

SCIENCE 1106

CHEMICAL REACTIONS, RATES, AND EQUILIBRIUM

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II. REACTION RATES

Chemical reactions occur at many different rates. The same reaction can occur at different rates under different conditions. For example, the body cells can metabolize food at a normal rate at a body temperature of 37°C (98.6°F). When a person gets a fever, the metabolism rate of the same cells is greatly altered. Only a few degrees change can greatly affect a reaction rate. In the case of a body fever, the change in the reaction rate is part of God's design to protect the human body. The reactions that aid the body defense system are speeded up, and those that contribute extra heat to the body are slowed down. Only an omniscient Designer could have made such a remarkable organism as the human body: it is certainly not a "chance" occurrence. David reminds us in Psalm 40:5, "Many, O LORD my God, are thy wonderful works which thou hast done, and thy thoughts which are to usward: they cannot be reckoned up in order unto thee: if I would declare and speak of them, they

are more than can be numbered." Psalm 139:14 states, "I will praise thee; for I am fearfully and wonderfully made: marvellous are thy works; and that my soul knoweth right well." How comforting to know that every reaction in our bodies from the very beginning of our being was known by a personal, loving, caring Creator. Psalm 139:16 says, "Thine eyes did see my substance, yet being imperfect; and in thy book all my members were written, which in continuance were fashioned, when as yet there was none of them." Even before we had form and shape as a human, God knew us personally and had written about us in His book. No wonder even the reactions of our body cells are known unto Him.

This section of the LightUnit will deal with reaction rates, rate variables, reaction diagrams, and activation energy. You will explore what factors control a reaction. Much of what you learned in the previous section will be used directly here.

SECTION OBJECTIVES

Read these objectives. When you have completed this section, you should be able:

2. To interpret energy diagrams.
3. To explain what factors affect the rates of reactions.

VOCABULARY

Study this word to enhance your learning success in this section.

catalyst



RATE VARIABLES

An iron nail reacts slowly in air as it rusts. White phosphorus immediately bursts into flame when exposed to air. Candle wax burns only after energy is added to light the wick of the candle. All these reactions with oxygen take place at different rates. Apparently, then, if the factors that control the rate of a reaction are known, one should be able to control that reaction.

First, let us review the definition of the word *rate*. The word *rate* can mean how fast some event occurs. A car may travel 90 km per hour as a rate of speed. A distance runner may run one mile in four minutes as a rate. A stream may flow at 3,785

liters per minute. A jet may fly at 1,200 km per hour. A space vehicle may travel at 58,000 km per hour. Our earth travels about 101,000 km per hour through space in its orbit around the sun. Light travels about 300,000 km per second. All of the examples have the same form. They all have some measurable event occurring in some measurable time interval. The rate of reaction is determined either by how fast one of the reactants is used up, or one of the products is formed. This rate of reaction can be stated:

$$\text{rate} = \frac{\text{change in amount of some component}}{\text{time interval}}$$

- c. Have you increased or decreased the concentration of square beads? _____
5. Now remove enough square beads so that you have only 5 square beads left.
6. Shake as before.

2.3 Compare the collision rates of the 10-10 and 10-5 bead systems.

- a. Is the number of collisions between spheres and squares more or less than in the 10:10 ratio? _____
- b. How many times more or less do you think it is? _____
- c. Have you increased or decreased the concentration of square beads? _____
- d. In general, as you increase the concentration of one of the items involved in some interaction, does the number of collisions increase, decrease, or remain the same? _____
- e. Explain your reasoning to your answer in d. _____

2.4 Transfer these ideas to a chemical system.

- a. Which has a higher concentration of B in solution, a 0.1 M or a 1.0 M solution? _____
- b. In any chemical system it is assumed that a collision between the reacting chemicals must take place before a chemical reaction can occur. If you added 5 ml of A to separate 10 ml samples of the two preceding B solutions, which system would you predict to have the largest number of A-B collisions, the 0.1 M or 1.0 M solution? _____
- c. Why? _____

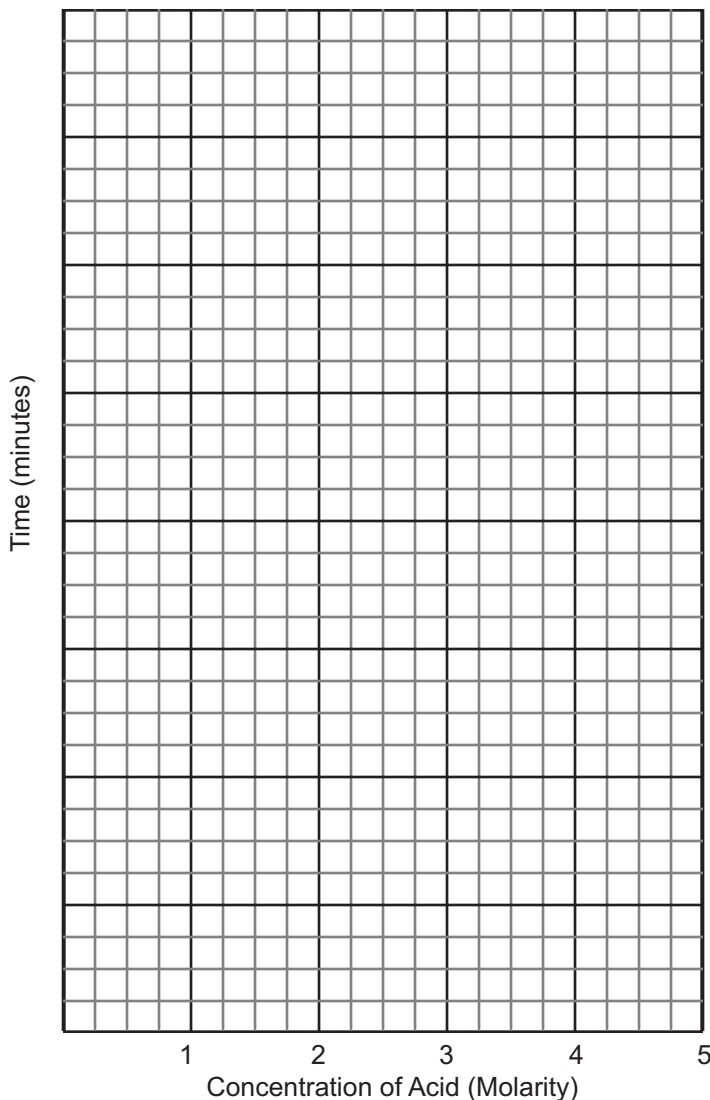
- d. Which do you predict to react the faster, 0.1 M or 1.0 M? _____
- e. Why? _____

7. Use the following investigation to check the preceding predictions. You will need to record timed data for this system. Start the timing as soon as the calcium carbonate chip is mixed with the appropriately diluted acid solution. The reaction is complete when the chip is all gone.
- a. Set up the experiment with 5 large test tubes in a rack. Label each one. Measure the water amounts into each and then add the acid amounts.
- b. The calcium chips may range in size from 0.1 g to 0.5 g, but be careful to have the same amount for each tube. Weigh out the 5 portions and keep them on separate holders (e.g. teaspoons).

2.5 Experimental data.

Chip	6 M HCl + Water	Molarity	Time (minutes)
a. 0.1 g	10 ml + 2 ml	5	_____
b. 0.1 g	8 ml + 4 ml	4	_____
c. 0.1 g	6 ml + 6 ml	3	_____
d. 0.1 g	4 ml + 8 ml	2	_____
e. 0.1 g	2 ml + 10 ml	1	_____

2.6 Plot this data as time vs. concentration of acid.



- 2.7 Analyze your results.
- a. As the concentration of acid increased, the required time (increased; decreased), so did the speed of the reaction increase or decrease? _____
 - b. Therefore, as the concentration of a reactant increases, does the rate of the reaction increase or decrease? _____
 - c. Do your predictions previous to this investigation agree with your results? _____
 - d. Make a *general rule* about the effects of concentration of reactants on reaction rates.

- 2.8 On the basis of your ideas about the number of collisions compared to concentration as investigated with the sphere and square bead model, justify your general rule for concentration of reactants versus reaction rates.
