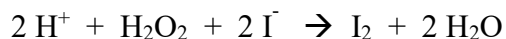


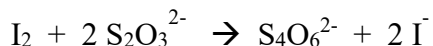
## Kinetics: Concentration Effect

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The purpose of this experiment is to investigate the kinetics of the reaction:



The concentration of  $\text{H}^+$  ion is held constant by using a buffer. Thus the  $[\text{H}^+]$  term will not be included in the rate law, or in determining the rate constant. The rate of this reaction is measured by using the so-called "clock reaction":



The clock reaction proceeds much faster than the reaction being studied, removing the  $\text{I}_2$  as fast as it is produced. The  $\text{S}_2\text{O}_3^{2-}$ , present in a known amount, must be consumed before any free  $\text{I}_2$  persists. The eventual presence of free  $\text{I}_2$  is detected by its reaction with the starch indicator to form a deep blue complex. Therefore the initial rate of the reaction can be determined by timing the appearance of the starch- $\text{I}_2$  complex ( $\Delta t$ ) and calculating the amount of hydrogen peroxide consumed during that time.

$$\text{Rate} = -\Delta[\text{H}_2\text{O}_2] / \Delta t$$

Note that 1 mole of  $\text{H}_2\text{O}_2$  reacts with 2 moles of  $\text{I}^-$  to produce 1 mole of  $\text{I}_2$  which reacts with 2 moles of  $\text{S}_2\text{O}_3^{2-}$ . It is necessary to consider this stoichiometry to calculate the amount of  $\text{H}_2\text{O}_2$  that reacted before the  $\text{S}_2\text{O}_3^{2-}$  ran out (and the deep blue color appeared).

To determine the order of the reaction for a target reactant, a series of reactions are run in which the concentration of only that reactant is varied. Then the rate law is:

$$\text{Rate} = k'[\text{A}]^n$$

where  $k'$  includes all other reactants,  $[\text{A}]$  is the concentration of the reactant which is being varied, and  $n$  is the reaction order with respect to reactant A. Taking the logarithm of this expression gives:

$$\ln(\text{Rate}) = \ln(k') + n \ln[\text{A}]$$

A graph of  $\ln(\text{Rate})$  vs  $\ln[\text{A}]$  is expected to be a straight line which has a slope equal to the reaction order.

### Procedure:

Work with a partner. Each pair should obtain from the designated point in the lab: 5 mL pipet, pipet pump, and rack.

1. First the effect of the concentration of the  $\text{I}^-$  will be investigated. Label your four 250 mL Erlenmeyer flasks. Use the graduated cylinder to measure the deionized water indicated in the table below – add the water directly to the 250 mL Erlenmeyer flask. Pipet 5.0 mL of the  $\text{Na}_2\text{S}_2\text{O}_3$  (0.020 M) into the Erlenmeyer flask, followed by the appropriate amounts (indicated in the table below) of buffer, KI and starch directly from the bottle-top dispensers into your labeled Erlenmeyer flasks.

All volumes are in mL:

Flask	H <sub>2</sub> O (deionized)	Buffer	KI (0.30 M)	Starch	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> (0.020 M)
1	129	6	2	2	5
2	127	6	4	2	5
3	123	6	8	2	5
4	115	6	16	2	5

Obtain about 125 mL (and only 125 mL) of the H<sub>2</sub>O<sub>2</sub> solution in a clean *dry* 150 mL beaker. Record the exact concentration of the H<sub>2</sub>O<sub>2</sub>. Use your graduated cylinder to measure 6.0 mL of the H<sub>2</sub>O<sub>2</sub> into each of four small test tubes. The timing of the reaction begins with the addition of the H<sub>2</sub>O<sub>2</sub>. The H<sub>2</sub>O<sub>2</sub> should be added quickly (one H<sub>2</sub>O<sub>2</sub> test tube per flask) and the contents of the flask mixed well. Start all four flasks at about the same time and measure the time required for each flask to turn blue.

2. Now the effect of the concentration of the H<sub>2</sub>O<sub>2</sub> will be investigated. Rinse your four 250 mL Erlenmeyer flasks thoroughly. Use the graduated cylinder to measure the deionized water indicated in the table below – add the water directly to the 250 mL Erlenmeyer flask. Pipet 5.0 mL of the Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> into the Erlenmeyer flask, followed by the appropriate amounts (indicated in the table below) of buffer, KI and starch directly from the bottle-top dispensers into your labeled Erlenmeyer flasks. Again, all volumes are in mL:

Flask	H <sub>2</sub> O (deionized)	Buffer	KI (0.30 M)	Starch	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> (0.020 M)
1	128	6	6	2	5
2	125	6	6	2	5
3	119	6	6	2	5
4	107	6	6	2	5

This time the amount of H<sub>2</sub>O<sub>2</sub> varies as follows (note that the total volume will be the same for all):

- Flask 1: 3.0 mL H<sub>2</sub>O<sub>2</sub>
- Flask 2: 6.0 mL H<sub>2</sub>O<sub>2</sub>
- Flask 3: 12.0 mL H<sub>2</sub>O<sub>2</sub>
- Flask 4: 24.0 mL H<sub>2</sub>O<sub>2</sub>

Use your graduated cylinder to measure the required amounts of peroxide. As before, measure the time required for the flasks to turn blue.

After completing the procedure but before leaving lab, write in your notebook a brief statement (two to three sentences) on the quality and reasonableness of the data you collected. Note what you might do differently if you performed the lab again.

3. Perform the necessary calculations and draw the required graphs to determine the order of the reaction with respect to peroxide, the order with respect to iodide, and the rate constant (just k, not k') for each trial:

$$\text{Rate} = k[\text{I}^-]^a[\text{H}_2\text{O}_2]^b$$