**The Rate and Order of a Chemical Reaction**

**lab adv comp 25**

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**INTRODUCTION**

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 Fe3+ (aq) → I2 (aq) + 2 Fe2+ (aq)

As this reaction proceeds, it undergoes a color change that can be precisely measured. 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 FeCl3 using various concentrations of reactants.

Determine the order of the reaction in KI and FeCl3.

1. Determine the rate law expression for the reaction.

MATERIALS

LabQuest five plastic Beral pipets

LabQuest App plastic cuvettes

Vernier Colorimeter or Spectrometer 0.020 M Potassium iodide solution

three 250 mL beakers 0.020 M iron (III) chloride solution

two 100 mL beakers in 0.10 M HCl

three 25 mL graduated cylinders distilled water

PROCEDURE

Both Colorimeter and Spectrometer Users

1. Obtain and wear goggles.
2. Obtain the materials you will need to conduct this experiment.

* Three 25 mL graduated cylinders
* Three 100 mL beakers
* Approximately 100 mL of 0.020 M KI solution in a 250 mL beaker *Potassium iodide, 0.5 M,* KI: *This chemical is considered nonhazardous according to GHS classifications. Treat all laboratory chemicals with caution. Prudent laboratory practices should be observed.*
* Approximately 100 mL of 0.020 M FeCl3 solution in a separate 250 mL beaker **DANGER:** *Iron (III) chloride hexahydrate,* Fe(III)Cl3: *Causes severe skin and eye burns and damage. Harmful if swallowed or inhaled. Do not eat or drink when using this product. Do not breathe mist, vapors or spray.*
* Approximately 60 mL of distilled water in a third 250 mL beaker.

1. Prepare a *blank* by filling a cuvette ¾ full with distilled water. To correctly use cuvettes, remember:
   * Wipe outside of each cuvette with a lint-free tissue.
   * Handle cuvettes only by the top edge of the ribbed sides.
   * Dislodge any bubbles by gently tapping the cuvette on a hard surface.
   * Always position the cuvette so the light passes through the clear sides.

**Spectrometer Users Only (Colorimeter users proceed to the Colorimeter section)**

1. Connect a V-Spec to the LabQuest and choose New from the File Menu.
2. Calibrate the Spectrometer.
3. Place the blank cuvette in the Spectrometer.
4. Choose Calibrate from the Sensors menu. Wait for the Spectrometer to warm up.
5. Select Finish Calibration. When the message “Calibration complete” appears, select OK.
6. Determine the optimal wavelength for the FeCl3 solution and set up the mode of data collection.
7. Empty the blank cuvette and rinse it twice with small amounts of 0.020 M FeCl3 solution. Fill the cuvette about ¾ full with the FeCl3 solution and place it in the Spectrometer.
8. Start data collection. A full spectrum graph of the solution will be displayed. Stop data collection.
9. Choose the absorbance peak (λ max) by tapping the graph (or using ◄or ► keys on LabQuest).

**Colorimeter Users Only**

4. Connect the Colorimeter to LabQuest and choose New from the File menu.

5. Calibrate the Colorimeter.

a. Open the Colorimeter lid, insert the blank, and close the lid.

b. Press the button on the Colorimeter to select the wavelength of 430 nm(Blue). Press the CAL button on the Colorimeter. When the LED stops flashing, the calibration is complete. Remove the cuvette from the Colorimeter and save it for Step 8.

6. Set up the data-collection mode.

a. On the Meter screen, tap Rate. Change the data-collection rate to 1 sample/second.

b. Change the data-collection duration to 200 seconds. Select OK.

**Both Colorimeter and Spectrometer Users.**

1. During this experiment you will conduct 5 trials of the reaction between KI and FeCl3, using the volumes of liquids described in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| Trial | FeCl3 (mL) | KI (mL) | H2O (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 |

1. Conduct Trial 1.
2. Measure 20.0 mL of FeCl3 solution into a 100 mL beaker.
3. Measure 20.0 mL of KI solution into a second 100 mL beaker.
4. Add the 20.0 ML of FeCl3 solution to the beaker of KI solution. Swirl the beaker to mix.
5. Rinse the cuvette twice with ~1 mL amounts of the reaction mixture, fill it ¾ full, and place it in the device (Colorimeter or Spectrometer). Close the lid of the Colorimeter.
6. Start the data collection. Observe the progress the reaction. Absorbance data will be collected for 200 seconds. You may stop data collection early if desired.
7. When data collection is complete, carefully remove the cuvette from the device. Dispose of the contents of the beaker and cuvette as directed. Rinse and clean the beakers and the cuvette for the next trial.
8. Examine the graph of the first trial. Tap and drag across a linear region in the first minute of data collection to select data to analyze (for example, from 20 seconds to 50 seconds). Select Curve Fit from the Analyze menu and choose Linear as the Fit Equation. Select OK. Record the slope, as the initial rate of the Trial 1 reaction, in your data. Note the time region that you selected; this same region should be used for all remaining trials. Tap the File Cabinet icon to store the data from Trial 1.
9. Repeat Steps 8-11 to conduct Trails 2-5 using the information in the table. It works well to add the distilled water to the beaker of KI solution before adding the FeCl3 solution. Use the same region of the graph to calculate the initial rates for Trials 2-5 that you used in Trial 1.

DATA TABLE

|  |  |  |  |
| --- | --- | --- | --- |
| Trial | [FeCl3] | [KI] | Initial rate (sec–1) |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |

DATA ANALYSIS

1. Calculate the molar concentration of FeCl3 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 FeCl3 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.