

Chemistry 60 Experiment E Determination of Cu in solution, using Beer's Law.

Introduction. When white light is passed through a solution of a substance, a percentage of the photons may be absorbed by the substance, or even the solvent. A spectrophotometer measures the percentage of light transmitted (or absorbed) by using either a single or double beam of light. If a single beam of light is used, a "blank" is inserted before each sample is run. In a double beam instrument, the blank is left in place and used to "zero" the absorbance. Usually, both the Absorbance and % transmittance scales are available on the instrument. If the instrument gives a digital readout, the absorbance can be recorded directly, but if a scale on a dial is shown, it is easier to read the percent transmittance (%T) scale and convert to absorbance, since the absorbance is not on a linear scale. The instrument in this case will provide the Absorbance reading.

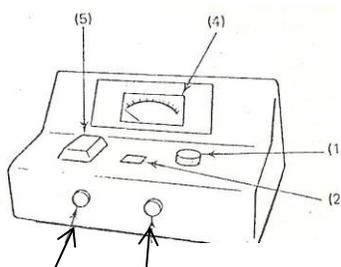
Beer's Law states that the absorbance is proportional to concentration:

$$A = abc \quad (\text{a is the "molar absorptivity constant" (b is the path length - usually 1 cm)})$$

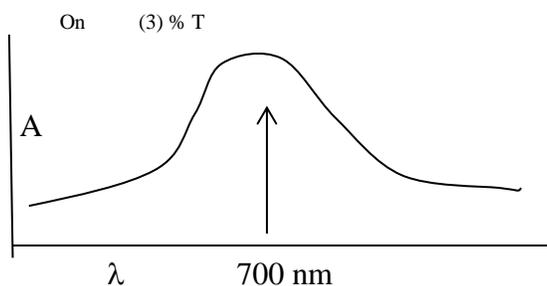
Constants a and b can be combined into one "k".

A Bausch & Lomb Spectronic 20 or similar instrument is used in this experiment

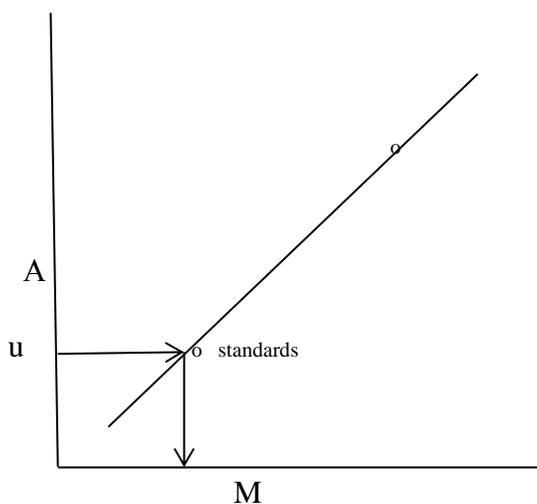
1. wavelength control
2. wavelength scale (old Spec 20 only) Spec 20D is all digital
3. 0% transmittance adjustment
4. Absorbance and %T scale and mode buttons
5. sample holder



The absorbance also varies with the wavelength used. A solute such as the Cu^{2+} ion absorbs light most efficiently at about 700 nm. But sometimes, to increase the efficiency of light absorption, the Cu^{2+} is combined with NH_3 which also lowers the wavelength of the λ_{max} to about 605 nm. For this lab we'll use Cu^{2+} without NH_3 .



A series of "standards", solutions with known molarity will be plotted at a fixed λ_{max} with the absorbance on the y axis and molarity on the x axis. Then the absorbance of a solution (u) with unknown concentration can be found, and the molarity is read off the graph.



The standards are prepared by a series of dilutions.

The initial primary standard, labeled PS is 0.100 M

The first dilution (flask #1) = (20 mL PS + 20 mL water) = 0.0500 M

The second dilution (flask #2) = (20 mL of #1 + 10 mL water) = $\frac{2}{3} \times 0.05 = 0.03335$ M

The third dilution (flask #3) = (10 mL of #2 + 20 mL water) = $\frac{1}{3} \times 0.03335 = 0.01112$ M

You now have 4 solutions whose absorbances will be read, starting with the most dilute.

Record the Molarities of the diluted solutions on the report sheet to the appropriate # of sig figs !!

Procedures Check out 2 cuvettes You may work with a lab partner in preparing and measuring your standards, but each student will obtain his or her own unknown solution. Record the code #. !!!!
You will need one 150 mL beaker and three 125 mL Erlenmeyer flasks, labeled 1,2,3

1. Obtain about 30 mL of 0.100 M Cu^{2+} solution (CuSO_4) in a 150 mL beaker. This is your “primary standard” . label it PS (Primary standard) Cover it with a watch glass.
2. Using your 50 mL grad cylinder – obtain 20.0 mL of 0.100M Cu^{2+} primary standard as precisely as possible. Use dropper to get the meniscus to 20.0 mL. Pour this into a 125 mL flask (label the flask #1). . *Do not rinse the grad cylinder.* Then using your wash bottle, deliver 20.0 mL of deionized water into the 50 mL grad cylinder. Pour this 20.0 mL sample into the Erlenmeyer flask (#1)
Keep this same procedure in mind when doing the following dilutions !
3. Measure 20.0 mL of solution #1 and 10.0 mL de-I water into another 125 mL flask – labeled #2.
4. Measure 10.0 mL of solution #2 and 20.0 mL de-I water into another 125 mL flask – labeled #3
5. Take all the above flasks, a wash bottle, an empty beaker for waste, and the cuvettes to the spectro – photometer. Stash the cuvettes in a small beaker.
- 6.. When doing spectrophotometry it is a good idea to start with the most dilute solution first. Keep one cuvette with water as the blank. Use the other cuvette for standard and unknown solutions. So fill the other cuvette with solution # 3. Fill it to about 1cm from the top. Wipe the cuvette with a Chemwipe tissue if it is wet !!!!!
7. Turn on the spectrophotometer if it is off (left front dial). Set the wavelength dial to 700 nm. Leave this dial alone.
12. Insert your blank cuvette containing water. The white mark on the cuvette should face you directly. Push the mode button on the top until transmittance is marked with the red light. Carefully dial the right front dial until % T = 100.0 .
13. Remove the blank, and insert the cuvette with solution #3. Push the mode button until Absorbance is selected with the small red light. Read the absorbance value and record it. Do not touch any of the dials – just empty your cuvette into the waste beaker and rinse it and fill with the next solution until you have obtained absorbance readings on all your solutions, including the unknown.

Sometimes the primary standard is too concentrated for the spectrophotometer to read the absorbance accurately. Consult with your instructor if this seems to be the case. If so – you will still have three points to graph. That should be sufficient. If the graph does not appear to be linear, you may wish to repeat your work. Use fine graph paper (10 sq/inch or finer).

Plot the absorbance vs molarity of the standards, then plot the absorbance of the unknown on the scale and read the molarity off the graph.

Expt E Spectrophometric Cu Name: _____ Section _____

Report sheet. due date: _____ date submitted _____

Data: Code # unknown used: _____

Molarity of Cu^{2+} in primary standard: _____ M	Absorbance readings: _____
Standard # 1: _____ M	_____
Standard # 2: _____ M	_____
Standard # 3: _____ M	_____

Absorbance reading of the unknown Cu^{2+} solution : _____

Analysis of data:

Plot the above data on a piece of graph paper (manually – 10 sq/inch paper)

From the graph: the molarity of Cu^{2+} in the unknown solution : _____

Questions

1. Discuss some possible systematic and random errors which you may have encountered in this experiment.

2. On the graph – find the slope “k”. Show the setup on the graph paper. k = _____

3. Given that absorbance is proportional to the concentration (Molarity) : $A = k M$
What would be the absorbance of a 0.120 M solution of Cu^{2+} ?