University of Science & Technology
Faculty of Engineering – First year - **Batch 31**

General Chemistry

Lecture 2 ~ Semester 1

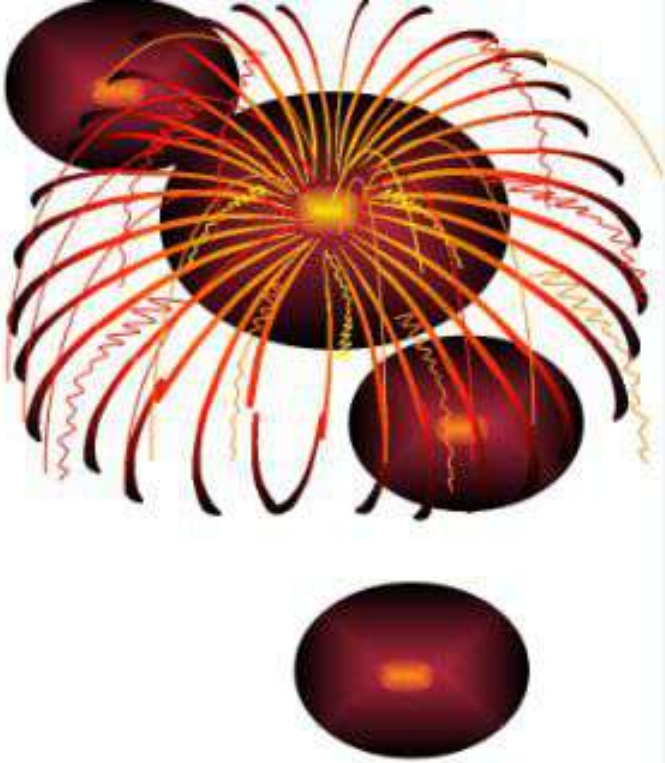
Volumetric Analysis

(Titrimetric Analysis)

By

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Objectives

The method of calculation in titration reactions:

► **Consider the following general reaction:**

$$aA + bB \longrightarrow C + D$$

One mole of A reacts with $^{b}/_{a}$ moles of B.

If in the titration, the end point is obtained after the addition of V_a cm³ of M_a molar solution of A to V_b cm³ of M_b molar solution of B, therefore,

$$\text{The number of moles of A} = \frac{V_a M_a}{1000}$$

$$\text{Number of moles of B} = \frac{V_b \times M_b}{1000}$$

$\frac{M_a V_a}{1000}$ **moles of A react with** $\frac{M_b V_b}{1000}$ **moles of B**

1 mole of A reacts with $\frac{M_b V_b}{M_a V_a}$ of B

$$\frac{M_b V_b}{M_a V_a} = \frac{b}{a}$$

$$\mathbf{\frac{M_a V_a}{a} = \frac{M_b V_b}{b}}$$

Example 1:

25cm³ of 0.1M sodium hydroxide solution were completely neutralized by 25cm³ of sulphuric acid solution. Calculate the molarity of the acid ?

Solution:

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

$V_a = 25cm^3$, $M_b = 0.1M$, $V_b = 25cm^3$,

a = 1mol, b= 2mol

$$\frac{25XM_a}{1} = \frac{25X0.1}{2}$$

$M_a \equiv$ Molarity of the acid = 0.05M

Types of the Reactions in Titrimetric Analysis:

There are several reactions which are used in titration:

- **Neutralization Reactions:**

Neutralization Reactions are Acid/Base reactions; the reactions involve the combination of hydrogen and hydroxide ions to form water.

$$HCl + NaOH \rightarrow NaCl + H_2O$$

- **Precipitation reactions**

Precipitation reactions or double decomposition reactions are reactions between two soluble salts that form an insoluble product (precipitate) and a soluble one.

$NaCl + AgNO_3 \rightarrow AgCl\downarrow + NaNO_3$

$BaCl_2 + Na_2SO_4 \rightarrow BaSO_4\downarrow + 2\ NaCl$

precipitate

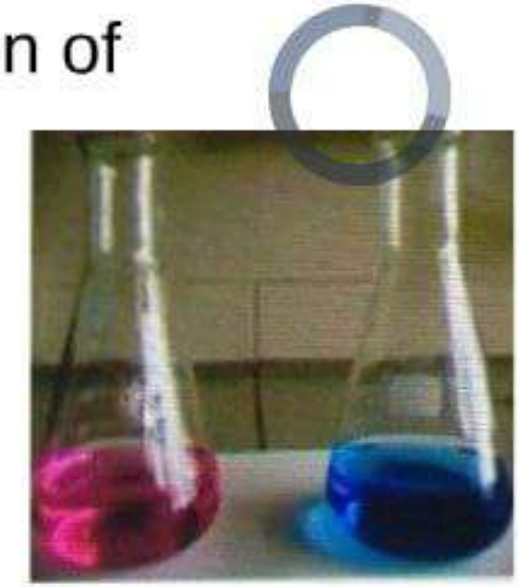


- **Complex-formation Reactions**

(Complexometric reactions) :

The standard solution forms complex with the analyte.

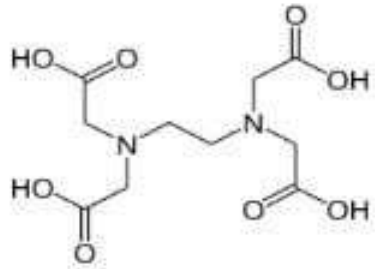
- The chelating agent EDTA (ethylenediaminetetra - acetic acid) is very commonly used to titrate metal ions in solution. These titrations generally require specialized indicators that form weaker complexes with the analyte e.g eriochrome black T for the titration of calcium and magnesium ions.



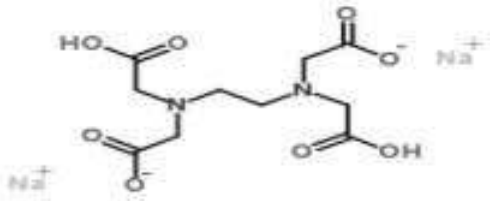
$$Mg^{+2} + H_2Y^{-2} \rightarrow MgY^{-2} + 2H^{+}$$

$$Ca^{+2} + H_2Y^{-2} \rightarrow CaY^{-2} + 2H^{+}$$

The structural formula of EDTA can be given as:



As the ethylenediaminetetra-acetic acid is sparingly soluble in water, its disodium salt is used for titration. Its formula:



- **Oxidation-Reduction Reactions:**

Oxidation-reduction reactions always occur simultaneously, and therefore they are generally known as redox reactions.

In redox reactions the chemical species which lose electrons and thus oxidized and these electrons are gained by other species Which are reduced.

★A species that donates electrons is called a reducing agent and that accepting the electrons is called an oxidizing agent.

Example:

$10\ FeSO_4 + 2\ KMnO_4 + 8H_2SO_4 \rightarrow 5Fe_2(SO_4)_3 + K_2SO_4 + 2MnSO_4 + 8H_2O$

Or:

$5Fe^{+2} + MnO^{-}_{4} + 16H^{+} \rightarrow 5Fe^{+3} + Mn^{+2} + 8H_2O$

Standard Solutions:

They are solutions of known concentration.

Every volumetric analysis is based upon a primary standard solution, which is a highly purified substance that is used to determine the concentration of other solution.

A primary standard substance should satisfy the following requirements:

► It must be easy to obtain, to purify, to dry and to preserve in a pure state.

► The substance should be unaltered in air during weighing and should maintain and unchanged composition during storage.

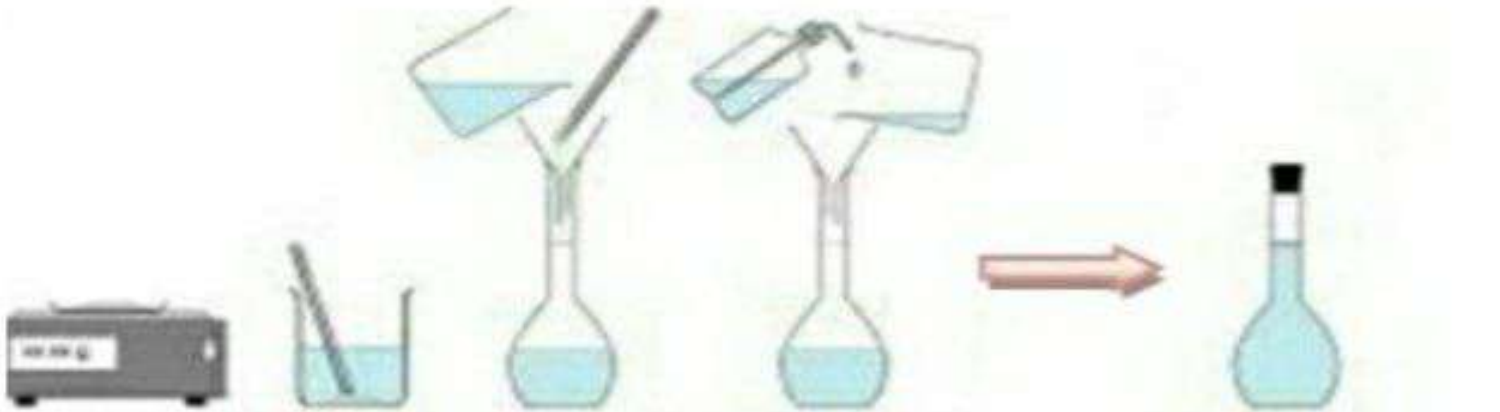
► It should have a high relative molecular mass.

►The substance should be readily soluble under the conditions in which it is employed.

► The reaction with the standard solution should be stoichiometric and practically instantaneous.

Preparation of Standard Solutions

- A standard solution is prepared by dissolving an accurately weighed amount of a highly pure substance, usually called a primary standard (using analytical balance), in an accurately known volume of an appropriate solvent usually water using a volumetric flask.



analytical balance

volumetric flask

► Examples of primary standard substances:

Potassium hydrogen phthalate $C_8H_5O_4K$,

anhydrous sodium carbonate Na_2CO_3,

Hydrated oxalic acid $H_2C_2O_4.2H_2O$

! The number of compounds that meet or even approach the above criteria is so small that only a limited number of primary standard substances are available to the chemist.

- The chemists employ a less pure substance instead of a primary standard, this substance called a secondary standard. It is prepared as follows:

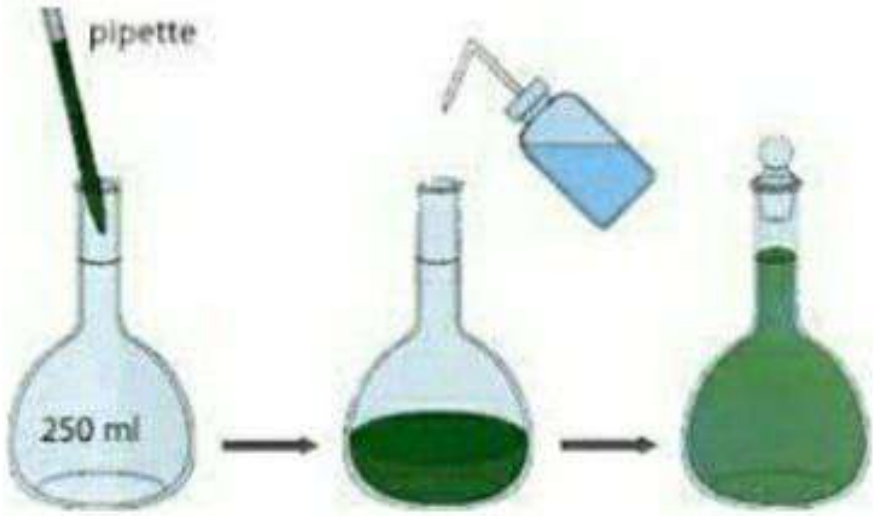
(i) A solution of approximately desired concentration is prepared as above steps, then

(ii) It should be standardized by titration against a primary standard solution.

► A second method of preparing standard solutions is to dilute a more concentrated solution.

In a dilution : a solution made by adding more solvent to a more concentrated solution.

$$VM(dil) = VM(conc)$$


pipette
250 ml

Assessment 2

Solve the following questions

1- What is the difference between neutralization and redox reactions ?

2- 12cm^3 of 0.24M sodium hydroxide solution were completely neutralized by 20 cm^3 of phosphoric acid solution. Calculate the molarity of the acid ?

3- What is the volume needed to prepare 100mL of 0.1M sodium hydroxide from 0.2M ?

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