**Lab [25 pts]**
**Molarity and Absorption**

Name _____
Lab Partner _____
Period _____ Date _____

**Purpose**: To become familiar with making solutions by dissolving solids into water and by diluting solutions. To experimentally verify that the concentration of a solution is directly proportional to the amount of light absorbed (absorbance) in a colorimeter (Beer's Law).

**Background:** Chemists often need to determine the concentration of a solute in a solution. They can do this by using a spectrophotometer or colorimeter to measure the amount of light of a given wavelength absorbed by the solution. By choosing a wavelength of light of the complimentary color to the solution, the absorbance of the solution is directly proportional to the concentration, a relationship called **Beer's Law**: $A = a \times b \times c$ where A is the absorbance (what you measure), a is the absorptivity of the solute, b is the path length of the cuvette (see below), and c is the concentration. For us, a and b will be constant, so $A = mc$, where m is the slope of the line formed by plotting A for set of solutions of known concentration, called a calibration "curve" (even though is should be a straight line). From this, you can determine an unknown concentration by measuring A.

**Prelab Calculations/Procedure**: Making solutions of $CuSO_4$ and testing their absorbance. *Perform all indicated calculations before coming into the lab!*

1) **0.50 M Solution: Make 50 mL of 0.50 M $CuSO_4$ solution from solid $CuSO_4$ crystals**
   a) [2 pt Prelab] Determine the grams of $CuSO_4$ needed to make 50 mL of 0.50 M $CuSO_4$ (aq).
   ** **Needed info**: *The molar mass is **249.6 g/mole** since $CuSO_4$(s) is a hydrate, which has 5 water molecules contained within the crystal lattice of the solid. Its formula is $CuSO_4 \cdot 5\ H_2O$. Show all work here!*

   b) Place the needed mass of $CuSO_4$ (from part a) into a **50 mL volumetric flask** (Careful, don't spill). Fill about 3/4 with distilled $H_2O$. Shake flask until all of the solid dissolves. Be patient!!! Add distilled water up to the 50 mL mark, cap flask and shake until well mixed. Pour solution into beaker.
   c) Fill a plastic cuvette with the 0.50 M solution you just made. Measure its absorbance and record in data table on page 2, below its concentration. *See directions on next page to learn how to measure absorbance. Record in Data Table on next page.*

2) **0.35 M Solution:** Make **25 mL of a 0.35 M $CuSO_4$** solution by *diluting* your 0.5 M solution from #1.
   a) [2 pt Prelab] Use the dilution equation to determine the volume of the 0.5 M $CuSO_4$ solution that must be diluted with water to make 25 mL of 0.35 M $CuSO_4$. Show all work here!

   b) Use a **10-mL graduated pipette** to measure out the needed volume (from part a) of your 0.50 M $CuSO_4$. Pour solution into a **25 mL volumetric flask**. Add distilled water up to the 25 mL mark. Cap the flask and shake until well mixed.
   c) Fill a plastic cuvette with the 0.35 M solution you just made. Measure its absorbance and record in data table on page 2, below its concentration.

3) **Making four solutions by dilution of your 0.50 M $CuSO_4$ solution:** a simpler method to make dilute solutions.
   a) [2 pt Prelab] Use the dilution equation to calculate the volume of 0.50 M solution (which is $M_1$ for all) needed to make 10.0 mL ($V_2$) of the 4 dilutions as shown in the table below. To find the volume of water needed, subtract $V_1$ from 10.0 mL. ***Show sample calculation for test tube #1 below table.***

| Test tube | #1 | #2 | #3 | #4 |
|---|---|---|---|---|
| Molarity of solution, M ($M_2$) | 0.10 | 0.20 | 0.30 | 0.40 |
| Vol of 0.5 M $CuSO_4$,mL ($V_1$) | | | | |
| Vol of water needed, mL | | | | |

Sample calculations for Test Tube #1:

b) Label four large test tubes #1, #2, #3, and #4. Place them in your test tube rack. Use two **10-mL graduated pipettes** to make the 4 different dilutions by filling each test tube with the amounts of each solution shown above. Put the $CuSO_4$ solution in each test tube first, then add the water.
c) Measure the absorbance of each of the solutions just made. *Record in Data Table, below proper concentration.*

*** **To measure Absorbance:** Use the colorimeter/computer setup:
a) Carefully fill a colorimeter **cuvette** (plastic container) with one of the solutions. **Cap and wipe dry!!!**
b) Take the filled cuvette to the colorimeter/computer. Put the sample into the sample chamber. *(Make sure that the clear sides face the white line on the colorimeter.)* Close the lid of the colorimeter. Read the **absorbance** off the computer screen. Record value in data table below concentration of solution.
c) Remove cuvette. Go back to lab bench. Pour solution down drain, rinse with a new solution, refill with the same new solution, and repeat absorbance measurement.
d) When you are done, empty 0.50 M solution into beaker at front, all other solutions can be rinsed down the sink, and all of your equipment *must* be rinsed with deionized $H_2O$ until no blue remains.

**Data Table** [2 pts]

| Molarity (M) | 0.10 M | 0.20 M | 0.30 M | 0.35 M | 0.40 M | 0.50 M |
|---|---|---|---|---|---|---|
| Absorbance | | | | | | |

**Graph:** [6 pts] **Beer's Law Plot of Absorbance vs. Molarity**
a) Make a graph of the absorbance vs. molarity of your six solutions. Remember-- labels, units, and title. *Absorbance goes on the y-axis and Molarity goes on the x-axis*.
b) You should have six points on your graph and they should lie in a straight line. **Draw the best fit straight line** (use a ruler!) through the six points, making sure that it goes through the origin (0,0) since a solution of 0 M should have A = 0!
c) Make sure you show all labels, units and have a descriptive title (Not just absorbance vs. Molarity)

**Post-Lab Questions:** [11 pts] ***Answer on separate sheet***.
1) [2 pts] Is absorbance directly or inversely related to molarity? How do you know?
2) [1 pt] Suppose you have a solution of $CuSO_4$ of unknown molarity. You measure its absorbance and it turns out to be 0.55. What is the molarity of the solution based on your absorbance data obtained in lab?
*** Look at your best-fit line and determine the molarity **on the line** that corresponds to a 0.55 absorbance.*
   - If the absorbance is 0.55, the molarity = _____
   - On your graph, show where the point is by drawing an asterisk (*) at the correct spot on the line.
3) [2 pts] By looking at your data, you know that absorption of light increases with increasing concentration. How would you have known this just by looking at the actual solutions that you made? [How would you describe the color of the 0.5 M solution compared to the 0.1 M solution?]
4) [3 pts] Suppose you wanted to make 100.0 mL of a 0.500 M $CaCl_2$ solution from solid $CaCl_2$.
   a) Calculate how many grams of $CaCl_2$ will be needed. Show **all steps** and **units** and **watch sig figs**!!
   b) Briefly describe how you would make this solution in the lab. *(Be specific about amounts of substances and the size and type of glassware!)*
5) [3 pts] Suppose you wish to make a 225 mL of 2.00 M $HNO_3$ (aq). You will accomplish your goal by diluting 15.0 M $HNO_3$ (aq).
   a) What volume of the 15.0 M $HNO_3$ (aq) solution is needed? *Watch units and sig figs!!*
   b) Briefly describe how you would make this solution in the lab. *(Be specific about amounts of substances and the size and type of glassware!)*