Chemical Kinetics

Factors Affecting Reaction Rate

OVERVIEW

Chemical reactions occur at different rates. In this experiment you will consider some of the key factors that influence the rate of a reaction:

- nature of reactants - particle size
- temperature
- concentration
- catalysts

According to the collision theory, the rate of a reaction depends on the frequency of collisions between reacting particles. The more frequent the collisions, the faster the rate of the reaction. However, in order for the collisions to be effective, the particles must collide with sufficient energy (activation energy). Furthermore, the particles must collide with the proper orientation.

The factors that will be examined in this lab influence reaction rate by either increasing how often collisions occur or by making collisions more effective.

PURPOSE

- To examine factors that increase reaction rate

SAFETY

- Portions of this lab may only be carried out under the supervision of a teacher
- Safety goggles must be worn when working with acids.

EQUIPMENT AND MATERIALS

Part 1. Effect of Particle Size

- solid zinc, approx. 0.5 cm × 2 cm, or solid marble chips
- zinc powder or calcium carbonate powder
- balance
- 2 test tubes
- 1M HCl (approx 10 mL per group)

Part 2. Effect of Temperature

- 3 Alka Seltzer tablets
- 3 250-mL beakers
- water at three temperatures – with ice, room temperature, warm (around 70°C)

Part 3. Effect of Concentration

- 1M HCl, 5 mL per group
- 3M HCl, 5 mL per group
- 6M HCl, 5 mL per group
- 3 pieces of zinc metal, each approx 1 cm × 1 cm
- 3 test tubes

Part 4. Effect of a Catalyst

- 3% hydrogen peroxide, H_2O_2 – 10 mL per group
- 0.1 M iron(III) nitrate, $Fe(NO_3)_3$
- 0.1 M sodium chloride, NaCl
- 0.1 M calcium chloride, $CaCl_2$
- 0.1 M potassium nitrate, KNO_3
- 0.1 M manganese chloride, $MnCl_2$
- 100-mL graduated cylinder
- 10-mL graduated cylinder
- 7 test tubes per group

PROCEDURES

Part 1. Effect of Particle Size on Reaction Rate

Powdered calcium carbonate and marble chips may be used instead of zinc

$$Zn + 2\ HCl \rightarrow ZnCl_2 + H_2$$

$$CaCO_3 + HCl \rightarrow CaCl_2 + H_2CO_3$$

1. Obtain a piece of solid zinc metal, approximately 0.5 cm × 2 cm. Find the mass of this sample, and place it in a test tube.

2. Using the balance obtain a sample of powered zinc that is close to the mass of your piece of solid zinc. Place this sample in the second test tube. *Caution: powdered zinc is flammable*.

3. Place both test tubes in a test tube rack. Add 5 mL of 1M HCl to both test tubes. Be sure to wear your safety goggles.

4. Observe both test tubes and record your observations and record your observations in the data table.

Part 2. Effect of Temperature

1. Half fill three 250-mL beaker with water. In one beaker add several ice cubes. A second beaker will contain water at room temperature. In the third beaker add water that has been heated to about 70°C.

2. Record the water temperature in the three beakers, then add an Alka Seltzer tablet to each.

3. Record the time it takes for the Alka Seltzer tablet to completely dissolve.

Part 3. Effect of Concentration

$$Zn + 2\ HCl \rightarrow ZnCl_2 + H_2$$

1. Pour 5 mL of each of the three HCl solutions into separate test tubes. Place the test tubes in a test tube rack.

2. Add one piece of zinc to each test tube.

3. Record the time you added the zinc to the tubes, and the time each reaction stops. Also record your observations for each tube.

Part 4. Effect of a Catalyst

In this part of the lab you will determine which substance/substances act as a catalyst for the decomposition of hydrogen peroxide.

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

1. Dilute the hydrogen peroxide by adding 10 mL of 3% H_2O_2 to a 100-mL graduated cylinder. Add 90 mL of distilled water to obtain 100 mL of diluted (0.3%) hydrogen peroxide.

2. Use a small amount of this solution to rinse out a 10-mL graduated cylinder and 7 test tubes. Pour the rinses away.

3. Place 5-mL of the 0.3% H_2O_2 solution into each of the 7 test tubes.

4. Add 5 drops of each of the following solutions to separate test tubes:

0.1 M $FeCl_3$	0.1 M NaCl
0.1 M $Fe(NO_3)_3$	0.1 M $CaCl_2$
0.1 M KNO_3	0.1 M $MnCl_2$

5. Mix each tube by swirling the test tube or gently stirring with a clean stirring rod.

6. Observe each solution, noting the production of any gas bubbles that form. Record each reaction rate as **fast, slow, very slow,** or **none** in your data table.

RESULTS

Record your results for each part of the lab in the data tables provided on the following page.

CONCLUSIONS

For each part of this lab present your results and conclusions in formal lab report format. A paragraph will be sufficient for each of the four parts to this lab.

In clearly worded and complete sentences describe what reactions were carried out and present your observations findings. When possible include the chemical equation involved. Refer the reader to the appropriate data table (for example – "See Table 1."). Use the collision theory to explain your findings.

RESULTS

Table 1. Effect of Particle Size on Reaction Rate

Substance Tested	Observations
powdered zinc or calcium carbonate	
solid zinc or marble chips	

Table 2. Effect of Temperature

Water Condition	Water Temperature (°C)	Time to Completion
cold		
room temperature		
warm		

Table 3. Effect of Concentration

Acid Concentration	Start Time	Time at Completion	Observations
1 M HCl			
3 M HCl			
6 M HCl			

Table 4. Effect of a Catalyst

	Possible Catalysts					
	$FeCl_3$	NaCl	$Fe(NO_3)_3$	$CaCl_2$	KNO_3	$MnCl_2$
Reaction Rate						