Rates of Reaction

Background

- **Kinetics is the study of reaction rates.**

  Rate is how *fast* a reaction occurs, the change in concentration per change in time.

  Rate = (–) ∆[Reactant] / ∆*time*

- **Rate constant equation or Rate Law shows the relationship between the rate and the concentrations of the reactants (A and B) in the slowest or rate-determining step.**

  Rate = k $[A]^{m}[B]^{n}$
  (k = rate constant; *m* and *n* are reaction orders)

  Reaction orders are generally small positive whole numbers.
  They are NOT the stoichiometric coefficients from the balanced equation.

  Overall reaction order is the sum of *m* and *n*.

Experiment

- **In this experiment, the sodium thiosulfate, $Na_2S_2O_3$, is the limiting reagent. The diluted $M_{Na_2S_2O_3}$ will be used in calculating the *Rate*.**

  The Rate Determining Step or slowest step is dependent on the concentrations of the other reactants: ammonium peroxydisulfate, $(NH_4)_2S_2O_8$, and potassium iodide, KI.

- **Add the chemicals as listed (from left to right) in Table 1. Record $time_{initial}$ as when you add the last chemical, $(NH_4)_2S_2O_8$.**

- **Swirl flask constantly !!**
  THIS COLOR CHANGE IS QUICK from colorless to dark blue.
  Record $time_{final}$ as when the blue color first appears in the solution.

Calculations

- **TIME CALCULATIONS:**
  Convert all times into seconds.
  $\Delta time = time_{Final} - time_{Initial}$
  Average the two values of $\Delta time$ for Trials 1A & 1B. Repeat for Trials 2A & 2B and Trials 3A & 3B

- **Diluted Molarity of $Na_2S_2O_3$:**
  $(M_{Na_2S_2O_3} \times V_{Na_2S_2O_3}) / (V_{total}) =$ diluted $M_{Na_2S_2O_3}$

  (Since $V_{Na_2S_2O_3}$ and V_{total} are same in all trials, the diluted $M_{Na_2S_2O_3}$ is the same for all Trials)
- **Rate for Trials 1, 2 & 3:**
  $Rate_{Trial\ 1} =$ [diluted $M_{Na_2S_2O_3}$] / *ave.* Δ*time*$_{Trial\ \#1}$
  Repeat for Trials 2 & 3
- **Diluted M of KI and $(NH_4)_2S_2O_8$ in <u>each</u> trial.**
  <u>Ex</u>. $(M_{KI} \times V_{KI\ in\ Trial\ \#1}) / V_{total} =$ dilute $M_{KI\ in\ Trial\ \#1}$
  $M_{(NH_4)_2S_2O_8} \times V_{(NH_4)_2S_2O_8\ in\ \#1} / V_{total} =$ dil. $M_{(NH_4)_2S_2O_8\ in\ \#1}$
- **Fill in Table 2 with dilute M's and Rates**
- **To determine m, the order for $[(NH_4)_2S_2O_8]$:**
  compare Trials 1 & 3 (where M_{KI} is constant)

$$\frac{\log\left(\frac{Rate_{Trial\ \#1}}{Rate_{Trial\ \#3}}\right)}{\log\left(\frac{[(NH_4)_2S_2O_8]_{Trial\ \#1}}{[(NH_4)_2S_2O_8]_{Trial\ \#3}}\right)} = m \text{ (round to a whole \#)}$$

- **To determine n, order for [KI]:**
  compare Trials 1 & 2 ($M_{(NH_4)_2S_2O_8}$ is constant)

$$\frac{\log\left(\frac{Rate_{Trial\ \#1}}{Rate_{Trial\ \#2}}\right)}{\log\left(\frac{[KI]_{Trial\ \#1}}{[KI]_{Trial\ \#2}}\right)} = n \text{ (round to a whole \#)}$$

- **Determine the value of the <u>rate constant (k)</u>:**

  $$k = \frac{\text{Rate}}{[(NH_4)_2S_2O_8]^m\,[KI]^n}$$

  Calculate k for each trial using Molarities & Rate (from Table 2), and values of *m* and *n*.

  Average the values of k.

- **Write the <u>Rate constant expression (Rate Law)</u> Substitute in the values of k and *m* and *n* into Rate = k $[(NH_4)_2S_2O_8]^m\,[KI]^n$**