AP CHEMISTRY

Copper Spectrophotometric Analysis

(135 Points)

Name, Date and Lab Partner (5 Points)

Procedure (10 Points)

Complete, step-by-step account

of actions performed

Data (35 Points)

Observation Table (10 Points)

Reagent Masses (5 Points)

Reagents Volumes (5 Points)

Reagent Concentrations (5 Points)

Solution Absorbance Values (10 Points)

Calculations (45 Points)

Equations (5 Points)

Reaction Explanation (5 Points)

Volume of Nitric Acid (5 Points)

Serial Dilutions (10 Points)

Concentration of Copper in Penny Solution (5 Points)

Grams of Copper in the Penny (5 Points)

%Mass Copper in Penny (5 Points)

Theoretical %Cu (2 Points)

Percent Error (3 Points)

Conclusion (30 Points)

Overall Neatness and Organization (5 Points)

Safety (5 Points)

This part is determined by proper lab safety which includes having your goggles and lab coat on properly at all times. Each reminder by the instructor will result in a deduction of 5 or 10 points. This component of the grade can be negative.

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**INTRODUCTION TO ANALYTICAL CHEMISTRY – LAB**

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**EXPERIMENT III**

**SPECTROPHOTOMETRIC DETERMINATION OF COPPER**

**INTRODUCTION**

What are the relationships between color, wavelength, absorbance, and concentration? You will need to understand these relationships to be able to design an experiment that can quantitatively measure the absorption of light by a colored solution in order to determine the concentration of the absorbing species in that solution.

As we have seen, the perceived color of an object is generally caused by the interaction of polychromatic (multiple wavelengths/colors) white light and the object. This interaction results in the unabsorbed wavelengths being reflected to our eyes. It is the unabsorbed light which our eyes see, causing us to perceive the object as that color.

**THEORY**

Solutions containing copper(II) ions have a distinctive color. As with most colored solutions, there is a relationship between the concentration of the solution and the amount of light that the solution absorbs. Analysis of the transmission/absorption of a solution to determine “optical density” or concentration is called spectrophotometry. Spectrophotometry can be used to determine the concentration of either a single chemical species in solution or even the concentration of a species within a mixture of species in solution. For example, it can be used to determine the mass percent of copper in brass shell casings collected at crime scenes to match the shell to a certain manufacturer.

Absorption spectrophotometry is based off the understanding that the more dissolved molecules you have in solution, the higher the level of absorbance that will occur when light waves are passed through the sample. Since all chemical species have unique energy levels (wavelengths) of light that they absorb, it is important to select a highly absorbed wavelength for your analysis depending upon the species of interest. This is typically done by studying an absorption spectrum of the species of interest, which provides information on the relative absorbance of the substance at all wavelengths on in the visible spectrum (~400-700 nm). The wavelength of maximal absorption is called the “optimal wavelength” and is the wavelength used in quantitative analysis of the substance in solution.

When a light beam of a specific wavelength and initial intensity passes through an absorbing sample, intensity of the light beam transmitted through the sample is dependent upon three things:

1. The wavelength of light: the sample must absorb light of that particular wavelength.
2. Pathlength: the cell width or the amount of actual sample which the light passes through.
3. The concentration of the absorbing species in the solution.

Beer’s law governs the measurement of light absorbance relative to a sample’s concentration. Beer’s law states that the amount of light absorbed by a solution varies directly with the concentration of a substance in solution.

The mathematical relationship (Beer’s Law) correlating concentration and absorbance is shown as:

**A = abc**

where **A** (absorbance) is equal to the product of **a** (molar extinction coefficient of the substance being measured; a constant for a particular solution), **b** (pathlength of the cuvette, usually 1 cm), and **c** (concentration of the substance being measured).

“a” must be determined experimentally by making a standard curve which plots the absorbance of standard solutions of known concentration. The slope of this plot represents the product of a & b. (ab = slope of std curve). A standard solution containing the copper (II) ion has been prepared for you at a molarity of 0.400M. Using that standard solution, you will make serial dilutions to produce solutions of lower concentration for a calibration curve. Once a calibration curve is obtained, the concentration of any unknown sample containing the copper (II) ion can be determined mathematically.

**Safety and Disposal**

Concentrated nitric acid is corrosive and will attack and destroy metals, proteins, and most plastics. Avoid skin contact and neutralize any spills with baking soda before rinsing the area thoroughly with water. The acid will discolor skin for days and will produce a toxic brown gas (NO2). All nitric acid procedures should be performed in a fume hood.

The remaining brass solution should be neutralized with baking soda prior to disposal.

***This lab will be performed in groups of four for efficiency. One pair will complete Investigation A while the other completes Investigation B.***

**Investigation A**

1. Determine the mass of 2 halves of a penny to +/- 0.001g. Place the sample in a small beaker capable of holding 150mL of solution.
2. Assume your penny is 100% copper by mass. Calculate the minimum volume of 6.00M nitric acid required to completely react all of the copper. Add 5.0mL to the calculated volume to assure the nitric acid is present in excess.
3. Label your beaker and carefully add the desired volume of 6.00M nitric acid to the beaker under the fume hood. Place a watch glass over the top of the beaker and let it sit in the hood until the metal has completely reacted.
4. While still in the hood, add 50mL of diH2O to the beaker slowly. Remove the beaker from the hood and transfer the solution to a:
   1. 100mL volumetric flask if your pennies were from bag 1
   2. 250mL volumetric flask if your pennies were from bag 2
5. Rinse the beaker thoroughly 3-4 times with diH2O, collecting all of the rinsate in the flask. (Do not go over the graduated line!)
6. Fill the flask to volume with diH2O, stopper, and mix thoroughly via inversion.

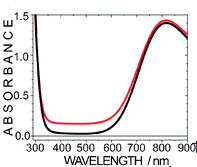
**Investigation B**

1. Obtain ~70mL of stock 0.400M copper (II) nitrate in a small beaker.
2. Determine the volume of stock solution required to make 100mL of a 0.200M copper (II) nitrate solution.
3. Prepare the dilute solution.
4. Repeat steps 2 & 3, each time using the last dilute solution made as your new “stock”. Prepare 100mL\* solutions of 0.100M, 0.0500M, and 0.0250M\*\*.

\*\*Prepare the final solution (0.0250M) in a 50mL volumetric

\*Have Mr. Walsh verify your calculations

5) Using the absorbance spectrum below for copper (II) nitrate, determine the optimal wavelength at which to analyze your solutions. Set the colorimeter to the nearest wavelength.



1. Calibrate the colorimeter to read 0% transmittance in the LoggerPro software, then place a clean cuvette filled with diH2O in the colorimeter, then hit [CAL].
2. Empty the water (blank) solution from the cuvette and dry it out as much as possible by tapping it gently upside down onto a paper towel.
3. Test your standard solutions for absorbance, starting with the most concentrated (0.400M) solution. Discard and tap out excess solution after each recording.
4. Enter the values into the LoggerPro software and print your calibration curve. Include the equation for the standard curve best fit line on the print out.
5. Record the absorbance of your dissolved metal sample from Investigation #1.

**DATA ANALYSIS**

1. Write the complete molecular, total ionic, and net ionic equation for the reaction performed.
2. Identify the type of reaction that took place and explain why it occurred.

Calculations

1. Volume of 6.00M nitric acid required to completely react your penny.
2. Volumes of solution required for the serial dilutions to make your standard solutions (mL).

0.200M

0.100M

0.0500M

0.0250M

1. Concentration of copper (II) ion in your sample solution.
2. Grams of copper in the penny.
3. Report your results as %mass copper of the penny.
4. Research penny alloy compositions to determine theoretical %Cu of your penny (bag 1 = after 1982, bag 2 = before 1982)
5. Calculate the percent error of your experimental %mass of copper.

**CONCLUSION**

Write a conclusionary paragraph that highlights your understanding of spectroscopy, Beer’s Law, and how the two can be utilized to determine solution concentrations. Discuss the results of your experiment & compare your results to those of pennies from the other bag (1 or 2). Evaluate possible sources of error and analyze whether your conclusions confirm the assumption that the penny was 100% copper.