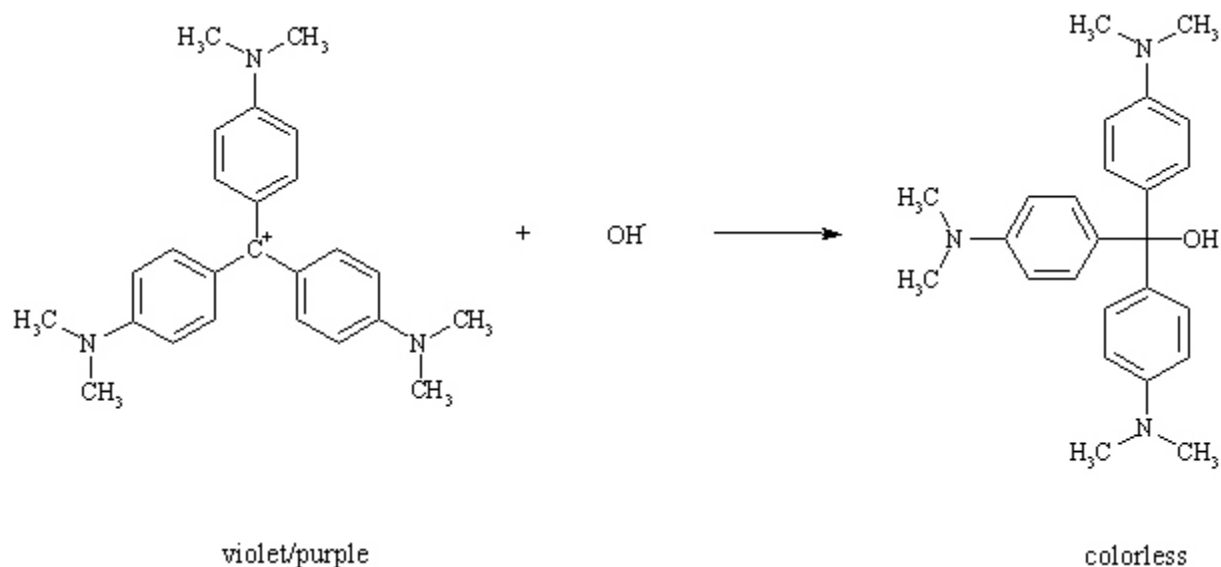


KINETICS

In this experiment you will find the order of a reaction using the instantaneous rate method as well as determine the activation energy. The reaction we will be studying is the reaction of a highly colored dye called crystal violet with hydroxide ion. The reaction is shown below:



The cationic form of crystal violet (on the reactant side) is purple-violet in color. The neutral form (on the product side) is colorless, as is the hydroxide ion. To simply referring to the two forms, we will use CV^+ to represent the colored form and $CVOH$ the colorless form.

Part 1: Beer's Law

To monitor the concentration of CV^+ we will measure the amount of light the solutions absorb. In your previous experiment you have determined the equation that relates the Absorbance of green light to the concentration of CV^+ . Retrieve the equation from your previous experiment, rearrange it so that you have solved for the concentration and write your result on your lab report.

Part 2: Order of the Reaction by the Instantaneous Rate Method

Open Logger Pro and open the file called "Kinetics". Confirm that you have the colorimeter and temperature probes set up by clicking OK. You will need to make one personal modification of this file. Double click on the table column heading labeled "[CV^+]", and delete what currently appears in the "Equation" box. Then enter into that box that part of the equation you determined in Part 1 that follows the equal sign (In other words, neither the variable "concentration" nor the equal sign of your equation will be shown). When you want to enter the "Absorbance" variable, select it from the box labeled "Variables (columns)". Exit the dialog

box by clicking “Done”. Now as the colorimeter records the Absorbance readings the program will convert the readings into concentration units. In your table there is also a column labeled “ln[CV+]”. Double click on this column heading and you will see that it will take the concentration values just calculated and compute the natural logarithm of the concentration. You do not need to make any changes in that column so click “Done.”. Right click on the table and select “Move to Back” so you can see the graphs and meter readouts. Save the file to YOUR DISK in drive A:

Record the value of room temperature to the nearest 1 °C on your data table. Then read the first section of Part 3 and place your solutions in the water baths as described so that they can come to constant temperature while you work on Part 2.

In the instantaneous rate method, one experiment is performed and the concentration of one of the chemicals monitored at various times. Plots of Concentration vs time and ln (Concentration) vs time are used to determine if the reaction is 0 or 1st order. Since the CV⁺ is colored and we now know the mathematical relationship between concentration of CV⁺ and Absorbance from Part 1, we will use the colorimeter to monitor the concentration of the CV⁺ as the reaction proceeds. The NaOH solution we will use is about 10,000 times more concentrated than the CV⁺ and will remain essentially constant as the CV⁺ reacts. This will insure that the rate of the reaction will be dependent only on the remaining concentration of CV⁺.

Use a 10 mL graduated cylinder to measure 10.0 mL of crystal violet into a dry, large test tube. With another 10 mL graduate measure 10.0 mL of 0.100 M NaOH into a second, dry large test tube. Fill a cuvette with water, dry off the outside and calibrate the colorimeter as you did in the previous lab experiment using the green light setting. Pour the water out of the cuvette. When you are ready to start the trial pour one of the two solutions into the other. At the same time start the trial by clicking on the green button in the toolbar. The computer is now measuring time from the moment of mixing. Mix the solutions by pouring back and forth between the test tubes a few times. Then rinse the cuvette by filling it twice with the solution, discarding each rinse and then fill the cuvette at least 3/4 full. Since the “clock is running” all the time you are doing this try to do these operations as quickly as feasible. Dry off the outside of the cuvette, insert it into the colorimeter and click on the “aperture” symbol. This will record your first absorbance. Leave the cuvette in the colorimeter. Now each time you click on the “aperture” the absorbance and the time since the start of the trial will be recorded. You can choose to collect as many data points as you would like but allow the trial to run for about 5 minutes or when the absorbance drops below 0.1. Terminate the run by clicking on the red button in the toolbar. From the toolbar select “Experiment” and then “Store Latest Run.” Then save your file to YOUR DISK.

Drawing the Graph:

Click on one of the graphs and select “Analyze” from the toolbar and either “Linear fit” or “Curve fit” depending on whether or not you think the data represent a straight line or some other function. Find the function that gives a suitable fit. Repeat for the other graph. If the graph of [CV⁺] vs time is linear then the order with respect to CV⁺ is zero order. In the graph of ln[CV⁺] vs time is linear then the order is 1st order. Save your file to your disk.

Part 3: Determination of Activation Energy

In this part of the experiment you will repeat the procedure in Part 2 with the exception that the two reacting solutions will be at a temperature other than room temperature. Prepare two water baths using large beakers. One water bath should be about 35°C and the other about 10 °C. You will need to monitor your warm water bath carefully and add more hot water as necessary to maintain the temperature within the specified range. Obtain 4 large test tubes. Into two of them place 10.0 mL of crystal violet. Into the other two tubes add 10.0 mL of 0.100 M NaOH. Place one of each kind of solution into each of the two water baths. Allow the temperature to equilibrate for at least 20 minutes. While you are waiting, do Part 2.

After Part 2 is complete, hide the boxes that contain the graph data. This will reduce the clutter on your graphs. To hide the boxes without erasing the line, right click on the box and unclick the “Show on graph” option. If you want the box back again you need to select “Options” from the toolbar, then “Additional Object Options” and then “Reveal Hidden Objects.” Rinse your cuvette with 1 M HCl to remove any crystal violet that may remain and then thoroughly rinse the cuvette with water. Fill the cuvette with water, wipe it dry and calibrate your colorimeter if the absorbance reading does not read within 0.005 absorbance units of 0.000.

Start with the cold water bath first. Since the reaction is slower it is less sensitive to your fumbling around with the steps that follow. When you select the warm water bath you will need to be more efficient since the reaction is faster. Fill the cuvette with water from your water bath in order to cool the cuvette to the solution temperature. After a minute or so, discard the water from the cuvette and pour the contents of one of the test tubes into the other back and forth several times in order to mix. At the same time start the run by clicking on the green button in the toolbar. As before, rinse and fill the cuvette and wipe it dry. You will need to be fast at doing this when you are using the higher temperature bath since the reaction is occurring much faster than it did at room temperature. After inserting the cuvette containing the reacting solutions into the colorimeter, click on the “aperture” symbol to take your first reading. Keep the cuvette in the colorimeter and record data for at least 2 minutes. Take as many readings as you would like but the slower the reaction the more time you will probably want to wait between data points. At the higher temperature you will probably want to record a reading about every 5 seconds or so. When you have collected several minutes worth of data (or the absorbance has dropped below 0.1) click the red button on the tool bar to stop the experiment. Store this run as described in Part 2 using the menu under “Experiment”. Record the temperature of your water bath to the nearest 1 °C . Save your file to your disk.

Rinse your cuvette with HCl and then distilled water. Calibrate the colorimeter as necessary. Repeat the experiment a third time but use the solutions in the warm water bath. You will need to be pretty fast getting the solution into the colorimeter since the reaction is occurring much faster. Store this run and then save the file to your disk. Record the temperature your warm water bath on your report sheet.

Drawing the Graph:

From Part 2, you know the order and which graph should be linear. Click on that graph, Since we had no way to keep the temperature of the solutions constant when we used warm and cold solutions, the temperatures of your solutions probably changed with time. To minimize this error, highlight only about the first 60 seconds of your data and draw the lines of best fit for all three of your trials. During 1 minute the temperatures probably didn't change much. Using the slopes of the lines, determine the values of the rate constants.

On the C: drive, in the folder labeled "Chem labs", open the file called "Arrhenius Plot" and save it to YOUR disk. Enter your values for the temperature and the rate constants. Draw the line of best fit and save the file to YOUR disk. Use the slope to calculate the activation energy for the reaction.

Lab Report:

Print a copy of each of the graphs drawn in Part 2. You can hide the other two trials using the option under "Data" in the toolbar. You can also enlarge the graphs by dragging the black squares at the corners and/or the sides. Also print a copy of the linear graph in Part 3 that shows all three trials. Be sure that you can see all three boxes that show the slope data. Finally, print a copy of your Arrhenius plot that also shows the slope data box.

Questions:

1. Highlight the last few data points of your warm and cold temperature trials. Use those points only to draw a line of best fit. Use the slope to find the rate constants.

water bath	rate constant from first 1 minute of data	rate constant from last few data points
cold		
warm		

You will probably find that the rate constant for the cold water bath is larger at the end of the trial than at the beginning but the rate constant for the warm water bath was lower at the end than the beginning. Explain these results. is