Experiment 24 – Determination of a Rate Law

Pre-Lab Hints

1. Refer to equations 24.7 and 24.8. Examine the graph to the left of equation 24.7.
   Note the axis labels and slope on this straight-line plot.
   Read the paragraph immediately below equation 24.7 also.
2. Refer to Part A, step 4. Also, read the paragraphs above and below equation 24.12.
3. a. Different trials have different amounts of deionized water in Table 24.1.
   The last sentence of step 2 in part B explains why.
   Add the volumes across each row of Table 24.1 to find the total volume for each trial.
   b. Refer to the paragraph below equation 24.3.
4. Skip.
5. Line B1. Multiply $S_2O_3^{-2}$ concentration (mol/L) times NaS_2O_3 volume (L).
   Line B2. The moles of I_3^{-1} produced are consumed by $S_2O_3^{-2}$ in equation 24.11.
   Multiply $S_2O_3^{-2}$ moles from line B1 by the stoichiometric ratio (1:2).
   Line B3. Divide moles of I_3^{-1} produced by the time.
   Line B4. Find log (base 10) of line B3.
   Line B6. Use $M_1V_1 = M_2V_2$. M_1 is given in section A.
   Convert line B5 into L for V_1. Convert 10 ml into L for V_2.
   Line B7. Find log (base 10) of line B6.
   Line B9. Use $M_1V_1 = M_2V_2$. M_1 is given in section A.
   Convert line B8 into L for V_1. Convert 10 ml into L for V_2.
   Line B10. Find log (base 10) of line B9.

Procedure Notes and Report Sheet Information

Part A. Trial 7 may require more than 10 minutes. Start this reaction first,
and do trial 1 simultaneously. Trial 8 can be skipped entirely.
Label one 10-ml graduated pipette each to transfer H_2O,
KI, and H_2O_2 from the reagent bottles to the test tubes.
Label one 1.0-ml volumetric pipette each to transfer $Na_2S_2O_3$
and the buffer from the reagent bottles to the test tubes.
Leave all of the labelled pipettes in the hood for everyone to share.
Do not use the same pipette for different solutions.

Part B. Moles of $S_2O_3^{-2}$ are determined by multiplying concentration
(mol/L) by volume (convert ml into L) from Table 24.1.
Moles of I_3^{-1} are determined from moles of $S_2O_3^{-2}$ using
the stoichiometric ratio of I_3^{-1} to $S_2O_3^{-2}$ in equation 24.11.
Concentrations of KI and H_2O_2 can be determined by multiplying concentration
(mol/L) by volume (convert to L) from Table 24.1 to get the moles, then dividing
the moles by the total combined volume (convert 10 ml into L).
Show all calculations on a separate sheet of paper.

Part C. Graph trials 1, 2, 3, and 4, in that order, for part 1. (Omit 5, 6, and 7 from graph 1.)
Graph trials 7, 1, 5, and 6, in that order for part 2. (Omit 2, 3, and 4 from graph 2.)
Use graph paper.
Make the scales for the x and y axes large enough to give a decently-sized line.
This can be done more easily if the graph does not use (0, 0) for its origin.
Also, if you change the signs on all of the log results to positive,
then the lines will both be in the upper-right quadrant of the grid.
Show calculations for p and q (slopes) as Δy / Δx (rise over run) from the graphs.
Write the rate law with the numerical p and q values on your report sheet:
Rate = $k' [I^{-1}]^p[H_2O_2]^q$

Part D. Rearrange the rate law to find k′ for all seven trials: $k' = \frac{\text{Rate}}{[I^{-1}]^p[H_2O_2]^q}$
Show calculations for k′. Skip the standard deviations.

Part E. Skip entire section.

Lab Questions

1. Carefully add equations 24.2 and 24.11 together. What happens to I^{-1} and I_3^{-1}?
   What should happen to their concentrations while $S_2O_3^{-2}$ is present?
   Inspect equations 24.2 and 24.11 again.
   What will happen to the concentration of I_3^{-1} when $S_2O_3^{-2}$ is gone?

2. When would the solution turn blue if $S_2O_3^{-2}$ was never added to the solution?
   When would the solution turn blue if starch was never added to the solution?
   Explain your answers.

3. Subtract equation 24.7 from equation 24.6. What is “C” equal to?
   Compare equations 24.4 and 24.5. What is “c” equal to?

4. Review your answers for questions 1 and 2. What would happen to the reaction time (when it turns blue) if the $S_2O_3^{-2}$ concentration was higher?
   Next, inspect your rate law. What affect does $S_2O_3^{-2}$ concentration have on the reaction rate? Explain your answers.

5. Suppose the experiment was set up with known higher concentrations of both KI and H_2O_2. Consider what a rate law means.
   What should happen to the values found for p, q, and k′?
   Explain your answer.