Experiment 7
Can You Slow It Down?

OUTCOMES

After completing this experiment, the student should be able to:

- tell which factors influence the reaction rate and how they influence the rate.
- change the temperature of a reaction mixture in order to affect the reaction rate.
- prepare a reaction mixture for the iodine-clock reaction which occurs in a specified amount of time.

DISCUSSION

Chemical reactions do not all occur at the same speed (rate). Some reactions, like the explosion of trinitrotoluene (TNT), are extremely fast, while others, like the rusting of iron on an automobile, are quite slow (though it does not always seem that way). Can you think of other examples? There are many other reactions having rates between these examples.

The study of reaction rates is called *kinetics*. Scientists study factors that influence the rates of various reactions in order to get an understanding of how the reaction is occurring and to determine means by which the reaction rate may be controlled. We may want to make certain reactions go faster, like the decomposition of waste materials or the perming of hair. We may also wish to slow certain reactions, like the rusting of iron or the spoilage of food. Scientists spend considerable time and money attempting to control reaction rates.

In order to understand more about reaction rates, we should first have an understanding of the collision theory of chemical reactions. A chemical reaction results from the effective collision of reactant molecules. Molecules are in constant motion and colliding all the time. In an effective collision, the molecules collide with the proper orientation and with some minimum energy, which is determined by the mass and speed of the reactant molecules. Some bonds are broken and other bonds are reformed. Not all collisions result in the formation of products. Sometimes particles rebound from a collision unchanged. Hence, we can affect the reaction rate by finding ways to make effective collisions more frequent. Most reactions are carried out in liquid solution or the gas phase so that the particles are free to move about and come in contact with each other. Reactions of solids usually take place only on the surface. For example, rust usually occurs on the exposed surface and then continues as more layers of iron atoms are exposed.

There are several factors that affect the rate of most reactions. These factors include the concentration of reactants, temperature, catalyst, and surface area of solid reactants. How do these factors affect the reaction rate? Hopefully, the answer to this question will be obtained through experimentation and analysis of results.

One of the reactions you will be examining is the iodine-clock reaction. This particular reaction has a color change which is sharp and dependable, hence its name. There are many variations of this reaction. The one examine in this experiment involves the reaction of the iodate ion with the sulfite ion:

$$IO_3^- + 3\,SO_3^{2-} \rightarrow I^- + 3\,SO_4^{2-}$$

The iodate ion is present in excess, so after all of the sulfite has reacted, the excess iodate reacts with the iodide now present to form iodine:

$$IO_3^- + 5\,I^- + 6\,H^+ \rightarrow 3\,I_2 + 3\,H_2O$$

A small amount of starch (used as an indicator for iodine) has been added to the sulfite solution, so once the iodine forms, a bluish-black color will be present in the solution.

As mentioned before, an attempt will be made to determine experimentally how certain factors affect the reaction rate. The concentration and temperature will be varied in order to observe the effect of these changes. Upon graphing the results, it should be possible to predict the time for a new set of conditions. It should also be possible to predict a set of conditions that will yield a given time.

Please read the instructions carefully for this experiment. If you are well organized and have read ahead, you should save a considerable amount of time. Each measurement is fairly short and there will be time to repeat if you make mistakes. Good luck...........

PROCEDURE

SAFETY GOGGLES MUST BE WORN AT ALL TIMES DURING THIS EXPERIMENT!

Part 1

Prepare a data table to record your observations for Part 1. Using a clock or watch, measure the amount of time it takes for the following mixtures to start reacting. Measure the time, starting at the instant the reactants come into contact with each other. In some cases, the reaction may be immediate (<1 sec), and in other cases, the reaction may take more than a minute. If the reaction appears to take more than a minute, set the test tube aside and observe periodically until the reaction appears complete. Measure times to the nearest second. Each of the reactions may be carried out in a small test tube. The volumes here are approximate (a pinkie-width in a small test tube is about 1 mL). In your data table, also record the relative rates of these reactions (*e.g.* slow, intermediate, or fast).

1. 1 mL of 0.1 M $CaCl_2$ and 1 mL of 0.1 M Na_2CO_3 .

2. 1 mL of 0.1 M HCl and a tiny piece of Mg.

3. 1 mL of solution A and 1 mL of solution B.

Part 2

It is important in this part of the experiment that all glassware is clean and that the solutions do not become contaminated before mixing. The reactions will be carried out in a 100 mL beaker, hereafter called the reaction vessel. Obtain two 10 mL graduated cylinders, labeling one "A" and the other "B".

1. Measure 10.0 mL of solution A into graduated cylinder A and 10.0 mL of solution B into graduated cylinder B. Prepare to make a time measurement.

2. Pour the contents of the two cylinders into the reaction vessel. Gently stir. Measure and record the reaction time. Also record the temperature of the mixture.

3. Empty the reaction vessel, rinse it with deionized water, and allow it to dry.

4. Repeat steps 1-3 and average your results.

5. Measure 10.0 mL of solution B into graduated cylinder B and pour into the reaction vessel. Measure 8.0 mL of solution A into graduated cylinder A and dilute by adding 2.0 mL of deionized water, bringing the total volume to 10.0 mL. Pour the contents into the reaction vessel and gently stir. Record the reaction time. Also record the temperature of the mixture. Repeat this step and average your results. Rinse and dry the reaction vessel.

6. Repeat step 5, using 6.0 mL of solution A diluted with 4.0 mL of deionized water.

7. Repeat step 5, using 4.0 mL of solution A diluted with 6.0 mL of deionized water.

   Do not put your materials away yet, as you will need these items to perform a few more experiments in your postlab questions.

Remember to put all waste in the designated containers.

Name______________________________________ Lab Section_____________

PRELAB QUESTIONS

1. Name *four* factors that affect the rate of a chemical reaction.

2. Give at least two everyday examples from *your* experience of chemical reactions that are fast. Give at least two examples of slow reactions.

3. What is the difference between reaction *rate* and reaction *time*? If the reaction *rate* increases, what happens to the reaction *time*?

4. State a hypothesis as to how you believe temperature and concentration affect the reaction *rate*.

5. In order to save time while performing the experiment, make a list of the equipment you will use for Part 2.

6. Which safety precautions must be observed during this experiment?

Name______________________________________ Lab Section_____________

Partner's Name________________________________

DATA

Part 1

Part 2

Mixture	Sol'n A (mL)	Water (mL)	Sol'n B (mL)	Total (mL)	Time 1 (sec)	Time 2 (sec)	Avg Time (sec)	Temp (°C)
1	10.0	0	10.0	20.0				
2	8.0	2.0	10.0	20.0				
3	6.0	4.0	10.0	20.0				
4	4.0	6.0	10.0	20.0				

Name______________________________________ Lab Section_____________

Partner's Name______________________________

POSTLAB QUESTIONS

1. Using the supplied graph paper or Microsoft Excel, prepare a graph in which you plot the average reaction time vs. the volume of solution A (which is related to the overall concentration of solution A in the mixture). Label the axes and draw a best-fit line or curve. Remember which variable belongs on each axis. Draw a best fit curve for your data.

2. Examine your data and the graph you have just prepared. What happens to the reaction *time* as the concentration of solution A increases? What happens to the reaction *rate* as the concentration of solution A increases? Explain, using collision theory.

3. a) Using your graph, determine the volume of solution A which should be used to yield a reaction time of 60 seconds. Draw dotted lines on your graph to show how you got your answer. How much deionized water and solution B should be mixed with it, in order to be consistent with the procedure used in Part 2 of this experiment?

   b) Prepare a mixture using the volumes given in your answer to question 3a. Measure and record the reaction *time* below. Repeat the trial, using the same volumes of each solution. How close were you to 60 seconds? Explain any variation.

4. a) How do you predict an increase or decrease in temperature will affect the reaction *time*?

   b) What was the reaction *time* when 10.0 mL of solution A was mixed with 10.0 mL of solution B? Using an ice water bath or a hot water bath, warm or cool 10.0 mL each of solutions A and B by about 10 °C, and then react the solutions together.

   c) At which temperature did you perform the reaction? What was the reaction *time* you obtained at the new temperature? Did the reaction *time* increase or decrease compared to the room temperature reaction? Was your prediction right? Did the reaction *rate* increase or decrease?