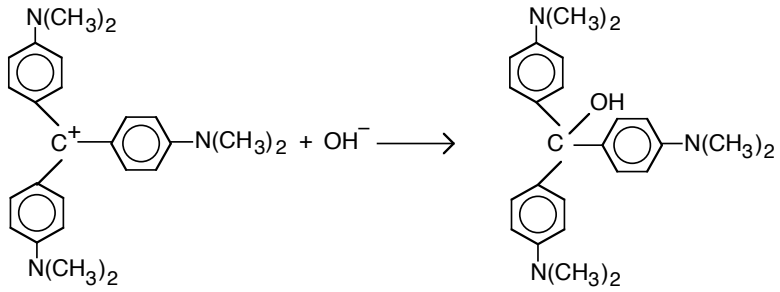
Rate Law of the Crystal Violet Reaction

In this experiment, you will observe the reaction between crystal violet and sodium hydroxide. One objective is to study the relationship between concentration of crystal violet and the time elapsed during the reaction. The equation for the reaction is shown here:



A simplified (and less intimidating!) version of the equation is:

$$\underset{\text{(crystal violet)}}{CV^+} + \underset{\text{(hydroxide)}}{OH^-} \longrightarrow CVOH$$

The rate law for this reaction is in the form: rate = $k[CV^+]^m[OH^-]^n$, where *k* is the rate constant for the reaction, *m* is the order with respect to crystal violet (CV^+), and *n* is the order with respect to the hydroxide ion. Since the hydroxide ion concentration is more than 5000 times as large as the concentration of crystal violet, $[OH^-]$ will not change appreciably during this experiment. Thus, you will find the order with respect to crystal violet (m), but not the order with respect to hydroxide (n). This will lead to what we call a *pseudo rate law*.

As the reaction proceeds, a violet-colored reactant will be slowly changing to a colorless product. We will assume that absorbance is directly proportional to the concentration of crystal violet (Beer's law). Absorbance will be used in place of concentration in plotting the graphs:

Once the order with respect to crystal violet has been determined, you will also be finding the pseudo rate constant, k, and the half-life for this reaction.

Prelab Questions

1) What do you plot to get a straight line for a first order reaction?

2) What do you plot to get a straight line for a second order reaction?

3) What do you plot to get a straight line for a zeroth order reaction?

4) What is Beer's Law?

5) What type of relationship exists between absorbance and concentration?

PROCEDURE

1) Obtain and wear goggles.

2) Use a 10-mL graduated cylinder to obtain 10.0 mL of 0.10 M NaOH solution. **CAUTION:** *Sodium hydroxide solution is caustic. Avoid spilling it on your skin or clothing*. Use another 10-mL graduated cylinder to obtain 10.0 mL of 2.0×10^{-5} M crystal violet solution. **CAUTION:** *Crystal violet is a biological stain. Avoid spilling it on your skin or clothing*.

3) Calibrate the spectrophotometer. Set the wavelength to 590 nm. Close the sample port and set the percent transmittance to 0%. Load a cuvette with distilled water, wipe it with a Kimwipe, and place it in the sample port. Set the percent transmittance to 100%.

You are now ready to begin monitoring data.

4) To initiate the reaction, simultaneously pour the 10-mL portions of crystal violet and sodium hydroxide into a 100-mL beaker and stir the reaction mixture with a stirring rod. Empty the water from the cuvette.

5) Rinse the cuvette with ~1-mL of the reaction mixture and then fill it ¾ full.

6) Place the cuvette in the cuvette slot of the spectrophotometer and close the lid. Monitor the percent transmittance reading on the spectrophotometer for about 10 seconds (the percent transmittance reading should be gradually increasing while the absorbance is slowly decreasing).

7) Collect absorbance data every 5 seconds for three minutes. During the 3-minute data collection, observe the solution in the beaker as it continues to react.
You may try recording the data straight into a computer program that graphs.

8) Dispose of the solution as directed by the instructor.

If the graphs are not suitable you may repeat the data collection.

POST LAB QUESTIONS

1) Create three graphs for this lab. One if it was 0^{th} order, one if it was 1^{st} order, and one if it was 2^{nd} order.

2) Determine if the reaction is first, second, or zeroth order and write the rate law.

3) Write the pseudo rate law for this reaction.

4) Determine the numerical value of the pseudo rate constant k and it's units.

5) How would the value of k change if we increased the temperature for the reaction?