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: Materials, Reagent Table, Procedures, and set up Data Tables before you get to class.
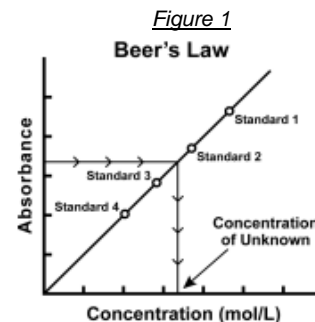   **During Lab:** Data section – Fill out your data table that is already set up from the prelab.
   Post-lab: Calculation section, Discussion Questions Section

Introduction

The primary objective of this experiment is to determine the concentration of an unknown copper (II) sulfate solution. The $CuSO_4$ solution used in this experiment has a blue color, so Colorimeter users will be instructed to use the red LED. Spectrometer users will determine an appropriate wavelength based on the absorbance spectrum of the solution. A higher concentration of the colored solution absorbs more light (and transmits less) than a solution of lower concentration.

Figure 1
Beer's Law

You will prepare five $CuSO_4$ solutions of known concentration (standard solutions). Each solution is transferred to a small, rectangular cuvette that is placed into Spectrometer. The amount of light that penetrates the solution is used to compute the absorbance of each solution. When you graph absorbance *vs.* concentration for the standard solutions, a direct relationship should result. The direct relationship between absorbance and concentration for a solution is known as *Beer's law*.

You will determine the concentration of an unknown $CuSO_4$ solution by measuring its absorbance. By locating the absorbance of the unknown on the vertical axis of the graph, the corresponding concentration can be found on the horizontal axis. The concentration of the unknown can also be found using the slope of the Beer's law curve.

Objectives

In this experiment, you will

- Prepare and test the absorbance of five standard copper (II) sulfate solutions.
- Calculate a standard curve from the test results of the standard solutions.
- Test the absorbance of a copper (II) sulfate solution of unknown molar concentration.
- Calculate the molar concentration of the unknown $CuSO_4$ solution.

Materials

Chemicals
- 0.40 M copper (II) sulfate solution
- Copper (II) sulfate solution, unknown concentration

Equipment
- Vernier computer interface
- Vernier Spectrometer
- Cuvette
- 20x150mm test tubes x 5
- 50 mL graduated cylinders x 2

- 100 mL beaker x 2
- Pipettes
- Test tube rack
- Stir rod
- Kimwipes
- Distilled H_2O

⚠️ **SAFETY PRECAUTIONS**
Copper (II) sulfate solution.
Do not eat or drink when using this product – harmful if swallowed. Causes skin and eye irritation.

Procedure

1) Obtain and wear goggles.

2) Obtain small volumes of 0.40 M $CuSO_4$ solution and distilled water in separate beakers.

3) Label five clean, dry, test tubes 1-5. Use pipettes to prepare five standard solutions according to the chart below. Thoroughly mix each solution with a stirring rod. Clean and dry the stirring rod between uses.

Test Tube	0.40 M CuSO₄ (mL)	Distilled H₂O (mL)	Concentration (M)
1	2	8	0.080
2	4	6	0.16
3	6	4	0.24
4	8	2	0.32
5	~10	0	0.40

4) Prepare a *blank* by filling a cuvette 3/4 full with distilled water. 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.
   ● Dislodge any bubbles by gently tapping the cuvette on a hard surface.
   ● Always position the cuvette so the light passes through the clear sides.

Using the Spectrometer

5) Connect the Spectrometer to the computer. Choose New from the File menu.

6) To calibrate the Spectrometer, place the blank cuvette into the cuvette slot of the Spectrometer, choose
Calibrate ▶Spectrometer from the Experiment menu. Wait for the Spectrometer to warm up, and then click ⬚ OK ⬚.

7) Determine the optimal wavelength for creating this standard curve.

   a. Remove the blank cuvette, and place the 0.40 M standard into the cuvette slot.

   b. Click ▶ Collect . The absorbance *vs.* wavelength spectrum will be displayed. Click ■ Stop .

   c. To set up the data collection mode and select a wavelength for analysis, click Configure Spectrometer Data
   Collection, 📊 .

   d. Click Abs *vs.* Concentration (under the Set Collection Mode). Under the list of wavelengths, click Clear
   Selection. Choose the wavelength nearest to 635 nm from the list. Click OK to continue and proceed to Step 8.

8) You are now ready to collect absorbance-concentration data for the five standard solutions.

   a. Click ▶ Collect .

   b. Using the solution in Test Tube 1, rinse the cuvette twice with ~1 mL amounts and then fill it 3/4 full. Wipe the
   outside with a tissue and place it in the device (Colorimeter or Spectrometer). Close the lid on the Colorimeter.

   c. After the absorbance readings stabilize, click ⊕ Keep , type **0.080** in the edit box, and click ⬚ OK ⬚.

   d. Discard the cuvette contents as directed. Using the solution in Test Tube 2, rinse and fill the cuvette 3/4 full.
   Wipe the outside and place the cuvette in the device. After the absorbance readings stabilize, click ⊕ Keep ,
   type **0.16** in the edit box, and click ⬚ OK ⬚.

   e. Repeat the procedure for Test Tubes 3–5. **Note**: Do not test the unknown solution until Step 9.

   f. When you have finished testing the standard solutions, click ■ Stop .

   g. Examine the graph of absorbance vs. concentration. Click Linear Regression, 📈 . A best-fit linear regression
   line will be shown for your five data points.

9) Write down the absorbance values, for each of the five trials, in your data table.

10) Determine the absorbance value of the unknown $CuSO_4$ solution.

   a. Obtain about 5 mL of the *unknown* $CuSO_4$ in another clean, dry, test tube. Record the number of the unknown
   in your data table.

   b. Rinse the cuvette twice with the unknown solution and fill it about 3/4 full. Wipe the outside of the cuvette,
   place it into the device. **Important**: The reading in the meter is live, so it is not necessary to click ▶ Collect to
   read the absorbance value.

   c. Read the absorbance value displayed in the meter. When the displayed absorbance value stabilizes, record its
   value as Trial 6 in your data table.

   d. Select Interpolate from the Analyze menu. Find the absorbance value that is closest to the absorbance reading
   you obtained in Step c above. Determine the concentration of your unknown $CuSO_4$ solution and record the
   concentration in your data table.

Disposal and Cleanup
Your teacher will provide disposal and cleanup instructions.

Data Table

Trial	Concentration (mol/L)	Absorbance
1	0.080	
2	0.16	
3	0.24	
4	0.32	
5	0.40	
Unknown # _____	6	Unknown number _____	

Calculations
Record all values into your Data Table
1. Print a copy of your Vernier graph and glue/tape it into your notebook. Make sure your graph includes a line of best fit with the equation for the line displayed, a descriptive title, and that both axis have labels/units where appropriate.

Post Lab Discussion Questions
Answer as part of your post lab. Do not recopy the questions, just paraphrase them into your answer so the reader can infer what the question was.
1. What is the equation for Beer's Law? Name each of the variables in the equation.
2. What is the molar concentration of your unknown sample of copper (II) sulfate solution based on the reading you got on your Vernier graph (not doing any calculations, just using the cursor on the graph software to find your A value and then seeing what C is)?
3. Calculate algebraically what the Concentration for the unknown is by using Beer's Law, your Absorbance reading for your unknown, the known path length of the cuvette, and the accepted molar absorptivity value of $CuSO_4$ at 635nm of 2.81 $M^{-1}cm^{-1}$. Show your work.
4. Does the answer you got from the graph in Question 3, match what you got from the algebra in Question 4? (Within reason, obviously there may be slight differences from lab errors).
5. What do you notice about the slope of your best fit line on your graph – meaning, does that number represent something from Question 3?
6. What factors are included in the Beer's law expression for determining how much light passes through a liquid solution?
7. How would your test results be affected if you left fingerprints on the sides of the cuvette in line with the light path of the Spectrometer
8. Could this method of testing be used to determine the concentration of a NaCl solution? Why or why not?