The Rate and Order of a Chemical Reaction

A basic kinetic study of a chemical reaction often involves conducting the reaction at varying concentrations of reactants. In this way, you can determine the order of the reaction in each species, and determine a rate law expression. Once you select a reaction to examine, you must decide how to follow the reaction by measuring some parameter that changes regularly as time passes, such as temperature, pH, pressure, conductance, or absorbance of light.

In this experiment you will conduct the reaction between solutions of potassium iodide and iron (III) chloride. The reaction equation is shown below, in ionic form.

$$2\ I^-\ (aq) + 2\ Fe^{3+}\ (aq) \rightarrow I_2\ (aq) + 2\ Fe^{2+}\ (aq)$$

As this reaction proceeds, it undergoes a color change that can be precisely measured by a Colorimeter (see Figure 1). By carefully varying the concentrations of the reactants, you will determine the effect each reactant has on the rate of the reaction, and consequently the order of the reaction. From this information, you will write a rate law expression for the reaction.

OBJECTIVES

In this experiment, you will

- Conduct the reaction of KI and $FeCl_3$ using various concentrations of reactants.
- Determine the order of the reaction in KI and $FeCl_3$.
- Determine the rate law expression for the reaction.

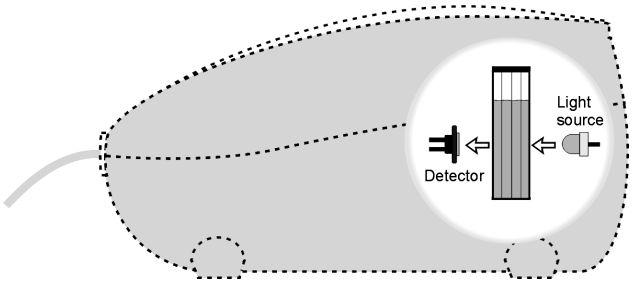

Figure 1

MATERIALS

LabQuest
LabQuest App
Vernier Colorimeter
two 100 mL beakers
plastic cuvettes
five plastic Beral pipets
0.020 M potassium iodide, KI, solution
0.020 M iron (III) chloride, $FeCl_3$, solution, in 0.10 M HCl
distilled water
three 25 mL graduated cylinders

PROCEDURE

1. Obtain and wear goggles.

2. Connect the Colorimeter to LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.

3. Calibrate the Colorimeter.

   a. Prepare a *blank* by filling an empty cuvette 3/4 full with distilled water.
   b. Place the blank in the cuvette slot of the Colorimeter and close the lid.
   c. Press the < or > buttons on the Colorimeter to set the wavelength to 470 nm (Blue). Then calibrate by pressing the CAL button on the Colorimeter. When the LED stops flashing, the calibration is complete.

4. Change the data-collection rate to 0.1 samples/second and the length to 120 seconds.

5. Obtain the materials you will need to conduct this experiment.

   - Three 25 mL graduated cylinders.
   - Approximately 100 mL of 0.020 M KI solution in a 100 mL beaker.
   - Approximately 100 mL of 0.020 M $FeCl_3$ solution in a separate 100 mL beaker. **CAUTION:** *The $FeCl_3$ solution in this experiment is prepared in 0.1 M HCl and should be handled with care.*
   - Approximately 60 mL of distilled water in a third 100 mL beaker.

6. During this experiment you will conduct 5 trials. This step describes the process for conducting the trials using the Trial 1 volumes. When you repeat this process, use the correct volume for each trial based on the table below.

Trial	$FeCl_3$ (mL)	KI (mL)	H_2O (mL)
1	20.0	20.0	0.0
2	20.0	10.0	10.0
3	10.0	20.0	10.0
4	15.0	10.0	15.0
5	10.0	15.0	15.0

   d. Measure 20.0 mL of $FeCl_3$ solution into a 100 mL beaker.
   e. Measure 20.0 mL of KI solution into a second 100 mL beaker.
   f. Remove the cuvette from the Colorimeter and pour out the distilled water.
   g. Add the 20.0 mL of $FeCl_3$ solution to the beaker of KI solution. Swirl the beaker to mix.
   h. Rinse the cuvette twice with ~1 mL amounts and then fill it 3/4 full. Wipe the outside of the cuvette with a tissue, place it in the Colorimeter, and close the lid.

7. Start data collection. Data will be gathered for 2 minutes. Observe the progress of the reaction in the beaker.

8. When the data collection is complete, carefully remove the cuvette from the Colorimeter. Dispose of the contents of the beaker and cuvette as directed. Rinse and clean the beakers and the cuvette for the next trial.

9. Determine the initial rate of the reaction. Examine the graph and locate a ~30 second section that is linear and represents the entire graph (for example, time 20 seconds to time 55 seconds).
   i. Identify a linear region of the graph. Select the data point at the beginning of the linear region and drag across 30–40 seconds of data to select the region.
   j. Choose Curve Fit from the Analyze menu.
   k. Select Linear as the Fit Equation.
   l. Record the slope, in your data table, as the initial rate for the reaction and select OK.
10. Repeat Steps 6–9 to conduct Trials 2–5. When you complete Step 9, use the same 30–40 second region to analyze Trials 2–5 that you used to analyze Trial 1. **Note:** You will skip Step 6c in Trials 2–5.

DATA TABLE

Trial	[$FeCl_3$]	[KI]	Initial rate (s^{-1})
1			
2			
3			
4			
5			

DATA ANALYSIS

1. Calculate the molar concentration of $FeCl_3$ and KI for each reaction and record the values in the table above. Provide one example to show how you completed the calculation.

2. What is the order of the reaction in $FeCl_3$ and KI? Explain.

3. Write the rate law expression for the reaction.

4. Is it possible to calculate the rate constant, *k*, from your data? If so, calculate the rate constant. If not, explain why not.