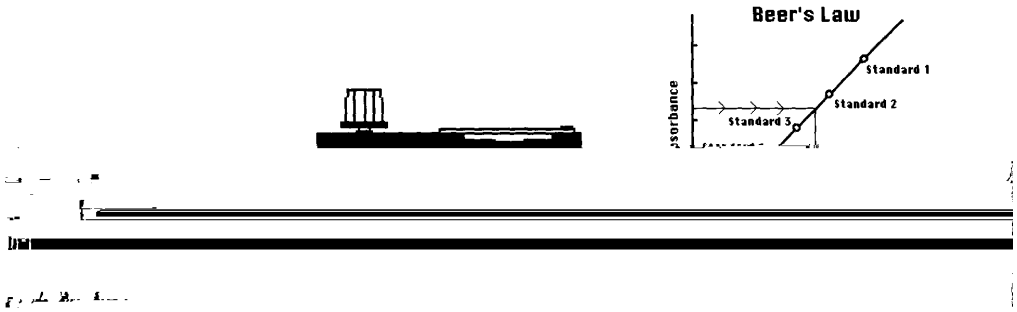
CHM 152LL, Determination of the Concentration of a Colored Solution — Beer's Law & Graphing Exercises

Introduction

In this experiment, you will be using the colorimeter similar to the one shown in the figure below.



In this device, light from a light emitting diode (LED) will pass through a solution placed in a cuvette in the colorimeter. The light that passes through the solution will strike a photo cell. A higher concentration of the colored solution absorbs more light and transmits less light than a solution of lower concentration. The computer interfaced colorimeter monitors the light received by the photo cell as either a *percent transmittance* or an *absorbance* value.

The amount of light that penetrates the solution and strikes the photocell is used to compute the absorbance of each solution (**Absorbance = 2 – log (%transmittance)**). When a graph of absorbance vs. concentration is plotted for a series of standard solutions, a direct relationship should result, as shown in the figure on the right above. This direct relationship between absorbance and concentration for a solution is known as Beer's law.

In the experiment, you will generate a standard plot of absorbance vs. concentration using a standard $CuSO_4$ solution. When a graph of absorbance vs. concentration is plotted for the standard solutions, a linear relationship should result, which is the calibration curve. After that, you can measure the absorbance of some $CuSO_4$ solution of unknown concentration and determine their concentrations using the calibration curve.

Besides achieving the above main purposes, you will also be graded on how accurately you dilute the standard solutions. 20% of the lab grade will be based on the correlation (R^2) value (how close it is to 1) and Y-intercept (how close it is to 0).

This lab is limited to 2 ~ 3 students per group. (We have 7 sets of the equipment.)

Procedure

Part A: The Calibration Curve

1. Add about 30 mL of 0.40 M $CuSO_4$ stock solution to a 100-mL beaker. Add about 30 mL of deionized water to another 100-mL beacker.

2. Label four **clean, dry**, large test tubes 1 through 4.

3. Pipet 2, 4, 6, and 8 mL of 0.40 M $CuSO_4$ stock solution into test tubes 1 through 4, respectively.

4. With a second pipet, deliver 8, 6, 4, and 2 mL of distilled water into Test Tubes 1 through 4, respectively.

5. Thoroughly mix each solution. If you use a stirring rod, clean and dry the stirring rod between stirrings.

6. Keep the remaining 0.40 M $CuSO_4$ in the 100 mL beaker to use for the fifth solution.

Volumes and concentrations for the test tubes are summarized below:

Test Tube #	*0.40 M $CuSO_4$ (mL)*	*H_2O (mL)*	*Concentration (M)*
1	*2*	*8*	*0.08*
2	*4*	*6*	*0.16*
3	*6*	*4*	*0.24*
4	*8*	*2*	*0.32*
5	*~10*	*0*	*0.40*

7. Connect the *Vernier Lab Pro* interface to the computer and turn on the interface. Connect the DIN plug of the calorimeter to Analog Channel 1 on the interface.

8. Open the *Logger Pro* file titled as *11 Beer's Law* inside the *Chemistry with Vernier* folder.

9. The document gives a Graph display of the Absorbance versus Concentration (Molarity), a Table display of Concentration, Transmittance and Absorbance, and a Digits display of Absorbance. (The Colorimeter needs to be powered about 5 minutes before calibrating in Step 10.)

10. Press the < or > button on the Colorimeter to 635 nm (Red LED color. Why red?) Perform a sensor calibration with the colorimeter as follows:

a. Prepare a blank by filling a cleaned cuvette at least ¾ full with distilled water. Wipe the outside of the cuvette dry with Kimwipe. Remember to only handle any cuvette only by the top edge of the ribbed sides and the solution in the cuvette should be free of bubbles.
b. Open the Colorimeter lid. Insert the cuvette in the slot. Making sure that the smooth sides of the cuvette is lined up with the arrow at the top of the cuvette slot. Close the Colorimeter lid.
c. Press the CAL button to begin the calibration process. Release the CAL button when the read LED begins to flash. The absorbance reading should now be 0.000 or 0.001.

11. Remove the cuvette from the calorimeter and empty the water from it. Use the solution in Test Tube 1, rinse the cuvette twice with approximately 1 mL amounts of the solution from the test tube, and then fill the cuvette ¾ full with solution.

12. Wipe the outside of the cuvette with a Kimwipe and place the cuvette in the colorimeter. Close the lid.

13. Click the "**Collect**" button. Monitor the Absorbance value displayed in the Digits display. (Notice that a data point will also appear on the graph.)

14. Wait for the Absorbance value displayed in the Digits display stabilized, Click on the "**Keep**" button. (DO NOT STOP SAMPLING). Then enter "0.08" in the Concentration box that pops up after.

15. The data pair you just collected should appear on the Graph and in the Table display of Concentration, Transmittance and Absorbance.

16. Remove the cuvette from the calorimeter and empty the cuvette into a heavy metal waste bottle. Rinse the cuvette twice with approximately 1 mL amounts of the solution in Test Tube 2 and then fill the cuvette ¾ full of the solution from Test Tube 2. Wipe the outside with a Kimwipe and place the cuvette in the colorimeter. Close the colorimeter lid.

17. When the Absorbance value displayed in the Digits display stabilizes, repeat steps of 13 to 14 and enter the new concentration, 0.16, as before.

18. Continue with each of your other samples entering concentrations of 0.24, 0.32, and 0.40 respectively for solutions 3, 4, and 5.

19. Click **"Stop"** to end data recording for the calibration curve.

20. Click on the Graph display to make it active. Click on the auto-scale, **"**  **"** button to resize the graph to fit the data. Obtain a linear curve fit for the graph using **"**  **"** button.

21. Print a copy of the graph for your lab report.

Part B. Unknown Concentration Determination

1. Obtain a $CuSO_4$ solution with unknown concentration from your instructor.

2. Measure about 7 mL of the unknown $CuSO_4$ solution into a clean, dry, test tube. Rinse your cuvette twice with approximately 1 mL amounts of deionized water and then unknown solution. Then fill the cuvette ¾ full of the unknown solution.

3. Monitoring the absorbance data. When the Absorbance value displayed in the Digits display stabilizes, record the value of the Absorbance in the Data Table of your notebook as the value for the unknown solution. (Record all raw experimental data in your laboratory notebook.)

4. Using your graph, or the equation obtained from the linear curve fit, you can determine the unknown concentration form its absorbance value.

5. Discard all solutions in the heavy metal waste bottle. Clean and carefully dry all glassware and the cuvette.

6. On a separate blank sheet of paper or on the printed Absorbance vs. Concentration graph itself, report your experimental data for the calibration curve and the unknown solution in a tabulated format. Do also remember to report the unknown identification number and give your name and section number.

III. Graphing Exercise:
(http://www.molsci.ucla.edu/pub/explorations.html#GraphLab)

Notice that Linear Regression Analysis (Least Square Fit) is extensively used in this experiment. Your pre-lab exercise gave you extensive practice in this area. We will discuss the lessons learned and how it relates to our experiment at the end of the lab.