Spectrophotometry/Colorimetry/Beer's Law

109 total points

Theory: In industry various methods of quantitative analysis are used to determine the concentration of chemicals in aqueous solutions. The amount of dissolved sodium and dissolved ions in drinking water, or the amount of cholesterol in blood are just a few examples. Spectrophotometry can also be used to find the mass percent of copper in brass shell casings that may have been found in a crime scene. The brass composition can then be matched to a certain manufacturer. A sample of brass will serve as our unknown in this lab. In each case, a standard curve must be created as a reference to compare the experimental results. The concentration of an unknown solution can then be extrapolated or calculated directly from this standard curve or equation.

To construct the reference (the standard line), a stock solution of known concentration along with various known dilutions of the stock solution are created. However, a method of detecting the concentration of the ions in solution must be created. One of the most common forms of detecting ions in solution (particularly colored solutions) is known as Spectrophotometry. By measuring the amount of light that is absorbed by a solution, one can obtain a very accurate relative reading of solution concentration. Remember, Cu^{2+} is a blue solution that absorbs at a wavelength of 660 nm.

The absorbance of a solution is directly proportional to the solution concentration. As the concentration of ions in a solution is increased, less light will transmit through the solution (more light will be absorbed). The Spectrophotometer displays data as % Transmittance (%T). The amount of light absorbed can be calculated using the following formula:

$$\text{Absorbance} = -\log(\%\text{Transmittance})$$

(e.g. %T as a decimal: If T =36.2%, A = -log(.362) A = 0.441

Purpose: **What you are going to do and how you are going to do it. (5 pts)**

Pre-Lab Questions: (26 pts)

1. Describe Beer's Law. What does it tell us about the relationship between absorbance and concentration? How many variables are in the equation? Define each of these variables. How does the Beer's law equation relate to the line equation? (8 points)
2. How will we deal with the variables "b" and "a" in the Beer's Law equation? (4 points)
3. How does a colorimeter/light spectrophotometer work? Include a diagram of a colorimeter. Why, specifically, will you use 660 nm? (8 points)
4. Research 4 different types of brass. What are the percentages of Cu and Zn in these alloys? What are some of the advantages of these different ratios? Why do these types of brass exist? (6 pts)

Create an Illustrated Procedure for the following: (10 pts)

Parts A, B, and C will be done all in one day.

Part A- Creating a stock solution

Create 100 mL of a 0.200 M $CuSO_4$ solution by measuring the appropriate mass (to 3 decimal places) of the compound and adding it to the 100 mL Volumetric Flask. Add distilled water to the flask to "bring the solution to volume". Invert the flask a minimum of 10 times.

A.) Calculate the mass of $CuSO_4 \bullet 5H_2O$ required to create 100 mL of a 0.200 M stock solution.
B.) As described by your lab instructor, program your colorimeter (display, check auto shutoff, set to 660 nm Transmittance) and calibrate the colorimeter with distilled water (should read 100%)
C.) Measure the % Transmittance of the solution.

Part B- Performing Dilutions

1. Measure **50.00 mL** of the original **stock solution** and add it to the 100 mL volumetric flask; fill to volume with de-ionized water. Calculate the concentration of the new solution and measure the % transmittance.
2. Measure **25.00 mL** of the original **stock solution** and add it to the 100 mL volumetric flask; fill to volume with de-ionized water. Calculate the concentration of the new solution and measure the % transmittance.
3. Measure **10.00 mL** of the original **stock solution** and add it to the 100 mL volumetric flask; fill to volume with de-ionized water. Calculate the concentration of the new solution and measure the % transmittance.
4. Measure **5.00 mL** of the original **stock solution** and add it to the 100 mL volumetric flask; fill to volume with de-ionized water. Calculate the concentration of the new solution and measure the % transmittance.

Part C – Determining the % of Copper in a sample of brass.

Your teacher will take a specified mass of brass with a known copper percentage. The brass will be dissolved in concentrated nitric acid and the solution will be diluted to a specific volume. The solution will be tested to determine the %Transmittance of 660 nm light. From here the copper ions molarity can be determined graphically [Cu^{2+}]. The mass of the brass and the volume of the solution can be used to determine the % copper in the brass.

Measure the % Transmittance of the **unknown** solution.

Inquiry/Safety/Chemical Properties Data Table: (10 pts)

Data Table: (8 pts)
Design your own! Only pertinent measurements for calculations are necessary. Focus on legibility, spacing, labels and chronology.

Observations: (8 pts)

Calculations: (10 pts)

Graph: (20 pts)
Plot a graph of **Absorbance vs. Concentration**. Draw a **line** of best fit through the data points. Determine the equation for the line. Form your graphically derived equation and absorbance value obtained for the unknown, determine the value of concentration of the unknown Cu^{2+} solution. Be sure to include a proper label for the x-axis, y-axis and a proper title. Include a best-fit line, the line equation and the regression value on the graph. Make the graph fill the page. Make a copy of the graph for your lab that you will turn-in. Also make an additional copy of the graph to tape to the back page of your originals.

Conclusion: (2 pts)

Error Analysis: (10 pts)
Get the actual percentage of copper in the brass sample from your instructor.