Purpose

Estimating Concentration of an Unknown Solution

Introduction

The concentration of an unknown solution is estimated by comparing the intensity of its colour to the intensity of the colour of standard solutions. Chemists use an instrument called a spectrophotometer to determine accurately how much light of a certain wavelength is absorbed by a solution. By plotting a curve based on the absorbances of solutions of known concentrations, it is then possible to determine the concentration of an unknown solution, if you know its absorbance.

Copper (II) sulfate pentahydrate, $CuSO_4 \bullet 5H_2O$, is a soluble salt that may be added to pools and ponds to control the growth of fungi. A solution of $CuSO_4 \bullet 5H_2O$ has a blue appearance. (why?) The intensity of the colour increases with increased concentration.

In this investigation, you will prepare a 100 mL solution of 0.500 mol/L $CuSO_4 \bullet 5H_2O$.

You will then perform a serial dilution in order to prepare 4 more solutions of known concentration.

Using the 5 solutions, you will estimate the concentration of an unknown solution by comparing its colour intensity with the colour intensity of the known solutions.

Prelab Calculations

In the space below: Outline all steps and calculations, (with uncertainty) needed to prepare 100.0 mL of a 0.50 mol/L $CuSO_4 \bullet 5H_2O$ and to prepare the following dilutions:

100.0 mL of a 0.50 mol/L

50.0 mL of 0.20 mol/L solution

50.0 mL of 0.10 mol/L solution

50.0 mL of 0.050 mol/L solution

50.0 mL of 0.025 mol/L solution

Materials

graduated cylinder (± 0.5mL)
permanent marker
6 volumetric flask
glass rod
dropper
copper (II) sulphate pentahydrate, $CuSO_4 \bullet 5H_2O$
distilled water
6 clean, dry identical test tubes
balance (± 0.01g)
25.00 mL pipette and bulb (± 0.01mL)
10 mL of copper (II) sulphate solution with unknown concentration

MSDS

Determine the safety precautions and the disposal of copper (II) sulphate pentahydrate

Procedure

Part 1: Making Solutions

First solution: Preparation of 100.0 mL of 0.500 mol/L $CuSO_4 \cdot 5H_2O$ solution.
1. Clean and dry a 100.0 mL volumetric flask.
2. Mass out the amount of $CuSO_4 \cdot 5H_2O$ calculated in the prelab. Place the calculated mass of copper (II) sulphate into the 100.0 mL volumetric flask.
3. Measure out 100 mL of distilled water in a clean graduated cylinder and add it to the solute. Stir to dissolve the solute.
4. Save 15 mL of this solution for Part 2

Serial Dilutions:
5. Using the original 0.50 mol/L solution, prepare 50.0 mL of 0.20 mol/L solution.
6. Using the 0.20 mol/L solution, prepare 50.0 mL of 0.10 mol/L solution.
7. Using the 0.10 mol/L solution, prepare 50.0 mL of 0.050 mol/L solution.
8. Using the 0.050 mol/L solution, prepare 50.0 mL of 0.025 mol/L solution.

Part 2: Estimating the Concentration of an Unknown Solution

1. Make up a table to record the concentration and absorbance of the standard solutions and the unknown solution.

1. Label each test tube, one for each solution (5 from part 1 plus the unknown).
2. Pour a sample of each solution into a test tube so that the height of the solution is the same. Use a dropper to add or take away solution as needed. Do not add water (this will change concentration).
3. Arrange the solutions of known concentration in order of concentration.
4. Compare the colour of the unknown solution with the colours of the other solutions to estimate its concentration. The best way to compare colour intensity is by looking down through the test tube. Wrap each test tube with a paper towel to stop light from entering the side then place the tubes over a diffuse light source.

Procedure with a spectroscope

A **spectroscope** may also be used where absorbance can be measured and plotted against concentration.
Check that the spectrophotometer is set to read a wavelength of 640 nm.
With the cuvette compartment empty and closed, set the meter to read 0% transmittance.
Obtain a special spectrophotometer tube (cuvette). These tubes should be handled by their top edge only.
Fill the tube about three quarters full with distilled water and place it in the compartment on top of the spectrophotometer. If necessary, use a lens tissue to dry the outside surface of the tube.
Adjust the instrument to read 100% transmittance. Fill the tube about three quarters full and make sure the outside is clean and dry.
Place the tube into the cuvette compartment, close the lid, and measure and record the absorbance.
Repeat with each solution and with the solution with unknown concentration supplied by your teacher.
Remember to rinse the tube each time with the solution to be tested.

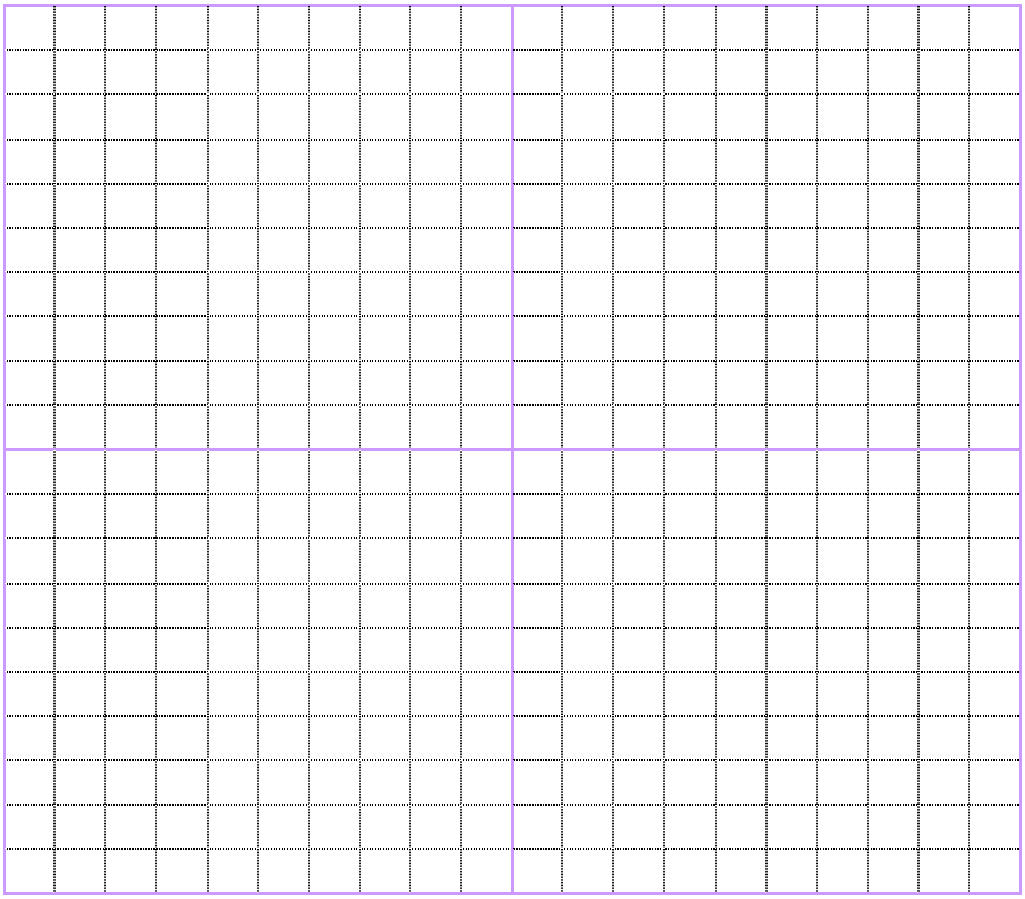
5. All solutions must be disposed of in the appropriate waste bin…not down the sink.

Analysis

1. If a spectroscope was used, plot a graph of absorbance at 640 nm on the vertical axis, and molar concentration (mol/L) on the horizontal axis.
Draw the best smooth line through the data.

2. Use your graph to determine the unknown concentration of the solution you were given.
Estimate of concentration of unknown solution _____

Plot a graph of absorption versus concentration to determine the concentration of the unknown.



Conclusion

Actual Concentration of unknown solution _____

% Error in your estimate _____