LABORATORY 7: Determining Concentration using a Beer's Law Equation

PRELAB
Read the following procedure completely in order to prepare for lab and complete the Moodle quiz.

Answer the following questions in your laboratory notebook:
1. In your own words, write the purpose and procedure for this experiment.

**Note: If you have not yet discussed Beer's Law in lecture, the information can be found in Chapter 4 of your textbook, beginning on pp. 156.*

Before beginning in lab, update the Table of Contents with the title of the experiment and corresponding page number. You will be working with computers, so be aware of aqueous solutions at all times.

PURPOSE

In this procedure, you will learn to prepare standardized copper(II) sulfate solutions and calculate the absorbance of each from transmittance readings. Your standardization curve corresponding to Beer's Law will be used to determine the concentration of an unknown $CuSO_4$ solution. You will prepare your solutions using graduated pipets and a volumetric flask.

INTRODUCTION

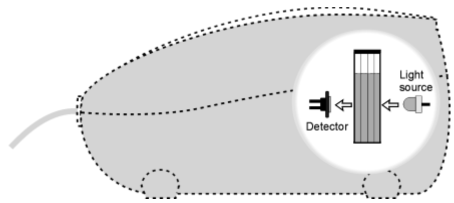
The primary objective of this experiment is to determine the concentration of an unknown copper(II) sulfate solution. A red LED lights source will pass through the solution and strike a photocell. The Colorimeter monitors the light received by the photocell as percent transmittance. A higher concentration absorbs more light, and transmits less, than a lower concentration.

You will prepare five standard solutions of known concentration. Each solution will be transferred to a small, rectangular container, called a cuvette, to be placed in the Colorimeter.

After the absorbances have been recorded, your standardization curve will be graphed. The linear trendline equation can then be used to determine an unknown concentration from a known absorbance, and vice versa.

EXPERIMENTAL PROCEDURE: PART 1 – Making a standard curve

Apparatus:



1. Connect the LabQuest Viewer with the Colorimeter, just like the thermometer or conductivity meter in the last experiments.

2. Obtain approximately 40 mL of the 0.40 M $CuSO_4$ solution in a 100 mL beaker.

3. Label 5 clean and dry test tubes with numbers 1 – 5. Use one 10 mL pipet for $CuSO_4$ and a second 10 mL pipet for water to prepare the five solutions according to the table below. Record the volumes you measured in your lab notebook to the nearest 0.1 mL. The total volume in each test tube should be 10.0 mL. Calculate the new concentration of each solution and record all information in your lab notebook.

Trial	**Volume (mL) 0.40 M $CuSO_4$**	**Volume (mL) DI H_2O**	**New Concentration $CuSO_4$**
1	2.0	8.0	
2	4.0	6.0	
3	6.0	4.0	
4	8.0	2.0	
5	10.0	0.0	

4. Prepare the *blank* to calibrate the Colorimeter. The *blank* is a cuvette ¾ filled with distilled water. To calibrate the Colorimeter, wipe the outside of the cuvette with a tissue and carefully place the *blank* in the instrument. Close the lid. Set the wavelength to 635 nm and select CAL.

5. Remove the *blank* and pour the water down the drain. Rinse the cuvette twice with 1 mL of Trial 1 and then fill it approximately ¾ full. Wipe the outside of the cuvette with a tissue and carefully place Trial 1 in the machine. Close the lid. Do not select CAL. Record the percent transmittance reading once it stabilizes.

6. Remove the cuvette and dispose of the solution. Rinse the cuvette twice with distilled water and then fill it approximately ¾ full. Recalibrate the Colorimeter.

7. Create a data table in your lab notebook. For each trial, calculate and record the concentration of each new $CuSO_4$ solution and the percent transmittance. Repeat steps 5 – 6 until you have recorded %T for all five trials. **(Remember use excel for ALL calculations.)**

8. Use the percent transmittance to calculate the absorbance of copper(II) sulfate in solution according to the following equation. **Be aware that the transmittance should be a decimal, not a percentage.**

$$Absorbance = log\left(\frac{1}{Transmittance}\right)$$

9. Create a scatterplot of your results; treat concentration as your independent variable (x variable), and absorbance as your dependent variable (y variable).

10. Be sure to add a trendline through the data series and display the linear equation. Record the linear equation clearly in your lab notebook.

11. Save the Excel file in Documents. Print off one copy of the <u>scatterplot per partner</u>.

<u>EXPERIMENTAL PROCEDURE: PART 2 –</u>
<u>Using the standard curve to determine concentration of an unknown.</u>

1. Obtain approximately 10 mL of the unknown $CuSO_4$ solution in a clean dry test tube. Record the number of the unknown in your lab notebook.

2. Rinse the cuvette twice with distilled water and then fill it approximately ¾ full. Wipe the outside of the cuvette with a tissue and carefully place the *blank* in the machine. Recalibrate the Colorimeter.

3. Remove the *blank* and pour the water down the drain. Rinse the cuvette twice with 1 mL of the unknown $CuSO_4$ and then fill it approximately ¾ full. Wipe the outside of the cuvette with a tissue and carefully place the unknown in the machine. Close the lid. Record the percent transmittance reading once it stabilizes.

4. Use the percent transmittance to calculate the absorbance of copper(II) sulfate in the unknown. Remove the cuvette and dispose of the solution.

EXPERIMENTAL PROCEDURE: PART 3

Making a solution and using the standard curve: How accurate are you?

1. Obtain a 100 mL beaker and a 100 mL volumetric flask. Prepare a 0.150 M $CuSO_4$ solution by adding the mass or volume you calculated in your prelab to the beaker. Add approximately 50 mL of distilled water to the beaker and stir until the solid has totally dissolved. Then, pour the solution into the flask and fill with distilled water until the bottom of the meniscus touches the single marking. Cover the opening of the flask with a cap or parafilm. Invert the solution three times to mix thoroughly.

2. Rinse the cuvette twice with distilled water and then fill it approximately ¾ full. Wipe the outside of the cuvette with a tissue and carefully place the *blank* in the machine. Recalibrate the Colorimeter.

3. Remove the *blank* and pour the water down the drain. Rinse the cuvette twice with 1mL of the 0.150 mL $CuSO_4$ solution and then fill it approximately ¾ full. Wipe the outside of the cuvette with a tissue and carefully place the solution in the machine. Close the lid. Record the absorbance reading once it stabilizes.

4. Use the percent transmittance to calculate the absorbance of $CuSO_4$ in your 0.150 M solution. Remove the cuvette and dispose of the solution.

WASTE MANAGEMENT

Once you have completed the experimental procedure and calculations, dispose of any $CuSO_4$ solutions in the designated waste container(s). Rinse your cuvette with distilled water. Do not put the solutions back into their original containers. Do not dump the solutions down the drain. Thoroughly rinse the beakers and flasks once emptied in the sink. Return all glassware to your drawer. Thoroughly wipe down the bench top with a wet paper towel.

LABORATORY 6: REPORT SHEET

NAME:

LAB PARTNER:

LAB DATE AND TIME:

The report sheet should be completed and turned in before you leave lab today.

1. Complete the table and fill in the blanks below using the observations of aqueous $CuSO_4$ you gathered in lab.

Trial	0.40 M Volume (mL)	Diluted Concentration (M)	Absorbance
1			
2			
3			
4			
5			

Linear standardization curve (Part 1): ____________________

Absorbance of unknown $CuSO_4$ (Part 2): ____________________

Absorbance of 0.150 M $CuSO_4$ (Part 3): ____________________

2. A standardization curve can be used to calculate an unknown concentration from an absorption. Calculate the concentration of the unknown $CuSO_4$ solution using your standardization curve from Part 1.

Ask your instructor or TA for the actual concentration of your unknown. Calculate the percent error in your solution to the nearest 0.1 %.

$$\%\ error = \left(\frac{Theoretical - Actual}{Theoretical}\right) x100$$

3. Calculate the concentration of your "0.150 M" $CuSO_4$ solution using your standardization curve from Part 1. Calculate the percent error in your solution to the nearest 0.1 %.

4. Predict the absorbance of a 0.60 M $CuSO_4$ solution using your standardization curve. Answer to the 0.01.

5. Would the colorimetry method used in this procedure be useful in determining the unknown concentration of a NaCl solution? Why or why not?

6. 2.50 grams of an impure unknown solid containing anhydrous $CuSO_4$ (M.W. 159.6 g/mol) was dissolved in 100.0 mL of distilled water. The absorbance of the solution in a colorimeter at 635 nm was 0.151. The standardization curve for this experiment was found to be $y = 2.40x$.

   What was the concentration of $CuSO_4$ in the unknown solution?

How many moles of $CuSO_4$ were there in the unknown solution? How many grams?

   What was the mass percent of $CuSO_4$ in the original unknown sample?

LABORATORY 7: RUBRIC

PRELAB

1. Purpose and clear procedure in notebook………………………………………………______/3 points
3. Molar absorptivity of $CuSO_4$, Concentration and Mass calculations…………______/3 points

LAB NOTEBOOK

Proper header information on every page………………………………………………______/1 point

%Transmittances and absorbances…………………………………………………………______/2 points

Unknown number and absorbance……………………………………………………………______/1 point

0.150 M solution and absorbance……………………………………………………………______/1 point

For the graph:

Present and clearly titled, axes labeled…………………………………………………______/1 point

Correct independent/dependent variables………………………………………………______/1 point

Trendlines w/equations present…………………………………………………………______/2 points

POSTLAB

1. Tables filled in completely………………………………………………………………______/1 points
2. Concentration of unknown………………………………………………………………______/2 points

   Percent error…………………………………………………………………………………______/1 point
3. Concentration of "0.150 M" $CuSO_4$………………………………………………………______/2 points

   Percent error…………………………………………………………………………………______/1 point
4. Absorbance of 0.60 M $CuSO_4$………………………………………………………………______/3 points
5. Colorimetry of NaCl…………………………………………………………………………______/2 points
6. Concentration, mass, moles, and mass percent……………………………………______/3 points

TOTAL……………………………………………………………………………………………______**/30 points**