Determining the Concentration of a Solution: Beer's Law

Background:

Beer's Law is the basis for the determination of the concentration of an unknown solution. It states that there is a linear relationship between the absorbance and the concentration of the absorbing substance.

To verify this law, we can measure the absorbances for different concentrations of a substance at the same wavelength, plot them on a graph paper and see if they will yield a straight line. Actually, the points will deviate more or less from an ideal straight line, due to the uncertainty in the measurements.

The concentration of an unknown solution can be found by measuring its absorbance and finding the corresponding concentration on the graph.

Materials:

Spectrophotometer or Colorimeter
Cuvette
0.40 M Nickel (II) Sulfate solution
Pipette or Buret
6 test tubes
Distilled water

Procedure:

1. Obtain about 30 ml of 0.40 M $NiSO_4$ stock solution in a small beaker and about 30 ml distilled water in another small beaker.
2. Label five clean, dry, test tubes 1-5. Using a pipet or buret, deliver 2, 4, 6, 8, and 10 ml of $NiSO_4$ solution into the test tubes 1-5, respectively. With a second pipet or buret, deliver 8, 6, 4, 2, and 0 ml of distilled water into test tubes 1-5, respectively. Thoroughly mix each solution with a stirring rod. Clean and dry the stirring rod between stirrings. These are your five standard solutions. Volumes and concentrations for the trials are summarized below:

Trial number	0.40 M $NiSO_4$ (mL)	Distilled H_2O (mL)	Concentration (M)
1	2	8	0.08
2	4	6	0.16
3	6	4	0.24
4	8	2	0.32
5	~10	0	0.40

3. Select a wavelength of 635 nm on your spectrophotometer or calorimeter. You will need to calibrate at this wavelength. Place a cuvette with distilled water into the sample compartment of the machine and adjust to 100%T.
4. Fill another cuvette with the first standard solution and insert it into the sample compartment. Measure the absorbance of the first standard and record as your first trial in the table.
5. Repeat step 4 for the other standard solutions. Be sure to clean and dry the cuvette each time you fill it with a new sample.
6. Obtain about 5 ml of the unknown $NiSO_4$ solution in another clean, dry, test tube. Record the number of the unknown in the table. Fill a cuvette with the unknown, measure and record the absorbance value.

Data:

Trial	Concentration (mol/L)	Absorbance
1	0.080	
2	0.16	
3	0.24	
4	0.32	
5	0.40	
6	Unknown number ____	

Concentration of unknown	mol/L

Calculations:

1. On a sheet of graph paper, label the horizontal axis "concentration" and mark it in equal intervals from 0 to 0.02M. Label the vertical axis "absorbance" and mark it in equal intervals from 0 to a convenient round value above your highest data points.

2. Plot absorbance vs. concentration for the five standard solutions.

3. Using a ruler, draw a straight line from the origin such that there are equal numbers of points above and below the line. This is the Beer's Law plot.

4. Using the absorbance value of you unknown, find the corresponding concentration on your graph and record this value to the nearest one-hundredth M in the table.