Absorbance and Concentration

Background

The fraction of light of a particular wavelength absorbed by a solution depends on how strongly the solute absorbs, how concentrated the solution is, and the distance the light must pass through the solution. This is quantified in *Beer's law*

$$A = \varepsilon cl$$

Where A = absorption, ε = molar absorptivity, and l is the path length. The absorbance is mathematically related to the light transmitted by the sample: the less light that gets through, the larger the absorption. The molar absorptivity ε tells how prone the solute is to absorb light of the given wavelength: the larger the ε, the more light will be absorbed. The path length l is the distance the light must pass through the solution. This formula assumes that only the solute absorbs the detected light, and that the solvent is transparent.

If you have a spectrometer that can measure absorption, you can directly quantify the concentration of the solution if you already know the molar absorptivity and the path length. Here, instead of measuring absorptivity, we will adjust the path length of the unknown sample so that its absorption matches the absorption of a solution of known concentration and path length. Then

$$A_1 = A_2$$

$$\varepsilon c_1 l_1 = \varepsilon c_2 l_2$$

$$c_2 = c_1 \, l_1 / l_2$$

As a check on our procedure and technique, we will repeat the experiment by adjusting the path length of the standard solution so that it matches the absorption of the unknown.

Objective

To determine the concentration of a solution by visually comparing its absorbance to a reference solution of known concentration.

Safety

Wear chemical splash goggles and gloves. Wear closed-toed shoes and long pants.

Materials

• Two flat-bottom test tubes	• White background paper
• Beral pipet	• ruler
• Standard solution	• "Unknown" solution

Procedure

Adjusting the unknown

1. With the beral pipet, place some standard solution in a flat-bottomed test tube. Measure the height of the solution in the test tube and record it in the data table.
2. Hold the two tubes level and together over the white background paper, so that you can see the colors of the solutions as you look directly down through them.
3. Drop the unknown solution into the other test tube until the two solutions have the same color intensity.
4. Measure the height of the unknown solution in the test tube and record it in the data table.
5. Pour the unknown solution into the waste container and rinse it with a little distilled water. Pour the rinse water into the waste container as well. Allow the rinse water to drain well.
6. Have all members of your lab group repeat the experiment. Use the same tube of standard solution, but each member should find the height of unknown solution that makes the absorptions match.

Adjusting the Standard

1. With the beral pipet, place some unknown solution in a flat-bottomed test tube. Measure the height of the solution in the test tube and record it in the data table.
2. Hold the two tubes level and together over the white background paper, so that you can see the colors of the solutions as you look directly down through them.
3. Drop the standard solution into the other test tube until the two solutions have the same color intensity.
4. Measure the height of the standard solution in the test tube and record it in the data table.
5. Pour the standard solution into the waste container and rinse it with a little distilled water. Pour the rinse water into the waste container as well. Allow the rinse water to drain well.
6. Have all members of your lab group repeat the experiment. Use the same tube of unknown solution, but each member should find the height of standard solution that makes the absorptions match.

Concluding

Clean up your lab area. Combine used solutions into the waste beaker. Rinse the containers once with water and pour the rinse water into the waste beaker.

Data

Identity of solute	
Concentration of standard solution	

Adjusting the unknown

Path length of standard solution	
Matching path length of unknown solution	

Adjusting the standard

Path length of unknown solution	
Matching path length of standard solution	

Calculations

Apply the formula to find the concentration of the unknown solution. Show your work.

Adjusting the unknown

Adjusting the standard

What did you find?

1. Do your two different estimates of the concentration of the unknown solution agree with each other? What does that mean?

2. Do your estimates of the concentration agree with the estimates by your lab partners? What does that mean?

Scoring

Lab technique, safety, procedure, housekeeping	9 points
Data Table	4 points
Calculations	8 points
Answers to Questions	4 points