasing the concentration of reactants increases the reaction rate.
- Reason: Increasing the concentration of reactants increases the relative number of particles, which increases the frequency of collisions between particles, thereby increasing the reaction rate. (Increased concentration → Increased collision frequency → Increased reaction rate)
- In solid reactions, increasing the surface area of the reactants increases the probability of collisions between particles, thus increasing the reaction rate.

(2) Surface Area and Reaction Rate

- Surface Area and Collision Frequency

  When each face of a cube is divided into two, the total mass remains the same, but the surface area doubles. When the reactants are finely divided, the surface area increases, leading to an increase in the collision frequency between reactant particles..

- Examples of Surface Area Affecting Reaction Rate

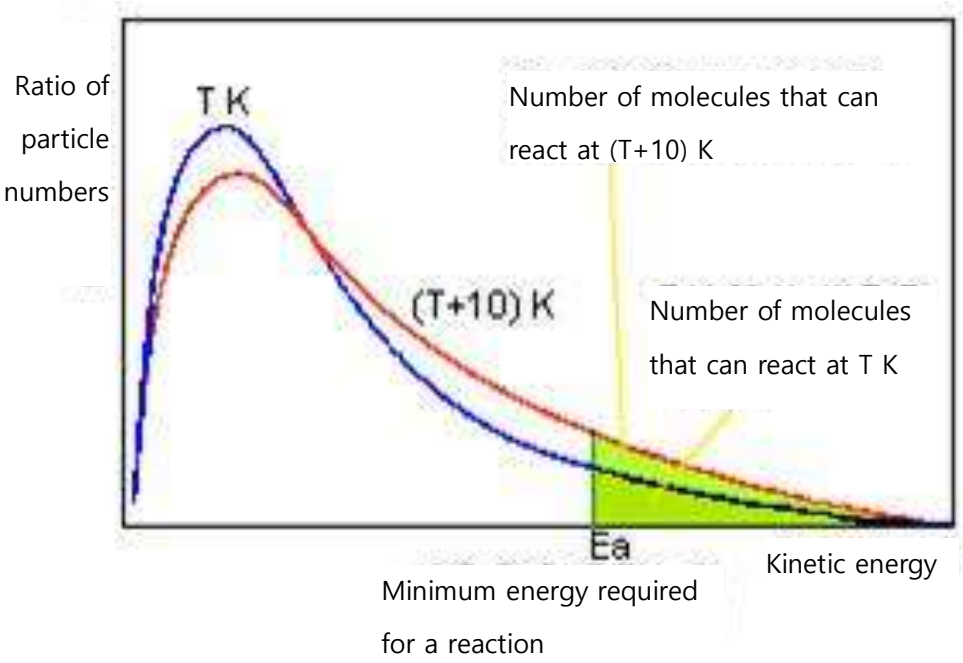
  Steel pieces are difficult to ignite, but steel wool ignites easily.

  Flour piled up in a warehouse poses a high fire risk even with a small spark.

  Rough steel plates corrode faster than smooth steel plates..

(3) Temperature and Reaction Rate

- As temperature increases, the number of molecules with activation energy increases, which increases the reaction rate.
- Reason: As temperature increases, more molecules reach the activation energy, thereby increasing the reaction rate.



Experiment

Materials Needed

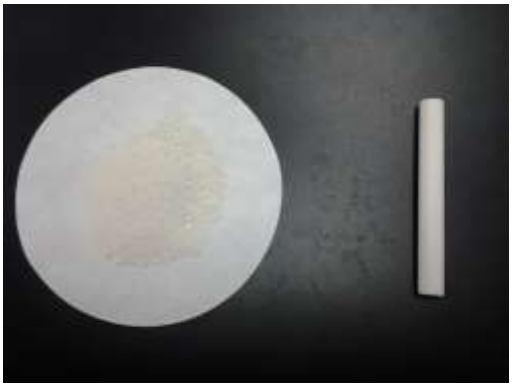
Interface, Science# program, Gas pressure sensor B (2), 250 mL Erlenmeyer flasks with side arms (2), Silicone tubes (2), Rubber stoppers (2), 100 mL beakers (2), Dilute hydrochloric acid (0.1M), Chalk (or seashells), Mortar and pestle, Filter paper, Permanent marker

Experimental Setup

1. Connect the ends of the silicone tubes to the gas pressure sensors and the side arms of the Erlenmeyer flasks.

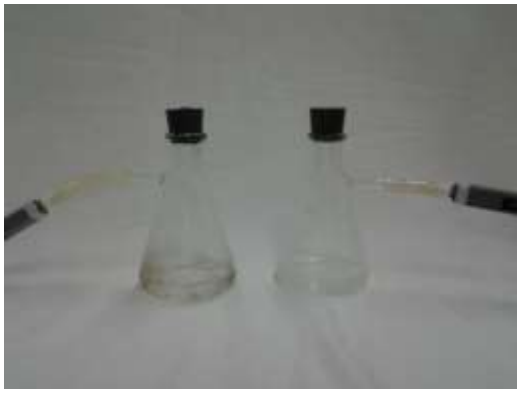
2. Add 50 mL of dilute hydrochloric acid to each of the two Erlenmeyer flasks.
3. Seal the flasks tightly with rubber stoppers, marking the position of the stopper on the flask with a marker.

4. Crush one of the pieces of chalk into fine powder using a mortar and pestle, and place it on filter paper.

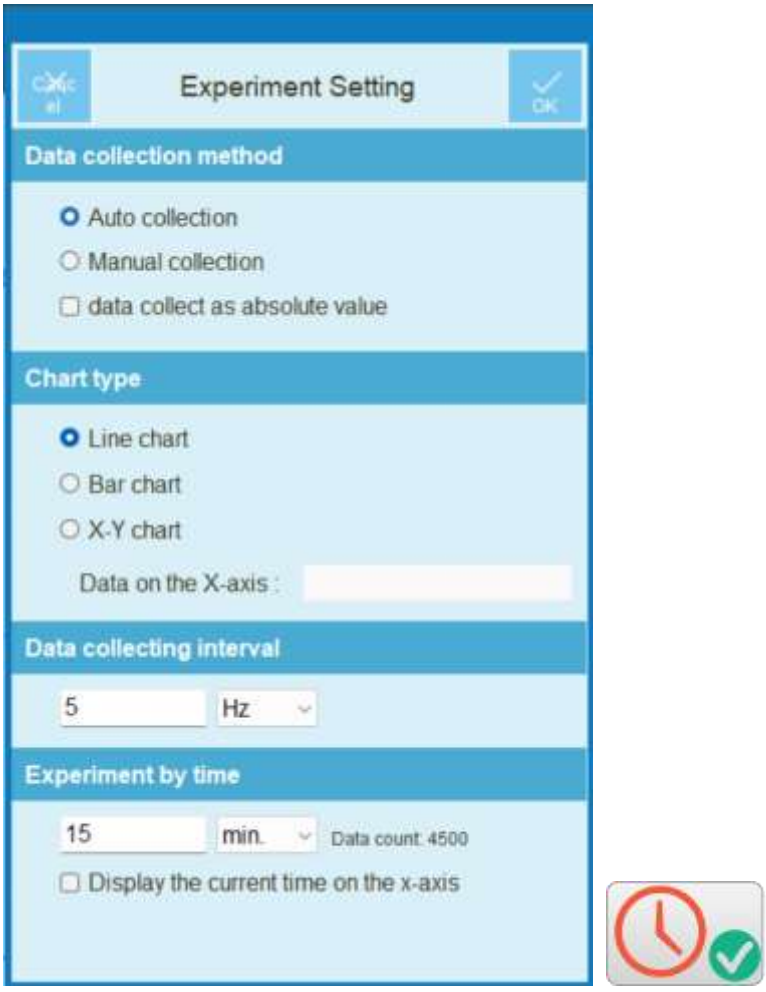


Interface Setting

1. Run Science#.
2. Connect the two gas pressure sensors to the interface.



3.  Press the button to set up the experiment environment as shown below or press the button  for automatic setup.



4.  Press the button on both gas pressure sensor snapshots to zero the sensors.

Data Collection

1. Open the stoppers of the two flasks, simultaneously add the two forms of chalk to each flask, and quickly seal them to the marked position.
2.  Press the button to start data collection..

Data Analysis

Recording Data

1. Plot the change in gas pressure generated in the two flasks over time on a graph.

2. From the graph showing the change in gas pressure in the two flasks, calculate the slope for the initial 5-10 minutes using the equation < F(X)= aX + b > to obtain the value of a (slope). Complete the table below and explain the relationship between the slope and reaction rate..

Sample Type	Slope
Chalk Chunk	
Chalk Powder	

Applying Data and Extended Activities

1. Compare the surface areas of the same mass of chalk in different forms (indicate using inequality signs).

Surface area of chalk chunk | | Total surface area of chalk powder

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2. Explain how surface area affects the reaction rate.

3. Describe how the slope of the graph changes over time and explain the reason.. .

4. If the experiment did not produce accurate results, reflect on the experimental design and consider potential reasons.

5. Find and describe two or more real-life examples where surface area affects the reaction rate..