

Name:

Period:

Seat#:

**Required Sections:** (Refer to R-15 for guidelines and requirements. Make note of any specific changes given by your teacher in class.)

**Prelab:** Prelab Questions, Materials, Reagent Table, Procedures, and set up Data Tables before you get to class.

**During Lab:** Data section – Fill out your data table that is already set up from the prelab.

**Post-lab:** Calculation section, Discussion Questions Section (both done in lab notebook)

**REMINDER - USE R-15 TO ENSURE YOU FOLLOW ALL GUIDELINES/EXPECATIONS/ REQUIREMENTS**

**Introduction**

Phenolphthalein is a dye that is used as an acid–base indicator. It is colorless in acidic or neutral solutions and turns bright red-violet as the solution becomes basic. In strongly basic solutions, the red-violet color slowly fades, and the solution again becomes colorless. The kinetics of this “fading” reaction can be analyzed by measuring the intensity of the fading color over time and then graphing the results.

The purpose of this technology-based experiment is to use colorimetry and graphical analysis to determine how the rate of the phenolphthalein fading reaction depends on the concentration of the dye. A colorimeter is a special instrument that measures the absorbance of light.

In order to determine the order with respect to phenolphthalein, the reaction will be performed under pseudo-order conditions in order to consider the sodium hydroxide as being held constant. It will appear to have no effect on the rate of the reaction, which makes it appear as though the order with respect to NaOH is zero.

A known amount of phenolphthalein will be added to a large excess of sodium hydroxide, and the absorbance (Abs) of the red solution will be measured at specific time intervals. Absorbance is directly proportional to concentration, so a graph of absorbance versus time has the same characteristics as a graph of concentration versus time (Figure 3). Graphing the absorbance data— $\ln(\text{Abs})$  versus time and  $1/\text{Abs}$  versus time—should reveal whether the fading reaction is first or second order with respect to phenolphthalein.

**Objectives**

In this experiment, you will

- Conduct the reaction of phenolphthalein and sodium hydroxide, using an excess of NaOH, and various concentrations of phenolphthalein.
- Determine the order of the reaction with respect to phenolphthalein.
- Determine the rate law expression for the reaction.

**Prelab Questions** – do not recopy questions, just paraphrase into answers!

Crystal violet (CV) is another indicator dye that combines with hydroxide ions to form a colorless product. Crystal violet was added to a large excess of NaOH, and the solution immediately turned violet. After 10 minutes the floor faded, and the solution was almost colorless. The absorbance measurements were recorded in Table 1.

Time (min)	Abs	$\ln(\text{Abs})$	$1/\text{Abs}$
1	0.366		
2	0.251		
3	0.176		
4	0.124		
5	0.089		
6	0.065		
7	0.048		
8	0.037		
9	0.029		
10	0.023		

Table 1 – Absorption of CV Fading in NaOH

1. Take notes on the following video about the crystal violet experiment. It is a good overview of the concepts and what our graphs will look like. It is a different brand of equipment/software but that is ok – we are just focusing on the general concept right now. <https://tinyurl.com/dvlabexample>
2. Copy Table 1 into your lab notebook. Calculate the values of  $\ln(\text{Abs})$  and  $1/\text{Abs}$  for each absorbance measurement, recording your values in your lab notebook.
3. Using a graphing program (Excel, graphing calculator, etc) – make the following three graphs
  - Abs vs. time,  $\ln(\text{Abs})$  vs. time,  $1/\text{Abs}$  vs. time.
4. Sketch a rough copy of the graphs into your notebook. For each graph, make sure to include a title and label the axis. While your graph does not need to be totally perfect, take some degree of care to sketch it accurately.
5. Just looking at the appearance of each graph, without generating any line of best fit or  $R^2$  values, which graph more closely approximates a straight line?
6. Is the reaction of crystal violet with hydroxide ions first or second order with respect to crystal violet?
7. What would the rate law of this reaction be? Remember – if it is being done under pseudo-order conditions, the reactant in large excess does not appear in the rate law. You can use CV to represent the formula for crystal violet.



**Materials** – don't forget to use an MSDS to do your reagent table! Remember that a \* means it should be in your reagent table!

#### Chemicals

- \* Diluted phenolphthalein, 2 drops
- \* Sodium hydroxide, NaOH, 2.0 M, 5mL
- Distilled water

#### Equipment

- Computer that has a standard USB or an adapter
- Spectral Analysis
- Spectrometer
- 50 mL beaker

- 1 cm plastic cuvette with lid
- Thermometer
- Disposable Pipette
- Kimwipes
- Disposable gloves



#### SAFETY PRECAUTIONS

*Sodium hydroxide is a corrosive liquid. Avoid contact with eyes and skin and clean up all spills immediately. Phenolphthalein is moderately toxic by ingestion. Wear chemical splash goggles. Wash hands thoroughly with soap and water before leaving the laboratory.*

[Google Folder with Most MSDS Files](https://tinyurl.com/2cyva3ku)

<https://tinyurl.com/2cyva3ku>

To help speed up your reagent table!



[Flinn's MSDS Website](https://www.flinnsci.com/sds/)

<https://www.flinnsci.com/sds/>

For anything that isn't in my Google folder.



**\*\*\*NOTE\*\*\*** You will only need to upload your final R2 value for each graph of each trial to the shared data spreadsheet.

**Shared Data Spreadsheet:** <https://tinyurl.com/2p894e48> Must be logged in with SRVUSD email to open file



#### Procedure

- 1) Obtain and wear goggles.
- 2) To correctly use cuvettes, remember:
  - Wipe the outside of each cuvette with a lint-free tissue.
  - Handle cuvettes only by the top edge of the ribbed sides to avoid fingerprints on the clear 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.
- 3) Obtain solutions of 2.0 M NaOH in a 50 mL beaker, and a dropper bottle of diluted phenolphthalein solution.
- 4) Connect the spectrometer to the computer using the cord given in the box. Open Vernier Spectral Analysis.
- 5) Start an Absorbance vs. Time (Kinetics) experiment.
- 6) Choose Calibrate → Spectrometer from the Experiment menu. The calibration dialog box will display the message: "Waiting 60 seconds for lamp to warm up." After 60 seconds, the message will change to "Warmup complete." To prepare a blank place a cuvette filled  $\frac{2}{3}$  –  $\frac{3}{4}$  full with 2.0 M NaOH. Place the blank cuvette into the cuvette slot of the Spectrometer, Click .
- 7) Once the spectrometer is connected, allow it to calibrate before continuing. Set the wavelength on the spectrometer to 565 nm (green) and press "Done."
- 8) Empty the cuvette and refill it  $\frac{2}{3}$  –  $\frac{3}{4}$  full with 2.0 M NaOH using a pipette. Measure and record the initial temperature of the sodium hydroxide solution. Wipe the clear sides with lint-free Kimwipe paper.
- 9) Add one drop of diluted phenolphthalein to the cuvette.
- 10) Quickly put the cap completely on and shake the cuvette to make sure it is properly mixed. Quickly place the cuvette into the spectrometer, with the clear sides facing the white arrow. Immediately press "Collect" on the main screen to begin measuring time.
- 11) When the absorbance has stabilized (around 2-3 minutes), press "Stop" on the main screen to end the data collection process.
- 12) Save the data on the computer. Record data points for every 4 seconds into your lab notebook. You will use all the data points to generate your graphs in the computer, but you can just record every 4 seconds.
- 13) Remove cuvette from the spectrometer compartment. Measure and record the final temperature of the solution.
- 14) Rinse the cuvette several times with distilled water and dry as well as possible.
- 15) Repeat steps 7-13 for multiple trials if necessary, and if time allows.

## Disposal and Cleanup

Your teacher will provide disposal and cleanup instructions.

## Data Table

Make your own data table! Remember, you need to make sure your data table has all required elements! A sample is provided. You will need to add a descriptive title, units on all rows/columns, and a spot for qualitative data, the one below is not adequate! Remember to use enough space, make it look professional, etc!

## Calculations

This time the computer is going to do the calculations for you. You will just be including glued in copies of your final graphs. Make sure they are each labeled with:

- o a descriptive title
  - o the line of best fit equation shown
  - o labels and units on axes when appropriate
1. Calculate the values of  $\ln(\text{Abs})$  and  $1/\text{Abs}$  for each absorbance measurement. *Note: This is done in the Vernier software using the data saved and by adding a calculated column.*
    - a. Click on the three dots next to Absorbance column, add calculated column.
    - b. Name it " $\ln(\text{Abs})$ " or " $1/\text{Abs}$ "
    - c. Insert expression " $\ln(x)$ " and " $A/x$ " \*note parameter  $A=1$ "
  2. Make three graphs – one graph of Abs vs. time, one of  $\ln(\text{Abs})$  vs. time, and one of  $1/\text{Abs}$  vs. time.
  3. Apply a curve fit, line of best fit, to each graph.
  4. Calculate the  $R^2$  value for all three lines.

Descriptive Title			
Initial Temp.		Final Temp.	
Time	Abs.	$\ln(\text{Abs})$	$1/\text{Abs}$

## Post Lab Discussion Questions – Do not recopy the questions, just paraphrase them into your answer.

1. What value do you use to determine which graph more closely approximates a straight line?
2. Using the value indicated in Question 1, which of your graphs more closely approximates a straight line?
3. What order is the reaction with respect to phenolphthalein?
4. Explain how you determined the order in Question 3. Explain it in detail! Good AP level explanation!
5. Why did we use a large excess of NaOH for this reaction? What is it called when we do this?
6. Write the rate law expression for the reaction.
7. Based on your rate law, what are the units on  $k$ , the rate constant?
8. Is it possible to calculate the rate constant,  $k$ , from your data?
  - o If yes – calculate the rate constant.
  - o If not – explain why it is not possible, and what you would need to do in order to find the rate constant.
9. Did the temperature of the solution change over the course of the reaction? What effect, if any, would the temperature change have on the results of the experiment?
10. A student prepared their blank cuvette properly, but then accidentally touched the smooth sides of the cuvette, without wiping it off with their Kimwipes, leaving fingerprints on it before they did the first trial. Would their absorbance readings appear too high or too low? Why?