Determination of Copper(II) Ion Concentration through Absorption Colourimetry

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Experiment Overview

Students are given a stock solution of 0.25 M copper(II) nitrate, $Cu(NO_3)_2$, and then they make a series of accurate dilutions. They then use the PASCO Colourimeter to produce a calibration absorption curve, and find the equation of best-fit. The absorbance from a sample of $Cu(NO_3)_2$ of 'unknown' concentration is measured and the calibration curve and its linear regression equation is then used to calculate the unknown's concentration.

An application of Beer's (Beer Lambert) Law.

The development of this experiment replaces an older manual one, in which a large number of wavelengths need to read, manually using the Shimadzu spectrophotometer, and plotted onto paper to ascertain the maximum absorption. While this cannot be duplicated using the Pasco colourimeter, the unit uses four wavelengths (red; 660 nm, orange; 610 nm, green; 565 nm, blue; 468 nm) and these can be investigated to look for maximum absorption.

The use of new technology to enhance the look and remove the repetition has been a secondary aim of this redeveloped practical.

A number of students have used graphics calculators, and mobile phones and so there should be a quick acceptance and learning for the keystrokes of the GLX. The Level 1 laboratory does not have and is not planned to have PC's on the benches. So the Xplorer GLX gives mobility, and functionality with sophisticated plug in sensors in particular the colourimeter (Pasco PS 2121), and even USB connectivity. If required data and files can be saved to a USB memory stick, and printing can be done directly through the USB port. Pasco also has PC software called "DataStudio".

Level of Experiment

First year undergraduate

Keyword Descriptions of the Experiment

Domain
general chemistry, analytical chemistry

Specific Descriptors
clourimetry, asorbance, tansmittance, copper(II) ntrate, Beer's Law, PASCO GLX

Course Context and Prerequisite Knowledge and Skills

Level one students are introduced to the measures of concentration in particular Molarity as moles per litre of solution. This represents a measure of the number of particles in a unit of volume.

Students are reminded of the nature of electromagnetic radiation, the E M spectrum, and the effects of visible and UV photons on the electronic configuration of atoms, ion, and molecules. The transmittance (and absorbance) of light by atoms, ions and molecules in aqueous solution is directly proportional to the concentration of the species, the nature of the solvent, the path length, and the spectator or impurity species present.

By accurately changing the concentration only, and keeping the other factors constant, a calibration curve can be constructed, and so an unknown can be determined.

Time Required to Complete

Prior to Lab: 1 h
In Laboratory: 3 h
After Laboratory: N/A

Experiment History

Experiment idea came from PASCO "Pasport University Chemistry Handbook" PS-2816 , and adapted for the Xplorer GLX at Adelaide University, with background information coming from the original experiment, University of Adelaide, Department of Chemistry, Level one Laboratory Manual.

The forensic idea was sparked by the experiment described by Dr Carol Lee (see references), in which she uses the discarded brass shell cases of .22 calibre rifle ammunition as the source of copper.

Comments

The use of pre prepared solutions was instigated to save the students' time, as the practical sessions are limited to 3 hours.

To extend the practical a sample of brass could be dissolved in the fume hood with concentrated nitric acid. The sample of brass could come from a used bullet casing, as was suggested in an experiment from Dr. Carol Lee (see references), or other metal or metallurgical sample.

The determination of copper from mined copper ore may be a level 2 extension as the removal of contaminating other metals' ions would be necessary.

The determination of a mixture of two metallic ions for example $Cu(NO_3)_2$ and $KMnO_4$ could be an extension or Level 2 experiment.

An interesting alternate experiment leaning toward biological was that of the investigation of the change in colour of bananas through the enzyme, catechol oxidase and its inhibition.

References

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Housecroft, C. & Constable E. (2002). *Chemistry: An Introduction to Organic, Inorganic and Physical Chemistry.* (2nd ed.). Essex UK: Pearson Education.

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Pasco Xplorer GLX at http://www.pasco.com/glx/home.html

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