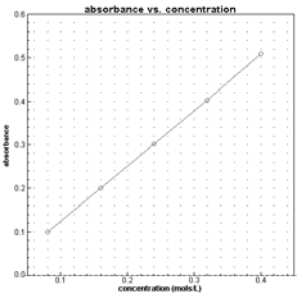
Lower Merion High School Chemistry

Beer's Law

Lab #20

Some solutions have color because they absorb some, but not all of the colors of light that hit them. For instance copper solutions appear blue because they absorb most, or all, of the orange, red and yellow light that hits them. As a result most of the light that is reflected or passes through is blue (with some green and purple). In all cased the color that we see is the opposite (on a color wheel) of the color that is most absorbed.



This absorption occurs through a Bohr-like process. Light with the right energy hits an ion of copper in solution. The energy is absorbed and an electron jumps to a higher level. When the electron drops back down, the light is re-emitted in a random direction (as opposed to the direction the photon was traveling). This results in a decrease in the amount of light of that color that emerges from the opposite side of the solution. Different ions can absorb different wavelengths of light and so have different colors.

The more ions that are present in solution, the more light which can be absorbed. As a result, the amount of light that is absorbed (called absorbance) is directly proportional to the concentration of the solution. In other words a graph of absorbance v. concentration will give a straight line.

If we plot absorbance v. concentration for a number of solutions whose concentration is known we can then use the graph to determine the concentration of an unknown by plotting its absorbance.

In this lab, you will be using Calculator based Laboratories (CBLs) and colorimeters to measure the absorbance of solutions. A colorimeter (see diagram) passes light of a given color through a small container of solution, called a cuvette. The solution we will be using is green and you will therefore be passing red light through it.

Materials:

CBL System	4 $NiSO_4$ solutions of known concentration
TI Graphing Calculator	1 $NiSO_4$ of unknown concentration
Vernier Colorimeter	deionized water
Vernier adapter cable	test tube rack
one cuvette	stirring rod
five 20 X 150 mm test tubes	

Procedure:

Number four of the test tubes 1-4 and label the last"**?**" Obtain about 10 mL of the known $NiSO_4$ solutions in tubes 1-4 and 10 ml of the unknown in the last test tube.

Set up the calculator, CBL and colorimeter.

Run the program CHEMBIO. From the main menu, go to SET UP PROBES. After telling the calculator the number of probes (one) and the channel (wherever you plugged in the probe) you will need to calibrate the colorimeter.

Prepare a blank by filling a cuvette 3/4 full of deionized water. Make sure that the smooth sides of the cuvette are clean and dry, and then place it in the colorimeter. Be sure that the cuvette is oriented so that the light travels through the smooth sides.

Close the lid of the colorimeter and turn the knob to 0% T. This position turns on the photocell (the light detector) but does not turn on any source of light, so that the photocell receives no signal. When the voltage reading on the CBL stabilizes, press TRIGGER, then hit 0 and ENTER on the calculator.

Turn the knob to the RED setting. This turns on the red LED (red is most readily absorbed by green solutions). When the voltage reading on the CBL stabilizes press TRIGGER, the enter 100 in your calculator.

After you have entered the 100, the calculator will display the calibration data. Press ENTER to return to the main menu. You do NOT need the calibration data.

From the main menu choose COLLECT DATA. From the data collection menu, choose TRIGGER/PROMPT.

Dump the deionized water from the cuvette. Fill the cuvette with the first solution and then dump it. Do this twice, then refill the cuvette with the solution. This will rinse the water from the cuvette so that any drops remaining will be of the solution you wish to measure. Place the cuvette in the colorimeter, being sure to orient the cuvette in the same direction used before. Close the lid of the colorimeter.

When the reading on the CBL stabilizes, press TRIGGER, then enter the concentration in the calculator. Remove the cuvette from the colorimeter, rinse it with the next solution and repeat the measurement. Continue with the other solutions of KNOWN concentration.

After taking the reading of the last known solution, choose STOP AND GRAPH. If the data displayed is linear, use the cursor buttons to move from point to point on the graph and copy down both the X (concentration) and Y (absorbance) values for each point. If the data is not linear, repeat the lab.

Press ENTER to return to the main menu. Note: Do NOT press SET UP PROBES! You will lose all data if you do. Go to the DATA COLLECTION menu and choose MONITOR INPUT. Remove the cuvette from the colorimeter and rinse and fill it with the unknown solution. Place the cuvette of unknown back into the colorimeter and close the lid. When the reading stabilizes record the absorbance value displayed on the calculator (not the CBL value!). Press + to return to the main menu.

Discard your solutions, rinse out your test tubes and cuvette and return all equipment.

Calculations:

Graph absorbance v. concentration for the solutions of known concentration and determine the equation of the best-fit line for the data. Use this equation to determine the concentration of the unknown solution.