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Beer's Law Lab

Abstract: An experiment was done to determine the concentration of a solution of nickel II sulfate (NiSO_4) using Beer's Law, which states that the absorbance of a solution is directly proportional to its molar concentration. Using a GLX and colorimeter, the absorbances of four NiSO_4 solutions with known concentrations were measured and then the absorbance of the unknown solution was measured. The graph obtained demonstrated the direct linear relationship and the equation obtained yielded a concentration of 0.262M for the unknown. Inaccuracies in this answer may be attributed to incompletely cleaned cuvettes and to the rinsing process used between solutions.

Introduction: When light passes through a solution, certain ions may absorb some of the light, reducing the amount of light that passes through the solution. This absorbance of light is responsible for the colors that we see: a solution that absorbs red light will appear green, its opposite.

Light is absorbed by electron transition. When a photon with the right amount of energy strikes an ion in solution, an electron in that ion is excited to a higher energy level. When the electron drops back to its original level the energy is released. Sometimes the ion will release a photon of the same energy, while other times the energy is released in several, lower-energy photons which may not be visible. Even when the photon is identical to the one absorbed, it will be emitted in a random direction. Both of these factors, the release of lower energy photons and the random nature of the release, result in a decrease in the amount of light that passes directly through the solution.

The more concentrated the solution is the more ions are present in the path of the photon. Therefore a given photon is more likely to be absorbed which decreases the amount of light that is transmitted. This idea, that the absorbance of light increases with the concentration is known as Beer's Law. This relationship will be used to determine the concentration of a NiSO_4 solution by comparing its absorbance to that of several solutions of known concentration.

Materials and Methods:

The following materials were used in the lab:

Pasco GLX	Pasco Colorimeter	Cuvettes
4 NiSO_4 solutions of known concentration		1 NiSO_4 of unknown concentration
Deionized water		

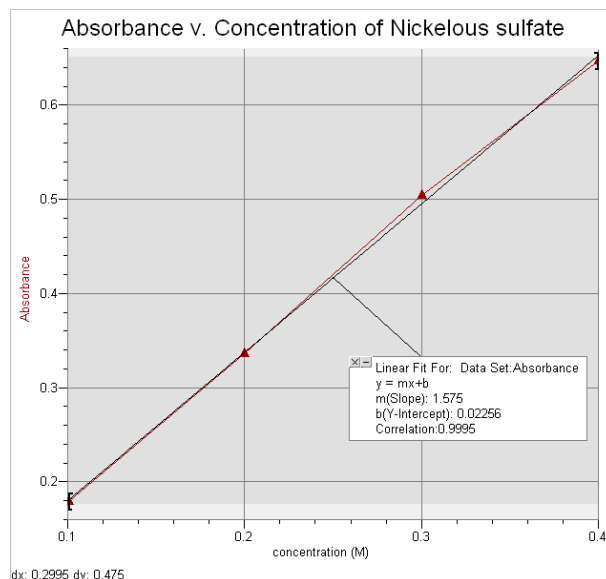
A Pasco GLX was set up with a colorimeter and was calibrated with deionized water. The red absorbance of the 5 solutions of nickel II sulfate were measured.

Data, Analysis and Results:

Concentration (mols/L)	Absorbance
0.1006 ± 0.0009	0.179 ± 0.005
0.200 ± 0.001	0.336 ± 0.005
0.300 ± 0.001	0.504 ± 0.005
0.400 ± 0.001	0.647 ± 0.005
unknown	0.436 ± 0.005

The graph of Absorbance v. Concentration shows that, as predicted by Beer's Law, the absorbance increased linearly with increases in the concentration of the solution.

The equation of the best fit line is
Absorbance = $1.575(\text{concentration}) + 0.02256$



This allows the calculation of the concentration of the unknown solution as follows.

$$0.436 = 1.575(\text{conc}) + 0.02256$$

$$0.413 = 1.575(\text{conc})$$

$$\text{conc} = 0.262\text{M}$$

Conclusion: By utilizing the linear relationship between concentration and absorbance known as Beer's law, it was determined that the concentration of the unknown solution was 0.262M. Although the linear correlation of the graph is very good the non-zero intercept suggests that there may have been some errors in the lab.

One possible source of error is that the cuvette, although wiped off before being placed in the colorimeter each time may not have been perfectly clean. Anything left on the cuvette would decrease the light that could pass and would result in a higher measured absorbance. If this happened on the first few solutions of known concentration it would have decreased the slope of the graph, resulting in a larger calculated concentration for the unknown. If this problem had occurred on either of the two more concentrated solutions, it would have increased the slope of the line, causing an decrease in the calculated value for the unknown concentration. If this had occurred with the unknown itself, the higher measured absorbance would have led a calculated concentration that was too high.

Another problem that may have been encountered was that each when each solution was placed in the cuvette, traces of the prior solution may have still been present. For each of the solutions of known concentration, this would have decreased their concentration and therefore their absorbance, lowering the line on the graph. This would have led to a lower

intercept value and a higher calculated concentration for the unknown. The unknown was placed in the cuvette after the most concentrated solution was measured and might therefore have been more concentrated, resulting in a higher absorbance and a higher calculated concentration.