

DETERMINING THE CONCENTRATION OF COPPER (II) SULFATE

LAB SPEC.17

The primary objective of this experiment is to determine the concentration of an unknown copper (II) sulfate solution. You will use a Vernier Spectrometer (V-SPEC) to measure the concentration of each solution. You will first measure the absorbance of a standard solution over the visible light spectrum (380 – 950 nm) and select the wavelength of maximum absorbance. A higher concentration of the colored solution absorbs more light (and transmits less) than a solution of lower concentration. The Vernier Spectrometer monitors the light passing through the sample as percent transmittance.

You will prepare five copper (II) sulfate solutions of known concentration (standard solution). Each solution is transferred to a small, rectangular cuvette that is placed into the V-SPEC. The amount of light that passes through 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 with the V-SPEC and using the slope of the Beer's law curve.

OBJECTIVES

In this experiment, you will

- Measure and analyze the visible light absorbance spectrum of a standard copper (II) sulfate solution to determine the maximum wavelength of absorbance.
- 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.

MATERIALS


Vernier Spectrometer	0.10 M copper (II) sulfate, CuSO_4 , solution
Computer	Copper (II) sulfate, CuSO_4 , unknown solution
Pipet pump or pipet bulb	Distilled water
One cuvette	Test tube rack
Five 20 x 150 mm test tubes	Stirring rod
Two 10 mL pipets or graduated cylinders	Tissues (preferably lint-free)
Two 100 mL beakers	

PROCEDURE

1. Obtain and wear goggles.
2. Use a USB cable to connect a Vernier Spectrometer to a computer.
3. Start the Logger Pro 3.4.5 program on your computer.
4. Obtain small volumes of 0.10 M CuSO₄ solution and distilled water in separate beakers.
5. Label five clean, dry, test tubes 1-5. Use pipets to prepare four standard solutions according to the chart below (the fifth standard is the stock 0.10 M CuSO₄ solution). Thoroughly mix each solution with a stirring rod. Clean and dry the stirring rod between uses.

Test Tube number	0.10 M CuSO ₄ (mL)	Distilled H ₂ O (mL)	Concentration (M)
1	2	8	0.02
2	4	6	0.04
3	6	4	0.06
4	8	2	0.08
5	~10	0	0.10

6. To set up the V-SPEC, open the Experiment menu and select Connect Interface→Spectrometer→Scan for Spectrometers.
7. Calibrate the Spectrometer.
 - a. Prepare a *blank* by filling an empty cuvette $\frac{3}{4}$ full with distilled water.
 - b. Open the Experiment menu and select Calibrate →(Spectrometer). The following message appears in the Calibrate dialog box: “waiting...seconds for the device to warm up.” After 60 seconds, the message changes to: “Warmup complete.”
 - c. Place the blank in the cuvette holder of the spectrometer. Align the cuvette so that the clear sides are facing the light source of the spectrometer. Click “Finish Calibration”, and then click .
8. Determine the maximum wavelength for CuSO₄ (aq) and set up the data collection mode.
 - a. Empty the blank cuvette and rinse it twice with small amounts of the 0.10 M CuSO₄ solution.
 - b. Click . A full spectrum graph of the CuSO₄ solution will be displayed. Note that one area of the graph contains a peak absorbance. Click to complete the analysis.
 - c. To save your graph of absorbance vs. wavelength, select Store Latest Run from the Experiment menu.
 - d. Click the Configure Spectrometer Data Collection icon, on the toolbar. A dialog box will appear.

- e. Select Absorbance vs. Concentration under Set Collection Mode. The peak absorbance will be automatically selected. Select a new wavelength, if necessary, by clicking on the graph or checking the box next to the desired wavelength. Click to proceed.
9. Collect absorbance-concentration data for the five standard solutions.
 - a. Remove the cuvette from the spectrometer and dispose the solution as directed. Use the solution in Test Tube 1 to rinse the cuvette twice with ~1 mL amounts, and then fill it $\frac{3}{4}$ full. Wipe the cuvette with a tissue and place it in the spectrometer cuvette holder. Click . When the absorbance reading stabilizes, click . Enter "0.08" as the concentration of the solution and click .
 - b. Discard the cuvette contents as directed. Using the solution in Test Tube 2, rinse and fill the cuvette $\frac{3}{4}$ full. Wipe the cuvette and place in the spectrometer. When the absorbance reading stabilizes, click . Enter "0.16" as the concentration.
 - c. Repeat Step 8b for the remaining test tubes of the standard CuSO_4 solution. When you have finished testing the standard solutions, click .
10. To determine the best-fit line equation for the CuSO_4 standard solutions, click the linear fit button , on the toolbar. Write down the equation for the standard solutions in your data table or lab book.
11. Determine the concentration of the unknown CuSO_4 solution.
 - a. Obtain about 5 mL of the *unknown* CuSO_4 solution.
 - b. Rinse the cuvette twice with the unknown solution and fill it about $\frac{3}{4}$ full. Wipe the outside of the cuvette and place it into the spectrometer.
 - c. Select Interpolation Calculator, from the Analyze menu. A dialog box will appear that displays the concentration of your unknown at the measured absorbance.
 - d. Click . Write down the concentration of the unknown in your data table or lab book.
 - e. Dispose of any of the remaining solutions as directed.
12. Print a copy of your graphs and/or data table.
13. (optional) Select Save As... from the File menu and save your experiment file.
14. Select Exit from the File menu to close down LoggerPro 3.

