## Determining the Concentration of a Solution

As you learned in section 2.6, chemists can use a spectrophotometer to determine the concentration of a solution. A spectrophotometer measures the amount of light energy that is absorbed or transmitted by dissolved solutes as light passes through the solution. In this activity, you will use a spectrophotometer to determine the concentration of a copper(II) sulfate solution, $CuSO_{4(aq)}$. When concentrated aqueous ammonia, $NH_{3(aq)}$, is added to aqueous copper(II) sulfate, $CuSO_{4(aq)}$, the pale blue copper(II) ion, $Cu^{2+}_{(aq)}$, is converted to the intensely blue-coloured $Cu(NH_3)^{2+}_{4(aq)}$ ion.

### Question

What is the molar concentration of a copper(II) sulfate solution?

### Materials

spectrophotometer
eight 50-mL beakers
burette stand
two 50-mL burettes
10-mL graduated cylinder
glass stirring rod
marking pens
10 test tubes or cuvettes (to fit the spectrophotometer)
100 mL 0.50-mol/L copper(II) sulfate solution, $CuSO_{4(aq)}$
5 mL copper(II) sulfate solution of unknown concentration

### Procedure

Copper(II) sulfate is toxic. Avoid contact with skin.

1. Copy **Table 1**, allowing enough space to record your observations for ten samples.

**Table 1** Observation Table

| Test tube | $[Cu^{2+}_{(aq)}]$ | Absorbance |
|---|---|---|
| | | |

(Assume that $[Cu^{2+}_{(aq)}] = [CuSO_{4(aq)}]$.)

2. Fill a clean burette with 50 mL of distilled water.
3. Fill another clean burette with 50 mL of 0.50-mol/L copper(II) sulfate solution.
4. Label eight clean, dry 50-mL beakers with the numbers 1 to 8.
5. Use the eight labelled beakers to prepare increasingly dilute copper(II) sulfate solutions, according to **Table 2**.

**Table 2** Concentrations of Dilute Copper(II) Sulfate Solutions

| Beaker | $[CuSO_{4(aq)}]$ (mol/L) |
|---|---|
| 1 | 0.50 |
| 2 | 0.25 |
| 3 | 0.14 |
| 4 | 0.07 |
| 5 | 0.04 |
| 6 | 0.02 |
| 7 | 0.002 |
| 8 | 0.0002 |

6. Label eight test tubes with the numbers 1 to 8. Label a ninth test tube "distilled water." (This test tube will act as a "blank.") Label a tenth test tube "unknown."
7. Pour 5.0 mL of each copper(II) sulfate solution that you prepared in step 5 into its corresponding test tube. Pour 5.0 mL of distilled water into test tube 9.

8. Use the operating instructions for your spectrophotometer to set the desired wavelength and zero the instrument. Ask your teacher for assistance if necessary. Keep the spectrophotometer well-covered at all times to prevent stray light from entering the instrument.
9. Place test tube 1 in the well of the spectrophotometer, and read the absorbance for the solution. Repeat for test tubes 2 through 8. Record the absorbance values in your observation table (**Table 1**).
10. Pour 5.0 mL of copper(II) sulfate of unknown concentration into test tube 10. Measure the absorbance for the solution, and record this value in your observation table.
11. Dispose of all solutions according to your teacher's instructions. Clean up your work area.

## Analysis

(a) Plot a graph of absorbance versus concentration of $Cu^{2+}_{(aq)}$ by plotting absorbance on the vertical axis. Draw a line of best fit through the points on the graph. If more points are needed to produce a smooth line, prepare additional concentrations of $Cu^{2+}_{(aq)}$ ions, measure the absorbance values, and add these values to your graph.

(b) What does your graph tell you about the relationship between absorbance and concentration?

(c) Answer the Question.

## Evaluation

(d) Why did you zero the spectrophotometer initially? Explain why you used a "blank."

(e) Describe possible sources of experimental error in this activity.

(f) Suggest improvements to the Procedure that would help to reduce error.