Differential Rate Law Lab: Bleaching of a Food Dye

Introduction:

The rate of a chemical reaction may depend on the concentration of one or more reactants (first order, second order, etc.) or it may be independent of the concentration of a given reactant (zero order). Exactly how the rate depends on reaction concentrations is expressed in an equation called the differential rate law. By varying the concentration of the reactants in the clock reaction in a regular way, we should be able to determine the order of each reactant and the rate law. For a general reaction of the form: A + B □ C, the differential rate law can be written as: Rate = k $[A]^x$ $[B]^y$
where k is the rate constant, [A] and [B] are the molar concentrations of the reactants, and x and y are exponents that define how the rate depends on the individual reactant concentrations.

Purpose:

The purpose of this experiment is to determine the rate law for a reaction in which the color of a blue dye fades as it reacts with bleach.

Materials:

2-Disposable pipettes	Spectrometer and cuvette	2-100 mL volumetric flasks
Blue food coloring (substance "A")	Bleach (substance "B")	4-150 mL beakers
DI Water	Micropipette	

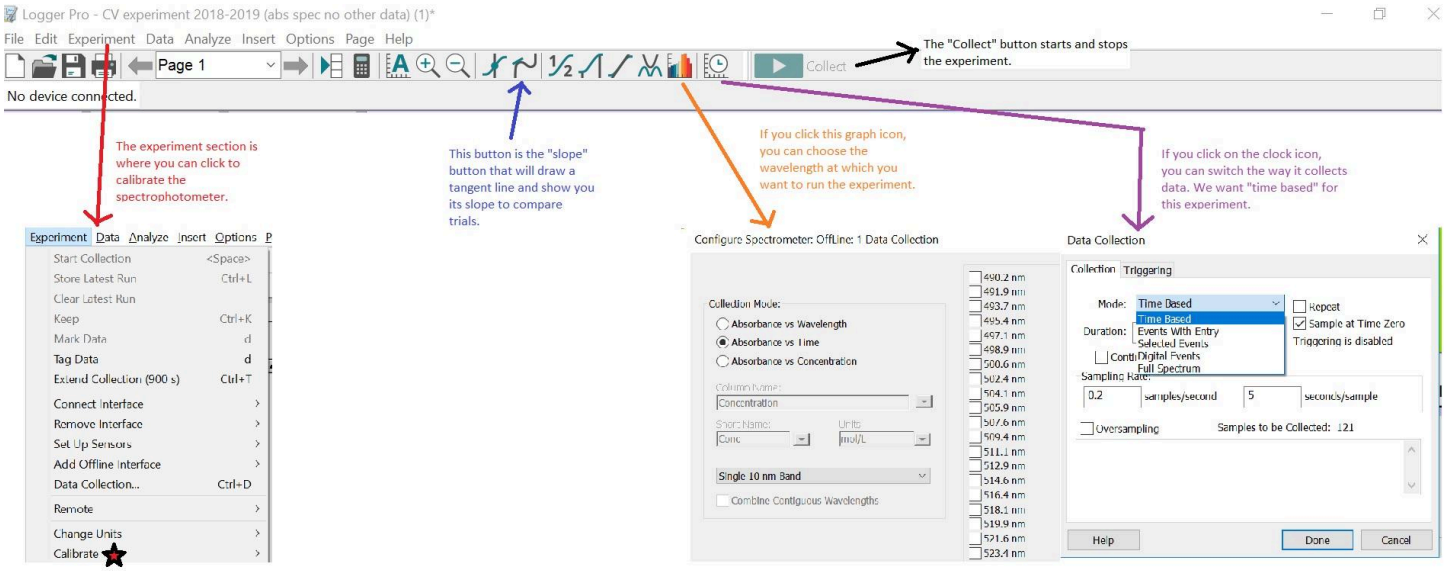
Procedure:

Producing Solutions

- Assume 1 drop of the blue food coloring has 0.0026 mol of the reactive substance. Using the dye and a 100 mL volumetric flask, prepare 100 mL of 0.052 M dye and 100 mL of 0.026 M dye. Put each of these into 2 separate, labeled 150 mL beakers.
- The bleach solution has a concentration of 0.60 M. Use this solution and a 100 mL volumetric flask to make 100 mL of 0.030 M bleach and 0.015 M bleach. Put each of these into 2 separate, labeled 150 mL beakers.

Measuring Reaction Rates Using Spectroscopy

- Set up and calibrate the spectrometer using a blank with water.
- Put 2 mL of 0.052 M of blue dye into the cuvette and measure the absorbance spectrum.
- Select "Experiment"… "Data Collection" and choose "Time Based."
- Set "Duration" to 600 seconds and check the "Continuous Data Collection" box. (trigger setting?)
- Select the wavelength of maximum absorbance.
- Rinse the cuvette and use a pipette to add 1 mL of the 0.026 M dye solution. Place the cuvette in the spectrometer.
- Add 1 mL of the 0.015 M bleach solution and immediately click the "Collect" button.
- Click "Stop" after the absorbance has reached 0.
- Click "Experiment" … "Store Latest Run" to save your data.
- Repeat these measurements for each combination as shown in the data table below.
- Once all of the data have been collected, you will use the slope tool to find the instantaneous rates from each graph at the same time. Choose a time near the beginning of the trial where the curves are "smooth", as sometimes random error variations in the measuring device can skew the data significantly. Record the rates for each trial in the table.
- Print 2 copies of the graphs for each member of your group to be included with your report.
- Save your file for later reference in case you need to review the data.



Data Table:

Trial	[A] added	[B] added	[A] in mixture	[B] in mixture	Rate (mol L^{-1} s^{-1})
1	0.026 M	0.015 M			
2	0.052 M	0.015 M			
3	0.026 M	0.030 M			

Post-Lab Calculations:

1. Show/explain a sample calculation showing how each solution was made.
2. Show/explain a sample calculation showing how the concentrations of each component in the reaction mixtures were found (hint: mixing solutions causes mutual dilution).
3. Show calculations used to determine the order (x, y) with respect to each reactant in the rate law.
4. Calculate the overall order of the reaction.
5. Calculate the value of the rate constant, k, and determine the appropriate units for the rate constant.
6. Write the rate law with all values. Use the general rate law: Rate = $k [A]^x [B]^y$

Post-Lab Questions:

1. How does changing the concentration affect the rate of reaction in this experiment? Explain using collision theory.
2. What reactant has the greatest effect on the rate? Explain.
3. What does the size of the rate constant indicate about “speediness” of a reaction by its nature? Explain by comparing how k for an explosion should compare to k for iron rusting.
4. Is the temperature held constant? If it increased, how would the rate of reaction have been affected? Explain using collision theory.

Teacher notes:

The order wrt dye was well behaved / 1st order

bleach may have been pseudo due to much higher concentration when using double, went too fast and looked 2nd orderish, but when testing ½ bleach, approached 0th order. Could there be some other confounding issue? bleach solutions looked cloudy - maybe should use standard NaOCl to make bleaching solution?

used acidified bleach (checked with pH paper - slightly acidic
multiple reactions and dilution effects differently?

slope tool had variable success. some groups seemed to get strange results (order of -1 for dye! - no idea what happened here).

using (exponential) curve fit and derivatives gave good results
-could use curve fit and output 2 points 10s apart and use deltas to find rates