2 Chemical Kinetics: The Rate of Reaction

Version: February 9, 2004

- **Measure the effect of concentration and temperature on the rate of decomposition of hydrogen peroxide with iodide as a catalyst.**
- **Calculate the rate law for the decomposition of hydrogen peroxide with iodide acting as a catalyst.**

DISCUSSION

In this experiment, you will add catalytic amounts of potassium iodide to a hydrogen peroxide solution, and you will measure the rate of decomposition of the hydrogen peroxide. It decomposes into oxygen and hydrogen.

$$2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$$

The rate of this reaction is normally very slow, but with the iodide catalyst present, the rate is increased significantly. As you can see, the iodide ion is not found in the overall chemical equation; however, it may be part of the rate law. Thus you need to determine the exponents *x* and *y* in the rate law:

$$rate = k\,[H_2O_2]^x[I^-]^y$$

The Effect of Concentration on the Rate

In the first part of the experiment, you will make three different mixtures of hydrogen peroxide, potassium iodide, and distilled water. In each mixture, the total volume will be 80 mL.

You will double the concentration of the hydrogen peroxide in the second mixture while holding the iodide concentration constant. In the third, you will double the concentration of iodide while keeping the hydrogen peroxide the same.

You will then measure the rate of reaction under these three different sets of concentrations at room temperature. In this way you will determine the effect of concentration of both chemicals on the rate of reaction.

The Effect of Temperature

In the next step, you will pick one set of concentrations and measure the reaction rate at a temperature ten degrees above room temperature and ten degrees below. You will then be able to compare the rates at three different temperatures.

PROCEDURE

A. The Effect of Concentration on the Rate

1. Find a partner to work with, and obtain an apparatus like the one pictured on the following page. Be sure there is enough water to fill the buret and part of the leveling bulb. Test the apparatus for leaks by stoppering the flask and moving the leveling bulb up and down. If the system is intact, the water level in the buret will change slightly but will not be the same as the water level in the leveling bulb.

2. Fill the water bath pan 5-10 centimeters deep with water at room temperature (about 22 ° C). Keep it at this temperature for all three mixtures. Place the flask in the water bath so that it is ready to start the reaction.

Mixture	#1	#2	#3
0.88 *M* H_2O_2	15.0 mL	30.0 mL	15.0 mL
0.10 M KI	20.0 mL	20.0 mL	40.0 mL
Water	45.0 mL	30.0 mL	25.0 mL

3. For *each* of the three mixtures above, do the following steps:

a. Measure out the amount of distilled water for the mixture, and add it to the flask that is used with the apparatus. Measure out the hydrogen peroxide solution, and add it to the distilled water. Rinse the graduated cylinder, and measure out the potassium iodide (but do not add it to the flask yet).

b. One student should hold the leveling bulb above the zero mark on the buret while the other student should add the potassium iodide solution to the flask and then quickly place the stopper that is connected to the rubber tubing into the flask.

c. The student who is holding the leveling bulb should move it to keep water level in the bulb even with that inside the buret. This student should signal the other student to start timing when the level reaches the zero point of the buret or just below. (It is not necessary to start right on zero, but be sure to record the volume that you do start on.)

d. The second student should continuously swirl the flask in the water bath and record the volume of oxygen at each half minute interval. Continue taking readings for ten minutes or until 25 mL has been produced.

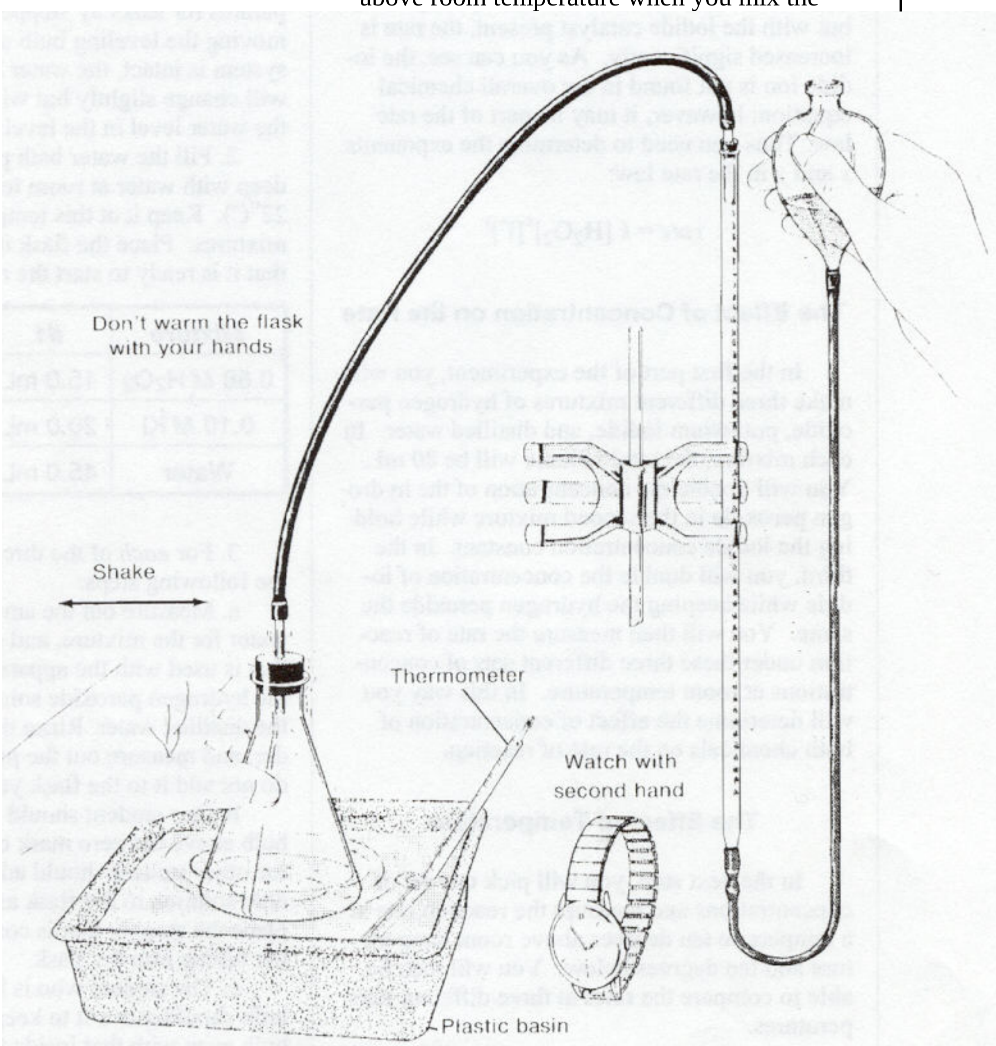
B. The effect of Temperature on the Rate

4. In this part of the experiment, repeat the procedure with mixture #1 at about 10 ˚C above room temperature. Start by replacing the water in the water bath with warm water (about 32 ˚ C). Before doing step 3, place all the solutions in the water bath for about five minutes so that everything will be ten degrees above room temperature when you mix the solutions. Check the temperature periodically, and add hot water as needed to keep the temperature constant.

5. Repeat the procedure with mixture #1 at about 20 ˚C above room temperature. Replace the water in the water bath with the hottest water possible from the tap (about 45 ˚C). Before doing step 3, place all the solutions in the water bath for about five minutes so that everything will be as hot as possible when you mix the solutions.

6. Determine the reaction rate for each run.

7. Calculate the exponents, *x* and *y*, for the rate law expression, and calculate the rate constant, *k*.



2 Chemical Kinetics:

Name ______________________________
Section __________________Locker ____
Instructor ___________________________

Data on the Rate of Oxygen Production (volume of gas in *m*L)

Time (minutes)	**Mix #1** ^oC	**Mix #2** ^oC	**Mix #3** ^oC	**Mix #1 (warm)** ^oC	**Mix #1 (hot)** ^oC
0.0					
0.5					
1.0					
1.5					
2.0					
2.5					
3.0					
3.5					
4.0					
4.5					
5.0					
5.5					
6.0					
6.5					
7.0					
7.5					
8.0					
8.5					
9.0					
9.5					
10.0					

Rate Data

Calculate the molarity of the (diluted hydrogen peroxide in each mixture. Do the same for the iodide ion. Record the reaction rate (from the computer) for each mixture.

	$[H_2O_2]$ (*mol/L* of sol'n)	$[I^-]$ (*mol/L* of sol'n)	Rate (*mL* of gas/min)
Mix #1			
Mix #2			
Mix #3			
Mix #1 (warm)			
Mix #1 (cold)			

From the room temperature data, determine the exponents, *x* and *y*, in the rate law expression, *Rate* = $k[H_2O_2]^x[I^-]^y$. Round them to the nearest whole number exponents. Show your work.

Determine the rate constant, *k*, at room temperature, in the rate law expression. Include the proper units. Average the three trials at room temperature. Show your work.

As a rule of thumb, a ten degree increase in temperature will double the reaction rate. Do your data support this rule? Comment on how your findings relate to changes in temperature.

APPLICATION OF PRINCIPLES

1. According to the rate law you must determined, what would be the rate of oxygen production at room temperature of 20.0 *mL* of 0.88 *M* H_2O_2 was mixed with 30.0 *mL* of 0.10 *M* I^- and 30.0 *mL* of distilled water? Show your work.

2. Calculate k for mixture 1 (warm) and mixture 2 (hot).

3. Determine Ea for the reaction by obtaining the slope of a plot of *ln* k versus 1/T.

mixture	k	T	*ln k*	1/T
1				
1 (warm)				
1 (hot)				

4. Propose a mechanism.