**TEACHER INFORMATION**

# Determining the Concentration of a Solution: Beer's Law

1.  Editable Microsoft Word versions of the student pages and pre-configured TI-Nspire files can be found on the CD that accompanies this book. See *Appendix A* for more information.

2.  The light source for the nickel (II) sulfate solution is the red LED (635 nm). Since the $NiSO_4$ is green in color, the nearly monochromatic red light is readily absorbed by the solution.

3.  The 0.40 M $NiSO_4$ solution can be prepared by using 10.51 g of $NiSO_4 \cdot 6H_2O$ per 100 mL. **HAZARD ALERT:** Toxic; avoid dispersing this substance; dispense with care; Nickel dust is a *possible carcinogen*. Hazard Code: B—Hazardous.

    The hazard information reference is: Flinn Scientific, Inc., *Chemical & Biological Catalog Reference Manual,* (800) 452-1261, www.flinnsci.com.

4.  Solutions of $Ni(NO_3)_2$ also work well, and can be prepared by using 11.63 g of solid $Ni(NO_3)_2 \cdot 6H_2O$ per 100 mL of solution.

5.  Unknowns can be prepared by doing dilutions starting with the 0.40 M $NiSO_4$ stock solution. For example, to prepare a 0.22 M unknown, use 55 mL of the standard plus 45 mL of water:

    $$(55 \text{ mL} / 100 \text{ mL})(.40 \text{ M}) = 0.22 \text{ M}$$

6.  This experiment works well using solutions of green food coloring. A solution with an absorbance similar to 0.40 M $NiSO_4$ can be prepared by dissolving 8–9 drops of green Schilling Food Coloring in 1 liter of distilled water. Check to see that the absorbance of this stock solution falls in the range of 0.40 to 0.80. Assign this solution a concentration of 100%. Students will follow the same procedure to dilute the stock solution to 80%, 60%, 40%, and 20%. Make the solutions fresh as they can discolor over time.

7.  The cuvette must be from 55% to 100% full in order to get a valid absorbance reading. If students fill the cuvette 3/4 full, as described in the procedure, they should easily be in this range. To avoid spilling solution into the cuvette slot, remind students not to fill the cuvette.

8.  Since there is some variation in the amount of light absorbed by the cuvette if it is rotated 180°, you should use a water-proof marker to make a reference mark on the top edge of one of the clear sides of all cuvettes. Students are reminded in the procedure to align this mark with the white reference mark at the top of the cuvette slot on the Colorimeter.

9.  The use of a single cuvette in the procedure is to eliminate errors introduced by slight variations in the absorbance of different plastic cuvettes. If one cuvette is used throughout the experiment by a student group, this variable is eliminated. The two rinses done prior to adding a new solution can be accomplished very quickly.

10. There are two models of Vernier Colorimeters. The first model (rectangular shape) has three wavelength settings, and the newest model (a rounded shape) has four wavelength settings. The 635 nm wavelength of either model is used in this experiment. The newer model is an auto-ID sensor and supports automatic calibration (pressing the CAL button on the Colorimeter with a blank cuvette in the slot). If you have an older model Colorimeter, see www.vernier.com/til/1665.html for calibration information.

11. This experiment gives you a good opportunity to discuss the relationship between percent transmittance and absorbance. At the end of the experiment, students can click the Absorbance vertical-axis label of the graph, and choose Transmittance. The graph should now be transmittance *vs.* concentration. You can also discuss the mathematical relationship between absorbance and percent transmittance, as represented by either of these formulas:

$$A = \log(100\,/\,\%T) \ \text{ or } \ A = 2 - \log\%T$$

## SAMPLE RESULTS
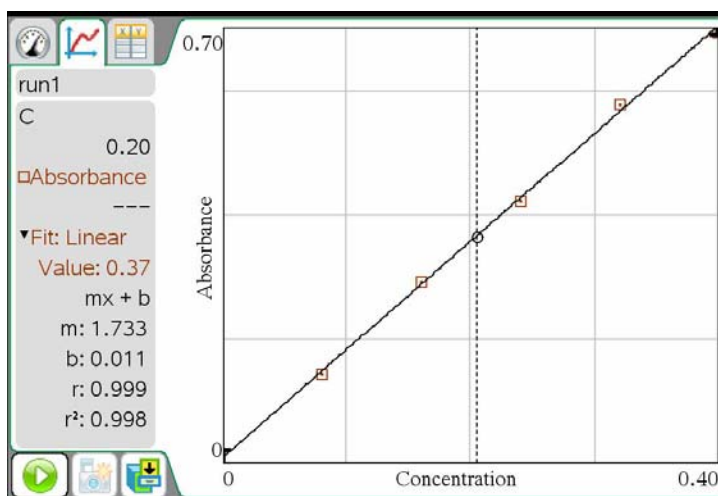


*Absorbance vs. concentration for NiSO₄*
*with interpolation of the unknown displayed*

| Trial | Concentration (mol / L) | Absorbance |
|-------|-------------------------|------------|
| 1 | 0.080 | 0.14 |
| 2 | 0.16 | 0.29 |
| 3 | 0.24 | 0.42 |
| 4 | 0.32 | 0.58 |
| 5 | 0.40 | 0.69 |
| 6 | Unknown number       1 | 0.37 |

| | |
|---|---|
| Linear Fit Equation: | Absorbance = 1.733*Concentration + 0.011 |
| Concentration of the unknown | 0.20 mol/L |