Experiment 9: Colorimetric Estimation of Copper

Significance of experiment: Colorimetry is used in chemistry and in other sorts of places such as in industries like colour printing, textile manufacturing, paint manufacturing and in food industries.[1-3]Colorimetry is also used in asprin. Colorimetery can detect the smallest colourdiffrence that the human eye can not pick up. Under the action of chemical agents, samples develop a specific colour that shows the concentration of the substance being tested. Colorimetry is just one of the types of photometric analysis techniques i.e. it is a way of measuring light.Colorimetry can be used to find out the concentration of any coloured substance. Such as inFood & Beverage Quality Control - Alpha Amylase Activity - Milk Quality - Miscellaneous Quality Tests etc.

Colorimetry measurements are made by using a light which passes through a colour filter. The light then passes through a little box (cuvette) with the actual chemical substance. The light leaving the actual sample should be less than the light that actually entered the compound. The loss of light always reflects the concentration of the compound.

Aim: To determine copper in copper sulfate solution using colorimeter.

Principle: When a monochromatic light of intensity I_0 is incident on a transparent medium, a part, I_a of it is absorbed, a part, I_r is reflected and the remaining part, I_t is transmitted.

$I_0 = I_a + I_r + I_t$

For a glass - air interface I_r is negligible, therefore,

$I_0 = I_a + I_t$

$I_t / I_0 = T$ called the transmittance, $\log I/T = \log I_0 / I_t$ is called the absorbance or optical density.

Colorimetry measurements are based on Beer-Lambert's law. This law gives the relation between absorbance A, concentration c (expressed in mo1/dm^3) and path length t, (ex-pressed in cm).

Beer-Lambert's law:When a monochromatic light passes through a transparent medium, the amount of light absorbed is directly proportional to the concentration and path length of the solution.

$A \propto Cl$

$A = \log I0/It = \varepsilon ct$

Where εis the molar extinction coefficient, c is the concentration, t is the path length and is a constant for a given substance at a given wavelength. If t, the length is kept constant, then, $A \propto c$. Hence a plot of absorbance against concentration gives a straight line.

Instrumentation: The instrument used to measure the absorbance of a solution is called photoelectric colorimeter.
It consist of

(i) Tungsten lamp as the light source.
(ii) A filter which provides the desired wavelength range wherein the solution gives the maximum absorbance.
(iii) A sample cell
(iv) A photocell detector

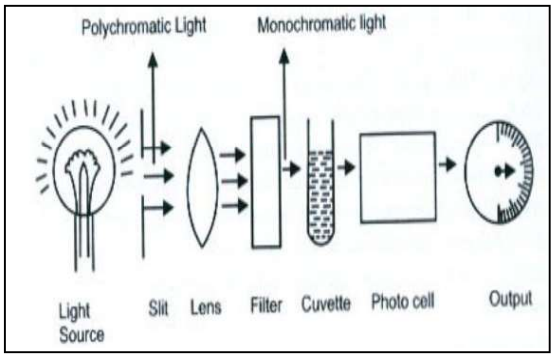


Fig: Schematic layout of colorimeter

Application: Colorimetry is versatile method of determining the concentration of metals and nonmetals present in small quantities in ores, soil, samples and alloys. Eg. Colorimetric estimation of cu in $CuSO_4$.

Procedure: Transfer the given copper sulphate solution (stock solution) to a burette and draw out 2, 4, 6, 8 and 10 cm^3 of the solution into 50 cm^3 volumetric flask.Add 5 cm^3 of ammonia solution to each of them and dilute up to the mark with ion exchange water. Stopper the flasks and mix the solutions well.

To the test solutions given in a 50 cm^3 measuring flask, add 5 cm^3 of ammonia solution, then dilute up to the mark with ion exchange water and mix well.

Prepare a blank solution by diluting 5 cm^3 of ammonia solution in a 50 cm^3 measuring flask upto the mark with ion exchange water and mixing well. After 10 minutes, measure the absorbance of the solutions against blank at 620 nm using a photoelectric colorimeter. Tabulate the readings as shown. Draw a calibration curve by plotting absorbance against volume of copper sulphate solution. Using the calibration curve, find out the volume of copper sulphate solution given i.e., the volume of test solution and calculate the amount of copper in the given solution.

Advantage

i) Colorimetry gives accurate results at low concentration.

ii) Colorimetry is also applied for biological samples.

Result:

From graph, volume of copper sulfate in test solution = ……..mL

The weight of copper in the given test solution = …… mg

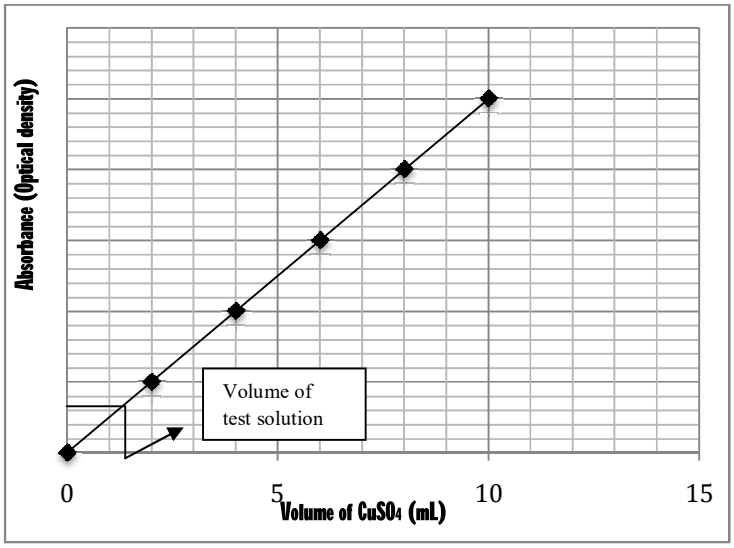
Links to the external sources of information about the topic:

1. http://www.fondriest.com/pdf/thermo_colorimeter_theory.pdf
2. http://en.wikipedia.org/wiki/Colorimeter_(chemistry)
3. http://en.wikipedia.org/wiki/Colorimetry_(chemical_method)

Experiment 9: Observation and calculations

Volume of $CuSO_4$ (mL)	Absorbance (Optical density)
2	
4	
6	
8	
10	
Test solution	

Graph:



1000 mL of stock solution contains `a' g of $CuSO_4$ (`a' value will be given).

249.54 g of $CuSO_4$ = 63.54 g of Cu.

`a' g of $CuSO_4$ = $\frac{63.54}{249.54}$ x a = ……. g of Cu in 1000 mL.

1 mL of $CuSO_4$=…… mg of Cu (say b)

`c' mL of test solution = b x c = ……..mg of Cu

Result:

From graph, volume of copper sulfate in test solution = ……..mL

The weight of copper in the given test solution = …… mg