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Dr. Pallavi Kadam

Analysis of Cu-based alloys

Introduction:

An alloy is a metallic substance composed of two or more elements, as either a compound or a solution or An alloy is a substance made by mixing

two or more metallic elements into a single crystalline structure.

The best way to think of an alloy is as a material that is made up of at least two different chemical elements out of these one is a metal.

The most important metallic component of an alloy (often representing 90 percent or more of the material) is called the **main metal**, the **parent metal**, or the **base metal**.

The other components of an alloy are called **alloying agents** can be either metals or nonmetals and they are present in much smaller quantities

The structure of alloys:

If you look at a metal through a powerful electron microscope, you can see the atoms inside arranged in a regular structure called a **crystalline lattice**.

In an alloy, apart from the atoms of the main metal, there are also atoms of the alloying agents dotted throughout the structure.

Types of Alloy:

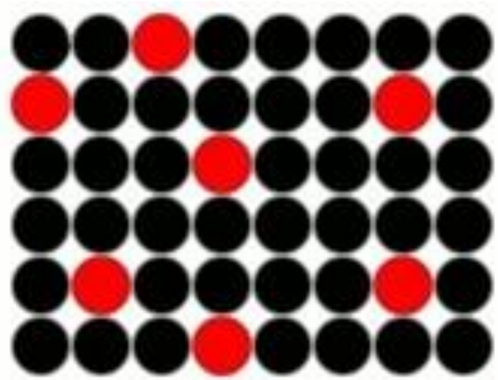
a) **Substitution alloys**
b) **Interstitial alloys**

Substitution Alloy:

If the atoms of the alloying agent replace atoms of the main metal, is called a substitution alloy.

substitution alloy form only if the atoms of the base metal and those of the alloying agent are of roughly similar size.

For example Brass, is a substitution alloy because 10-15 % zinc atoms are replaced by copper atoms. Brass works as an alloy because copper and zinc are close to one another in the periodic table and have atoms of roughly similar size.


Substitution Alloy

Interstitial Alloy:

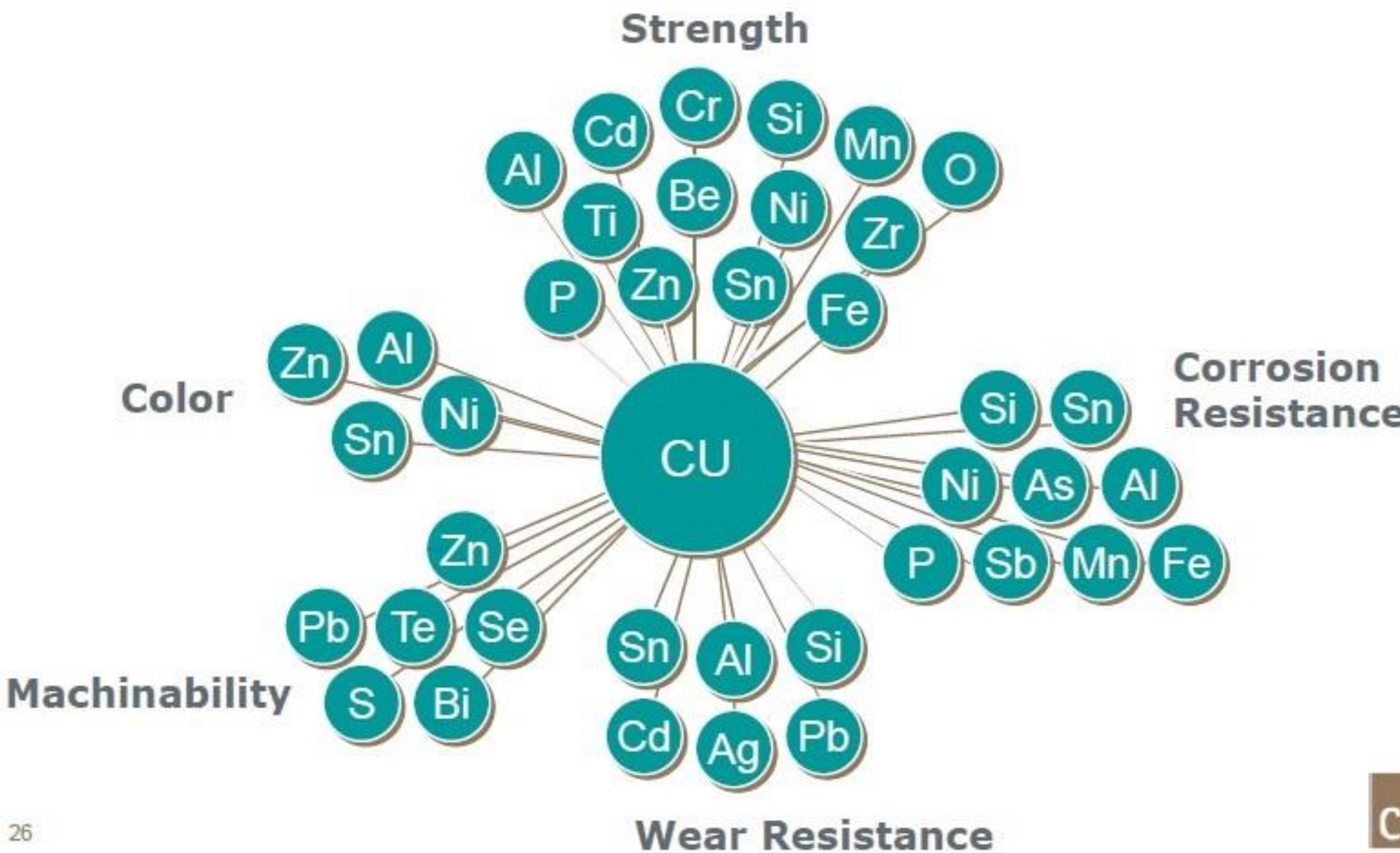
Alloys can also form if the alloying agent or agents have atoms that are very much smaller than those of the main metal.

In that case, the alloying agent slip in between the main metal atoms (in the gaps or "interstices") that's why it is called an interstitial alloy.

Steel is an example of an interstitial alloy in which a relatively small number of carbon atoms slip in the gaps between the huge atoms in a crystalline lattice of iron.

INTRODUCTION TO COPPER AND ITS ALLOYS

- **Symbol: Cu**
- **Atomic Number: 29**
- **Atomic Weight: 63.546**
- **Standard state: solid at room temperature**
- **Color: copper, metallic**
- **Properties:** Ductile, Malleable, High thermal conductivity, High electrical conductivity, Easily alloyed, Good corrosion resistance, Readily available, Highly recyclable, Antimicrobial


Strength
Cd
Cr
Si
Mn
O
Al
Be
Ni
Ti
Zr
P
Zn
Sn
Fe
Zn
Al
Color
Ni
Sn
CU
Corrosion Resistance
Si
Sn
Ni
As
Al
P
Sb
Mn
Fe
Zn
Pb
Te
Se
Machinability
S
Bi
Sn
Al
Si
Cd
Ag
Pb
Wear Resistance

COPPER BASED ALLOYS:

a) **Brass alloy (Cu and Zn)**

b) **Bronze alloy (Cu and Sn)**

c) **Gun Metal alloy (Cu, Sn and Zn)**

Brass alloy:

Brass is a alloy which is composed of **copper (Cu) and zinc (Zn).**

Brass with a high copper content is often used to produce musical instruments due to its malleability, workability, and resistance to corrosion.

Naval brass is a particular mixture of copper, zinc, and tin and is commonly used for various hardware components. The added tin imparts an extra degree of corrosion resistance.

Other common applications of brass include plumbing fittings, electrical applications, and architectural or design use where a golden finish is desired.

In each case, the composition of the brass is tailored to give the best physical properties for the application.

Types of Brass Alloy:

1) **Alpha Brass Alloy (α- brass):** It contains Cu (65%) and Zn (35%). Alpha brass alloy is a malleable and it can be worked in a cold condition. Alpha brass alloy has a face centered cubic crystal structure (FCC).

2) **Beta Brass Alloy (β- brass alloy):** It contains Cu (50-55%) and Zn (45-50 %). This type of brass alloy only works in hot condition. Beta brass alloy has a bady centered cubic crystal structure (BCC).

3) **Gamma Brass Alloy (γ- brass alloy):** It contain Cu (33-39 %) and Zn (61-67 %).

4) **Alpha- Beta brass Alloy (α-β brass Alloy):** It contains Cu (55-65 %) and Zn (35- 45 %). It is used in the instruments which can be worked in hot condition. It contains both alpha and beta phases so it is harder and stronger than individual alpha and Beta brass alloy.

Introduction of brass alloy:

The colour of brass alloy is ranges from red to yellow and gold to silver.

The major constituents of brass alloy is copper (50-90 %) and zinc (20-40%). But small amount of Tin (0-6%), Lead (0-2 %), Iron (0-1 %) and trace amount of Aluminium, Nickel and Manganese was also present

Estimation of Brass Alloy

Oxidation of metals:

❖ Since the copper and zinc in brass exist in their elemental forms, they need to be oxidized to their ionic forms to get them into solution.

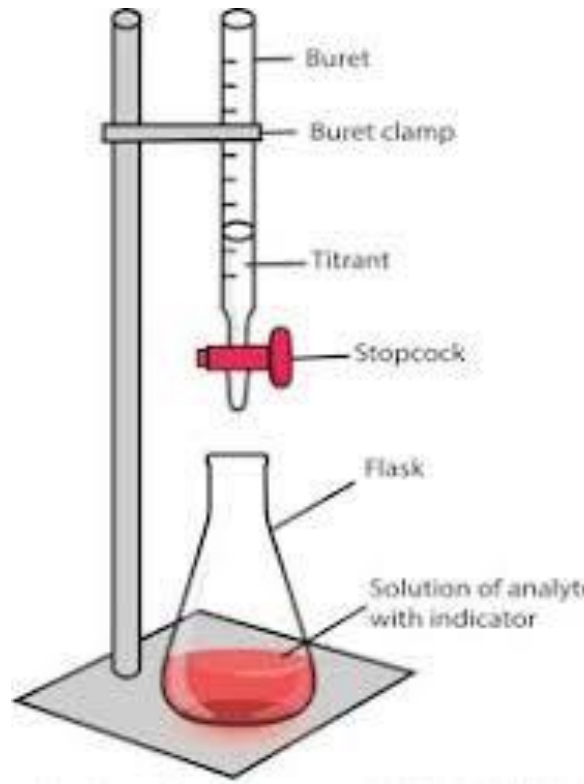
❖ For active metals like **zinc**, this can be done by adding an **acid (H+)** where the following reaction takes place:

$$\mathbf{Zn + 2H^{+} \longrightarrow Zn^{2+} + H_2}$$

❖ Less active metals like copper require a stronger oxidizing agent. Concentrated nitric acid (HNO_3; ~15 M) at room temperature or hot 7.0 M nitric acid are each strong enough to oxidize copper by the following reaction:

$$\mathbf{Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O}$$

Estimation of Copper (Cu): Spectrophotometric estimation



- Estimation of Zinc (Zn): Complexometric estimation

Estimation of Copper (Cu): Spectrophotometric estimation

Metal coordination chemistry:

i. Since metal ions carry a positive charge, negatively charged species in a solution, like anions or negatively charged atoms of complex ions, will be attracted to them.

ii. the metal is a d-block element (Cu) the d-orbitals split, with the dxy, dxz and dyz forming one group and the dx^2-y^2 and dz^2 forming a second group at a different energy level.

iii. If a photon with the right energy strikes an electron in the lower energy orbital, that photon can be absorbed and the electron is promoted to the higher orbital.

iv. This absorbance gives the metal ion solution its color and allows us to measure the concentration by colorimetry.

Reagents:

- Brass Samples
- 7.0 M Nitric acid (HNO_3)
- 0.1 M Copper(II) sulfate ($CuSO_4$)
- 2.0 M Ammonia (NH_3)

Part 1. Getting brass samples into solution:

a) Weigh ~0.5 g of the brass directly into the labeled beaker.

b) Carefully pipette 10.0 mL of 7.0 M HNO3 into the beaker.

c) Perform this step in a fume hood or in a well ventilated area. Cover the beaker with a watch glass and set it on a hot-plate set to low. Observe and record what happens.

Part 2. Preparation of standard $[Cu(NH_3)_4]^{2+}$ solutions:

a) Pipette 3 mL of a 0.1 M CuSO4 solution into a clean cuvette and record its absorbance spectrum from 400 nm to 900 nm using the SPECTRONIC 200 Spectrophotometer. Use the cursor to determine the wavelength of maximum absorbance, λmax and record the data in the Lab Report.

b) For each solution, use a pipette to add the amount of 0.1 M CuSO4 indicated in the table below to a 25 mL volumetric flask.

Standard solution	Volume of 0.1 M $CuSO_4$
1	1.0 mL
2	2.0 mL
3	4.0 mL
4	5.0 mL

c) Using 2.0 M NH3, dilute the solutions to the mark on the volumetric flask. The final deep blue color indicates formation of the $[Cu(NH_3)_4]^{2+}$ complex. Place the stopper in the flask and mix the solutions well by inverting and swirling.

d) Transfer the prepared solutions to clean, dry, labeled 50 mL beakers and save for analysis.

e) Measure your standards using the SPECTRONIC 200 Spectrophotometer

1. Using Standard Solution 4, perform a scan from 400 nm to 900 nm in absorbance mode.
2. Record the wavelength of maximum absorbance (λmax) for [Cu(NH3)4]2+.
3. Record the measured absorbance at this wavelength for your solution.
4. Either in Scan mode, or in Live Display mode, measure the absorbance of the other three standard solutions at λmax and record the data.
5. Using your concentration and absorbance readings, construct a Beer's Law plot. Use a spreadsheet program or a graphing calculator to plot your data and determine a best-fit line to calculate the slope of your line. Record the slope of the line in the Lab Report.

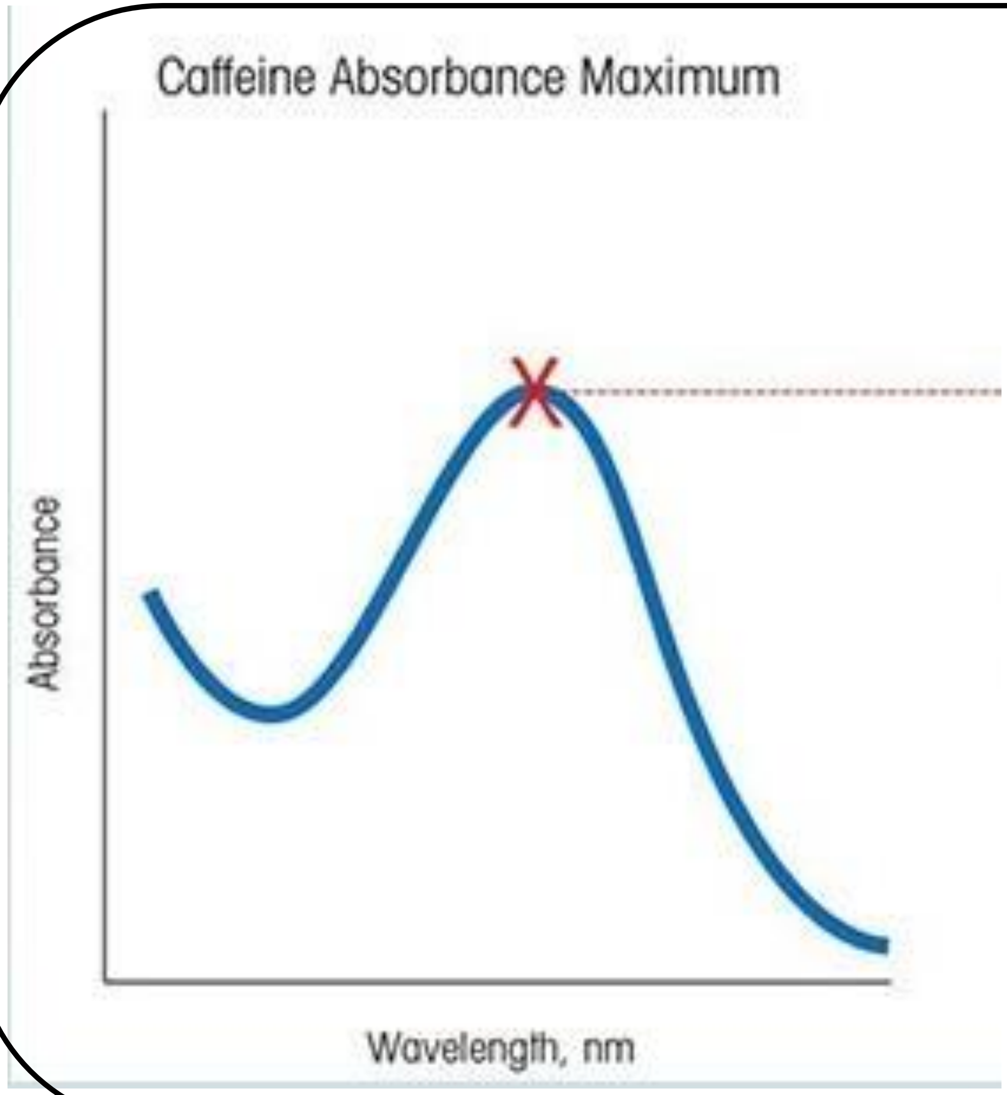
Part 3. Analysis of the brass samples:

a) After all the brass has reacted away, pipette ~3 mL of the solution into a clean, dry cuvette and record its absorbance spectrum from 400 nm to 900 nm. Use the cursor to determine the wavelength of maximum absorbance, λmax and record the result in Data Table 3 of the Lab Report. Discard the sample.

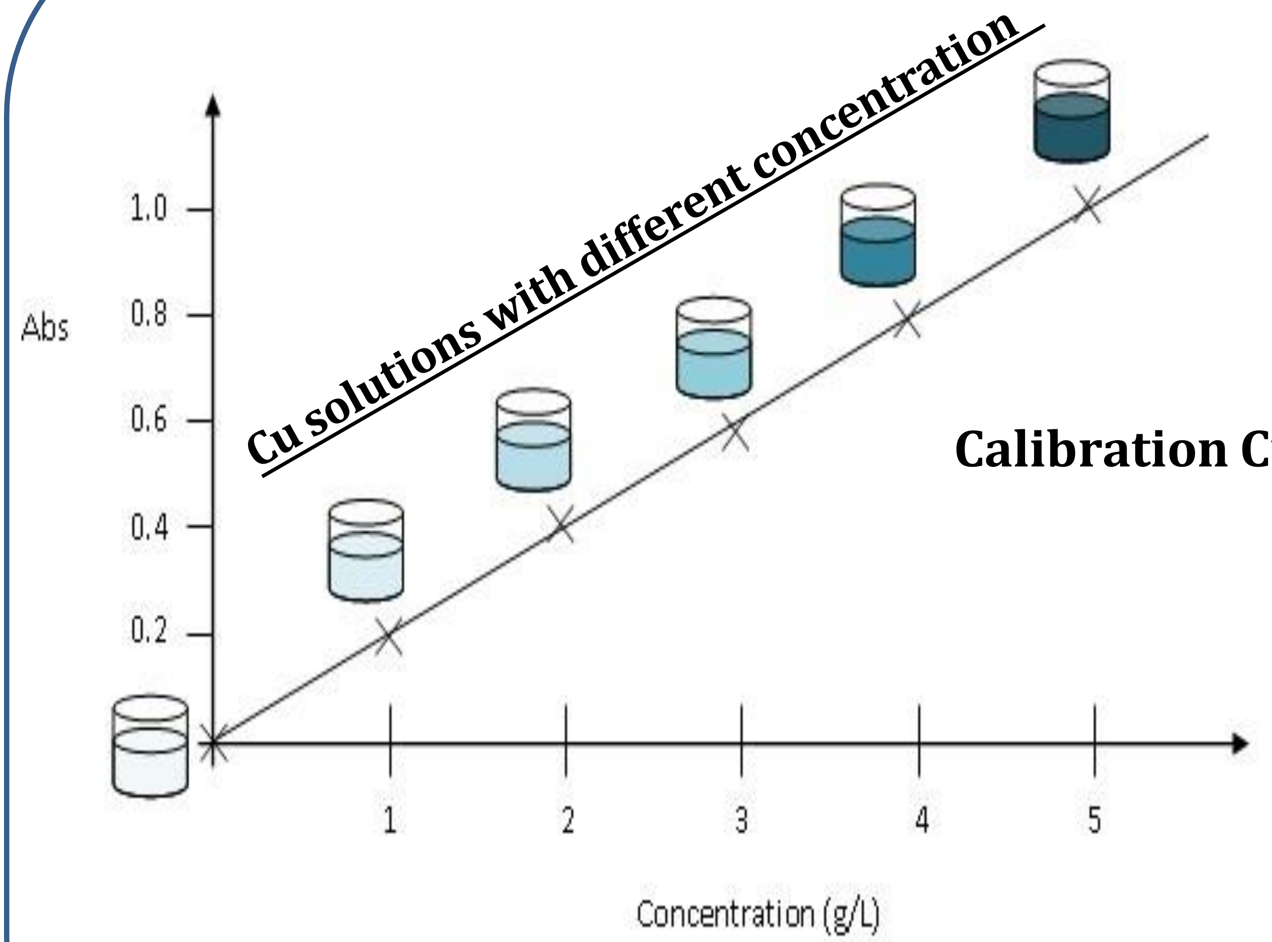
b) With the remaining solution:

1. Pipette 2.0 mL of the solution into a 100 mL volumetric flask. Be as careful as you can to deliver exactly 2.0 mL.
2. Add 20 mL of 2.0 M NH3 solution to the volumetric flask and swirl the contents.
3. Pour or pipette ~3 mL of this solution into a clean, dry cuvette. Record the absorbance of the solution at the same wavelength that you used for the [Cu(NH3)4]2+ standards in Data Table.

❖ Measurement of λ_{max} :

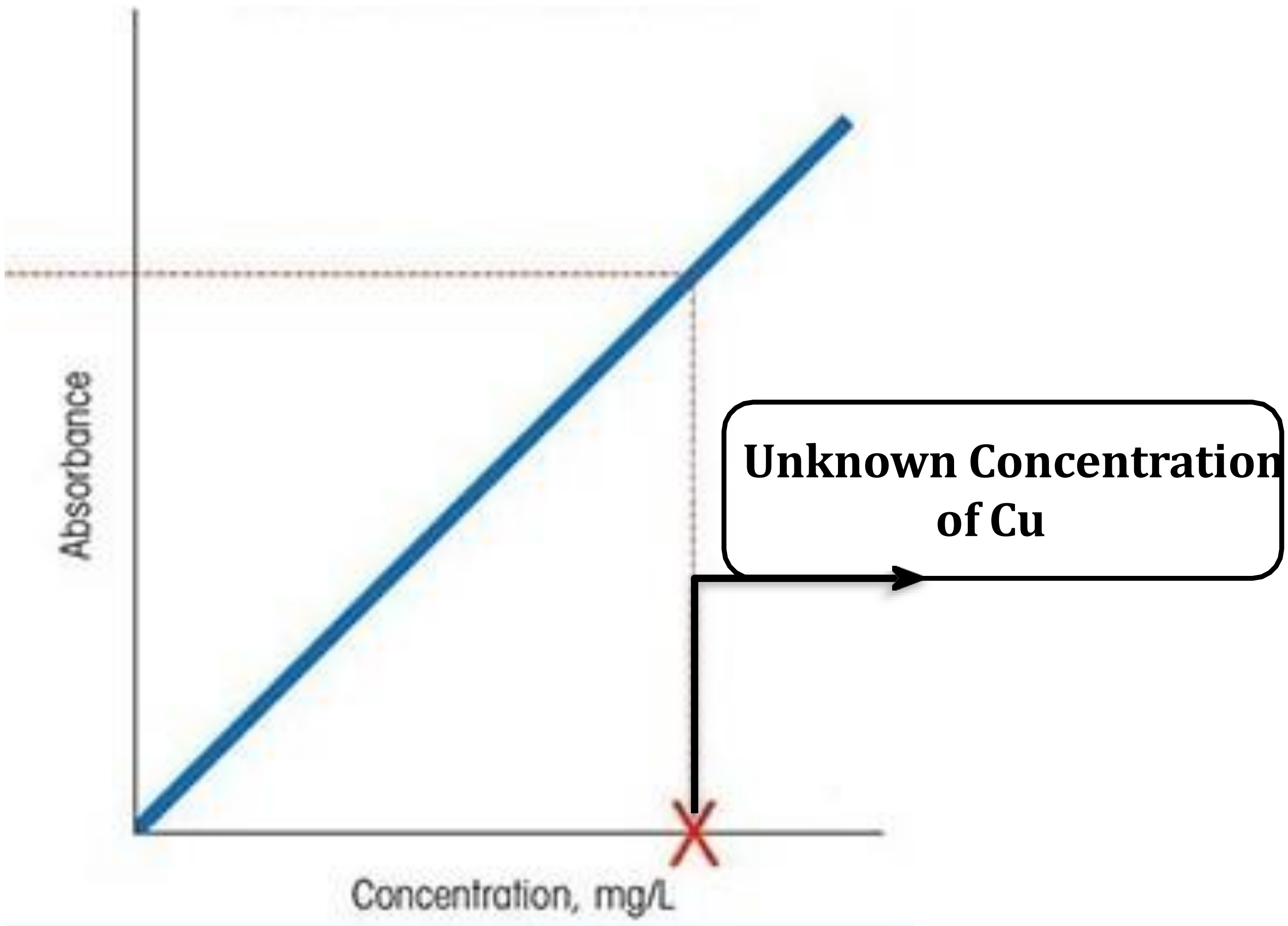


λ_{max}

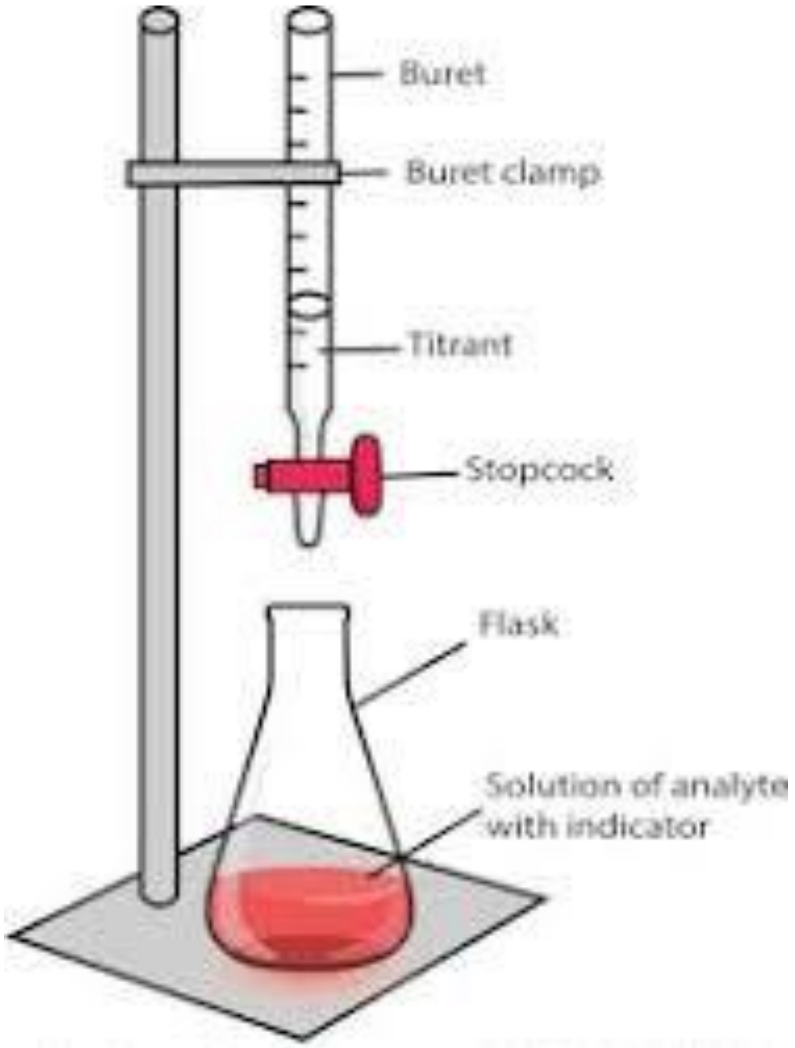


Calibration Curve measurement

Measurement of Copper Concentration:



Estimation of Zinc (Zn): Complexometric Titration:



Estimation of Zinc (Zn): Complexometric Titration:

Reagents:

1) Brass Alloy
2) Conc. HNO_3
3) EDTA (Ethylene Diamine Tetra acetic Acid)
4) Acetate Buffer
5) Sodium Thiosulphate
6) Xylenol Orange Indicator

Test Procedure:

a) Take 0.5 gm of Brass alloy in beaker and add 10 ml conc. HNO3. Heat the solution to dissolve the all brass alloy and dilute the solution to 250 ml.

b) Take 10 ml of unknown zinc solution and add equal volume of acetic acid buffer solution (10 ml) to maintain the pH of solution between 5-6.

c) After that add sodium thiosulphate solution.

d) Add 2-3 drops of Xylenol orange indicator

e) Titrate the solution against 0.01 M EDTA solution.

f) End point of titration is red to green.

Reactions:

1) The role of buffer solution is to maintain the pH of the solution is between 5-6.
2) The role of **Sodium thiosulphate is to mask the Cu+2** ions to prevent the interference in the titration.
3) When the xylenol orange indicator was added to the solution it forms a chelate with the Zn+2 ions which is red in colour.
4) Then the whole solution was titration against EDTA the chelate is breaks down and there will **formation of complex Zn-EDTA** which is green in colour.

Calculations:

Calculate the percentage of Zn as below,

1 ml of 0.01 M EDTA = 0.6538 mg of Zn

$$\textbf{Zinc (Zn) percent} = \frac{\mathbf{0.6538 \times 25 \times V}}{\mathbf{W}}$$

where

W = Weight of the brass in gm

V= Volume of EDTA required

Thank You!