

# The spectrophotometric analysis of copper in a copper oxide ore

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## The Spectrophotometric Analysis of Copper in a Copper Oxide Ore Abstract

In this experiment, the mass percent of copper in an unknown copper oxide ore was determined by using a spectrophotometer and Beer's Law. The mass percent of copper was found to be 5.120.14%. Introduction In spectrophotometric analysis, the concentration of a solute is measured in a solution by measuring the amount of light that is absorbed by the solution in a cuvette placed in a spectrophotometer. A spectrophotometer measures the intensity of light after it is directed through and emerges from a solution. In general, the higher the concentration of an analyte, the higher the absorbance. Spectrophotometric analysis exploits Beer's Law, which predicts a linear relationship between the absorbance of the solution and the concentration of the analyte, assuming all other experimental parameters do not vary (1). In this experiment, a series of standard solutions are prepared. A standard solution is a solution in which the analyte concentration is accurately known. The absorbances of the standard solutions are measured and used to prepare a calibration curve, which is a graph showing how the absorbance with the concentration. For this experiment, the points on the calibration curve should yield a straight line (2). The slope and intercept of that line provide a relationship between absorbance and concentration:  $A = \text{slope} \times x + \text{intercept}$  The unknown solution is then analyzed. The absorbance of the unknown solution,  $A$ , is then used with the slope and intercept from the calibration curve to calculate the concentration of the unknown solution,  $x$ . The absorbance varies linearly with both the cell path length and the analyte concentration. These two relationships can be combined to yield a general equation called Beer's Law (3).  $A = \hat{\mu} l c$  The quantity  $\hat{\mu}$  is the molar

absorptivity; in older literature it is sometimes called the extinction coefficient. The molar absorptivity varies with the wavelength of light used in the measurement (3). In this experiment, a stock solution was prepared that contained  $\text{Cu}(\text{NO}_3)_2 \cdot 5 \text{H}_2\text{O}$  and distilled water. Ammonia was added to the stock solution to make the complex ion copper(II) tetraamine. Ammonia acts as a Lewis base and donates electrons to copper, which acts as a Lewis acid. The reaction that occurs is as followed:  $\text{Cu}^{2+} (\text{aq}) + 4\text{NH}_3 (\text{aq}) \rightarrow \text{Cu} (\text{NH}_3)_4^{2+} (\text{aq})$

(1) Experimental Methods  $\text{Cu}(\text{NO}_3)_2 \cdot 5 \text{H}_2\text{O}$  (0.9029g) was weighed on a balance and then transferred to a clean 100mL volumetric flask. Distilled water was then added to the mark on the neck and the solution was mixed thoroughly. Five 25mL volumetric flasks were labeled 1-5 and different volumes of the  $\text{Cu}^{2+}$  stock were added to each one. 2mL of 15 M  $\text{NH}_3$  was added to each flask and then distilled water was added to the mark on the neck. The spectrophotometer was used to record the absorbance of each flask in triplicates after blanking it with distilled water between every reading. In the second part of the experiment, 0.8007g of dried copper oxide ore sample was weighed and put in a 100mL beaker with a watch glass. The beaker was warmed on a hot plate until the solution was dissolved. The solution was then transferred to a 50mL volumetric flask and distilled water was added to the mark on the neck. Three 25mL volumetric flasks were labeled 6-8 and 10mL of the copper oxide solution was transferred to each of the flasks. 4mL of 15 M  $\text{NH}_3$  was added to each of the flask and the absorbance was recorded for each flask in triplicates. Results:

Table 1: Preparation of  $\text{Cu}(\text{NH}_3)_4^{2+} (\text{aq})$  solutions

Flask #	mL $\text{Cu}^{2+}$ stock solution	mL conc. $\text{NH}_3$	Concentration $\text{Cu}(\text{NH}_3)_4^{2+} (\text{M})$	Average
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Absorbance | 1 | 2.00 | 2.00 | 0.003104 | 0.117 | 2 | 4.00 | 2.00 | 0.006208 | 0.216 | 3 | 6.00 | 2.00 | 0.009312 | 0.519 | 4 | 8.00 | 2.00 | 0.012416 | 0.689 | 5 | 10.00 | 2.00 | 0.015520 | 0.761 |

The following equations were used to calculate the concentrations of  $\text{Cu}(\text{NH}_3)_4^{2+}$  for the standard curve: Moles  $\text{Cu}(\text{NO}_3)_2 \cdot 5 \text{H}_2\text{O}$  = (grams  $\text{Cu}(\text{NO}_3)_2 \cdot 5 \text{H}_2\text{O}$ )  $\cdot$   $\frac{1}{232.58 \text{ g/mole}}$  (2) Mol  $\text{Cu}(\text{NO}_3)_2 \cdot 5 \text{H}_2\text{O}$  = Mol  $\text{Cu}(\text{NH}_3)_4^{2+}$  (3) Molarity (M) = moles  $\cdot$  liters (4)  $M_1V_1 = M_2V_2$  (5) Sample calculation  $[\text{Cu}^{2+}]$  in flask #1: 0.9029g of  $\text{Cu}(\text{NO}_3)_2 \cdot 5 \text{H}_2\text{O}$  was used to prepare the stock solution for the standard curve Using Equation 2: Moles  $\text{Cu}(\text{NO}_3)_2 \cdot 5 \text{H}_2\text{O}$  = (0.9029grams  $\text{Cu}(\text{NO}_3)_2 \cdot 5 \text{H}_2\text{O}$ )  $\cdot$   $\frac{1}{(232.58 \text{ g/mole})}$  = 0.00388 moles Using Equation 3: 0.00388 moles  $\text{Cu}(\text{NO}_3)_2 \cdot 5 \text{H}_2\text{O}$  = 0.00388 moles  $\text{Cu}(\text{NH}_3)_4^{2+}$  Using Equation 4: Molarity(M)  $\text{Cu}(\text{NH}_3)_4^{2+}$  = (0.00388moles)  $\cdot$   $\frac{1}{(0.1\text{L})}$  = 0.0388 M Using Equation 5: Molarity  $\text{Cu}(\text{NH}_3)_4^{2+}$  after dilution with water =  $M_2 (0.0388 \text{ M})(0.002\text{L}) = (M_2)(0.025\text{L})$   $M_2 = 0.0031\text{M}$  Standard Curve at 580nm  $Y = 56.806X - 0.0679$  (6) Moles  $\text{Cu}(\text{NH}_3)_4^{2+}$  = moles Cu (7) Mass Cu = (moles Cu)  $\times$  (63.55g/mole) (8) Percent mass = (mass copper)  $\cdot$  (mass copper oxide ore)  $\times 100$  (9) Calculation for the mass of copper Absorbance was found to be 0.220 nm in Flask 6 Using Equation 6:  $0.220 = 56.806X - 0.0679$   $x = 0.0051 \text{ M}$   $\text{Cu}(\text{NH}_3)_4^{2+}$  in the 25.0 mL flask 10 mL of solution from the 50 mL volumetric flask was transferred into each of the 25 mL volumetric flasks Using Equation 5:  $(0.0051)(0.025\text{L}) = (M_2)(0.01)$   $M_2 = 0.013\text{M}$   $\text{Cu}(\text{NH}_3)_4^{2+}$  in the 10.0 mL sample  $0.013 \text{ M}$   $\text{Cu}(\text{NH}_3)_4^{2+}$  = moles  $\cdot$  (.05L) moles  $\text{Cu}(\text{NH}_3)_4^{2+}$  = 0.00065 moles within the 50 mL flask Using Equation 7: 0.00065 moles  $\text{Cu}(\text{NH}_3)_4^{2+}$  = 0.00065 moles Cu Using Equation 8: Mass Cu = (0.00065 moles Cu)  $\times$  (63.55g/mole) Mass Cu = 0.

0.041g Using Equation 9: Percent mass =  $(0.041\text{g copper}) \div (0.8007\text{g copper oxide ore}) \times 100$  %Cu = 5.1205% Table 2: Copper calculations for unknown sample

Flask #	mL copper oxide ore solution	mL conc. NH <sub>3</sub>	Average Absorbance	Moles Cu	Mass Cu (g)	Mass percent Cu
6	10.00	4.00	0.220	0.000650	0.04131	5.1205
7	10.00	4.00	0.218	0.000628	0.03991	4.9843
8	10.00	4.00	0.236	0.000663	0.04213	5.2616

The equations needed to calculate standard deviation include:  $\bar{x} = \frac{\sum xi}{n}$  (10)  $s = \sqrt{\frac{\sum (xi - \bar{x})^2}{n-1}}$  (11) The mean mass percent copper was found to be 5.12 ± 0.14%. Discussion: The mass percent copper in copper(II) oxide was found to be 5.12 ± 0.14%. The mass percent of copper in the same unknown sample of copper(II) oxide was previously found to be 4.957% using electrogravimetric analysis. These results are very close to each other suggesting that both the spectrophotometric and electrogravimetric techniques are useful for determination of copper in a copper oxide ore. Despite the similar results in both experiments, there was still room for human error during this experiment. While transferring and diluting solutions, there is a possibility that not all the solution was transferred or that the solution was not diluted accurately. These mistakes can impact our data and lead to inaccurate results. The mass percents of copper in flasks 6, 7 and 8 were very close to each other, confirming the precision of the results. The absorbance recorded for flask 6 and 7 was very close to each other but the absorbance for flask 8 was a little different, owing to the errors made while recording absorbance i. e. not blanking the spectrophotometer with distilled water, or not wiping the cuvette properly. Difference in absorbance suggests difference in concentration which could have been a

result of human error. Since a calibration curve was made in the first part of this experiment and then used to determine the mass percent of copper, it is very essential that these absorbance measurements are accurate in order to accurately determine our unknown. By measuring the absorbance in triplicates and averaging the values, we tried to avoid human error as much as possible. Spectrophotometric analysis to determine copper in a copper oxide ore is very useful since the spectrophotometer allows us to take accurate measurements of the absorbance of the solution but this technique is limited by the accuracy of the investigator. Therefore, in the future, we should be careful when making solutions and try to be as accurate and careful as possible. References: 1) Spectrophotometric Analysis.

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