***Demonstration 4***

***Chemical Kinetics***

***OBJECTIVES***

The objectives of this experiment are: (a) to observe the effect of concentration on the rate of chemical reaction, (b) to observe the effect of temperature on the rate of chemical reaction.

***INTRODUCTION***

Chemical kinetics is the study of the rate (speed) of chemical reactions, factors affecting reaction rates, and the mechanism of reactions. The rate of reaction is defined as how fast or how slow a reaction occurs. For example, the formation of rust is considered a slow reaction (low rate) as it occurs over a long period of time measured in days or months. Nuclear decay takes place over periods of millions and billions of years for some isotopes. On the other hand, combustion reactions are fast reactions (high rate), like combustion of hydrogen in air. Advanced technology available these days enables scientists to study changes that occur at rates measured in nano-seconds (10-9 second) and femto-seconds (10-15 second). The rate of a chemical reaction is expressed as the change in the concentration of the reactants per unit time:

A 🡪 B …………………..…………………….. (1)

 ………………………………………… (2)

The following are the factors that influence the rate of chemical reactions:

1. The nature of the reactants.
2. The concentration of the reactants. Higher concentration allows more collisions between the molecules, which will result in a higher probability of effective collisions. *(The instructor will explain the meaning of effective collision)*
3. The temperature at which the reaction occurs. Higher temperature increases the chance of effective collisions, therefore making the reaction faster.
4. The surface area of the reactants. This factor concerning reactants in the solid phase. Reactions occur faster if a solid reactant is ground up into a powder.
5. The use of a catalyst. Catalysts speed up reactions without being transformed. *(Instructor might remind students of the catalyst they used to prepare oxygen from hydrogen peroxide, Exp. 4)*.

In this demonstration, the effects of temperature, concentration of reactants, and surface area of a solid reactant upon the rate of a reaction will be illustrated by recording the time elapsed to change the reactants’ color. The rate of the reaction is **inversely** proportional to elapsed time. Therefore; the longer the recorded time, the smaller is the rate of the reaction, i.e. the reaction is slower and vice versa.

EXPERIMENTAL PROCEDURE

1. ***The Effect of Concentration on Reaction Rate:***

The reaction to be examined is that of a green coordination complex with the hydroxide ion (OH-) to form a red coordination complex and chloride ion (Cl-). *(this coordination complex was prepared by chemistry students at SUU according to reported procedures).*

[Co(en)2Cl2]+ + OH- → [Co(en)2(OH)Cl]+ + Cl- …………… (3)

green red

The instructor will show you the reactant complex.

*Question 1: What are its physical properties?*

***Green crystalline solid that is water soluble. (1pnt)***

The instructor has two solutions with different concentrations of the hydroxide ion: 0.10 M and 10-4 M, (1,000 times less concentrated than the first solution). The instructor will dissolve about 100 mg of the reactant complex in about 20 mL of distilled water. Then the instructor will mix about 4 mL of the resultant green complex solution with about 2 mL of 0.1 M hydroxide solution and record in the table below the time elapsed before the red color of the product appears. The procedure will be repeated using the 10-4 M hydroxide solution.

**Table 1:** Concentration Effect.

|  |  |  |
| --- | --- | --- |
| Concentration of OH- | 0.1 M | 10-4 M |
| Time | ***instantaneously*** | ***Longer than 5 min*** |

*Question 2:*  *What can you say about the dependence of the rate of reaction upon the concentration of hydroxide?*

***The higher the reactant concentration, the faster the rate. (2pnt)***

1. ***The Effect of Temperature on Reaction Rate:***

The instructor has two samples of the dilute hydroxide solution used above (10-4 M): and places one in ice and the other one in boiling water. About 4 mL of the reacting complex is added to each of the two samples and the time of the reaction is recorded in Table 2.

**Table 2:**  Temperature Effect.

|  |  |  |  |
| --- | --- | --- | --- |
| Temperature | Ice | Room Temp.  *Same as part 1* | Boiling water |
| Time | ***Longer than 5 min*** | ***~ 5 min*** | ***instantaneously*** |

*Question 1: What is the effect of temperature upon the rate of reaction?*

***The higher the temperature, the faster the rate. (2pnt)***

*Question 2:*  *What is the reason food is kept in refrigerators in the store and your home?*

***Lower temperature extends the lifespan of food by slowing down the biochemical reactions that spoil food. (3pnt)***

*Question 3:*  *Do you recommend storing medication in the fridge or on the pantry shelf? Why?*

***In the fridge, because high temperature might cause damage to the active ingredients of medication. (3pnt)***

1. ***The Effect of Surface Area on Reaction Rate:***

Measure ~0.50 g of zinc mesh-shot and the same amount of mesh-powder (granular) and place them in two separate large test tubes. To each test tube, add 10 mL of 6 M hydrochloric acid.

*Question 1: Record your observations.*

***Both samples react with hydrochloric acid and produce bubbles of hydrogen gas. The mesh-powder zinc reacts more vigorously (faster) as evidenced by the bubbling rate in the solution. (3pnt)***

*Question 2: What is the effect of surface area upon the rate of reaction?*

***The larger the surface area of the reactant, the faster the reaction. (2pnt)***

*Question 3: What gas is produced in the reaction? Is it combustible?*

***Hydrogen gas and it is combustible. (2pnt)***

*Question 4: Write a chemical equation for the reaction that occurred.*

***Zn + 2HCl 🡪 H2 + ZnCl2 (2pnt)***