How Does the Concentration of Copper II Sulfate Solution Affect Absorbance of Light?

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Contents

1 Background

A colored solute's unknown concentration can be measured in varies ways and one popular way of measuring solute's concentration is by using the colorimeter. The concentration can affect the absorbance of light, and the absorbance of light can be measured by the colorimeter. In this experiment, we are asked to quantify the relation between the concentration and the absorbance of light, and then use this relation to measure the concentration of an unknown solution, with the solute copper II sulfate ($CuSO_4$).

2 Aim

This practical is designed to conduct a quantitative study of the effect of the absorbance of light at a specific wavelength with the change in concentration of solute $CuSO_4$, and then use the derived relation to calculate the concentration of an unknown $CuSO_4$ solution

- Learn the basic principle of how colorimeter works
- Learn how to use the colorimeter and Logger Pro to measuring one solution's absorbance of light
- Know the relation between the concentration of the colored solution and the absorbance of a light at a specific wavelength.

3 Materials (Per Pair)

- Distilled Water
- Copper II Sulfate Solutions

- Cuvettes (about 5)
- Beakers
- Colorimeter and light filters

4 Procedure

1. Turn on the colorimeter and connect to computer by using Logger Pro, also do heat up
2. Fill one cuvette with distilled water and put it in the colorimeter, use the distilled water to calibrate
3. Fill (the same cuvette) cuvettes with $CuSO_4$ solutions in different concentrations and measure its absorbance of light three times under a fixed wavelength set for the light (in the experiment specifically we use 650 mm).
4. Wash the cuvettes with distilled water and the solution, then use the cuvette to measure another solution in another concentration.

5 Data Collection & Processing

Concentration	1st Measurement	2nd Measurement	3rd Measurement
0.0313	0.096	0.095	0.097
0.0625	0.199	0.195	0.198
0.125	0.372	0.373	0.374
0.25	0.778	0.774	0.772
0.5	1.515	1.52	1.518

Table 1: Raw data showing the solution's concentration and their corresponding absorbance of light in 650 mm wavelength.

The raw data is measured 3 times to reduce the random error, and average is taken to derive the absorbance.

5.1 Example of Data Processing

We take the solution with concentration 0.0313 as example, the absorbance of light is calculated by

$$\begin{aligned} A &= \frac{0.096 + 0.095 + 0.097}{3} \\ &= 0.096. \end{aligned}$$

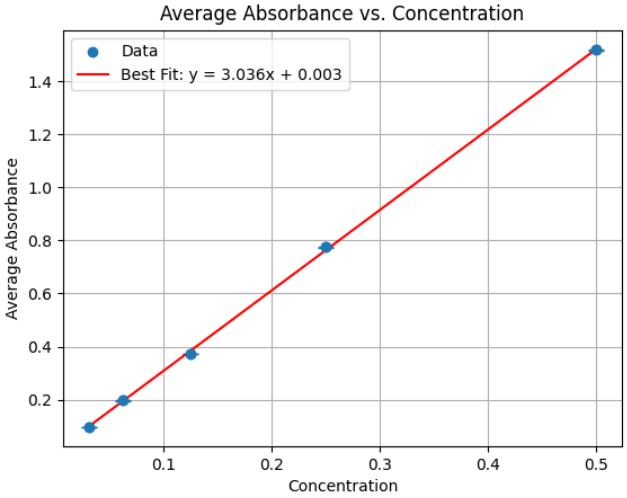
and the systemetic error is ± 0.001 for the colorimeter.

Concentration (M)	Absorbance
0.0313	0.096
0.0625	0.197
0.125	0.373
0.25	0.775
0.5	1.518

Table 2: Processed data showing the solution's concentration and the average absorbance of light in 650 mm wavelength.

6 Data Plot

According to the processed data, I plot a diagram with the independent variable concentration and dependent variable absorbance, and a vertical error bar ±0.001 to conclude the systemetic error of colorimeter.



7 Conclusion and Evaluation

From the graph we plotted above, it is clear that there exists a proportional relationship between the concentration of the colored solution and the absorbance.

There also exists a systematic error that causes the best-fit line to not strictly pass through the origin. And the reason of the systematic error could be caused by the failing of calibration, or the solutions were filled in different cuvettes and the difference of the cuvettes' original absorbance for light. Also, the uncertainty of the concentration of $CuSO_4$ solution is also unknown. Therefore, the small systematic error exists.

The unknown solution has a The unknown solution has measured absorbances of 0.640, 0.642 and 0.644. Therefore, the average absorbance is 0.642.

By applying the relationship between concentration and average absorbance

$$\text{Absorbance} = 3.036 \cdot \text{Concentration} + 0.003,$$

we can derive that the concentration of the unknown $CuSO_4$ solution is 0.211 mol/L.