Shri R.L.T.College of Science, Akola

Department of Chemistry

B.Sc. II Year Semester-III

Unit-II

Volumetric Analysis

Introduction:

- Analytical chemistry is the branch of chemistry which deals with the analysis of substances, which is mainly divided into two main classes.
- Qualitative Analysis & Quantitative Analysis.
- Quantitative Analysis: The basic Principle of Quantitative analysis is to determine the amount of a given sample.
- **There are many methods of Quantitative Analysis such as**
- **1.** Volumetric Analysis
- 2. Gravimetric Analysis
- 3. Refractometery
- 4. Polarimetry
- 5. Fluorimetry and Photometry
- 6. Electrochemical, Chromatography and biological methods.

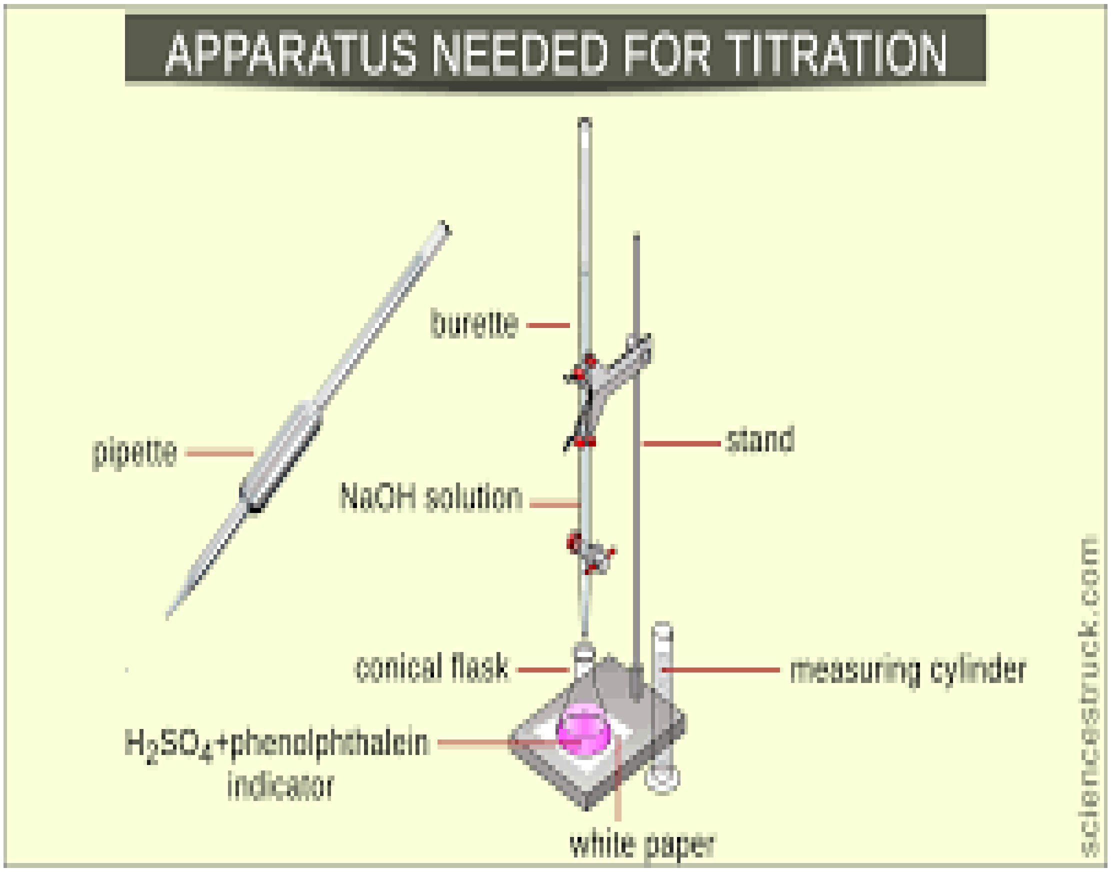
Volumetric Analysis:

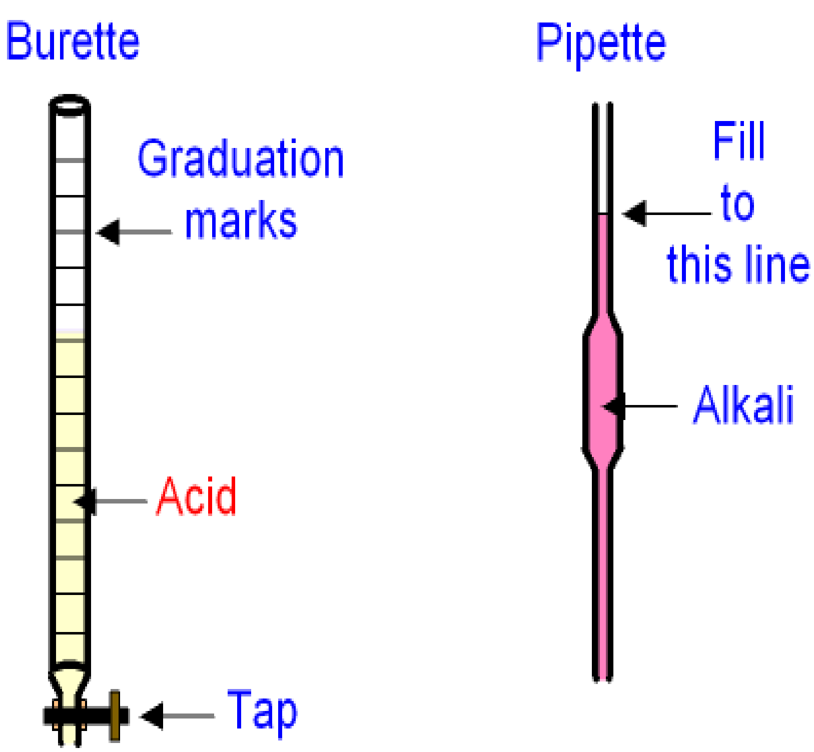
- Volumetric analysis is a quantitative analysis in which volume of known concentration solution (standard) required to react with a solution of unknown concentration is determined.

Volumetric reactions are

1. Simple and easy
2. Fast and can be done on site.
3. Less Expensive
4. Estimation of content or Assay of Chemical
5. Precise and accurate-depends on method and specificity.

Apparatus Needed for Volumetric Analysis:





Important Terms:

1. **Titration:**

Titration is the process of determining the volume of the known strength (concentration) solution required to react with a known volume of unknown strength solution.

2. Titrant and Titrate:

The solution taken in a burette use in titration is called the titrant and the solution taken in a conical flask is called titrate.

3. Equivalence Point or Theoretical end point:

The volume at which reaction actually completed by addition of stoichiometric amount of titrant is known as equivalence point or theoretical end point.

4. Indicator:

A substance which is used for the visual detection of the completion of a particular reaction to determine the end point of a titration is called as indicator.

5. End Point:

The volume at which the completion of the reaction is observe by using an indicator is called the end point, the visual observation is colour change or fluorescence or turbidity formation.

6. Titration error:

In practice, there is difference between equivalence point and end point. This difference is known as titration error.

Requirements of volumetric Analysis

1. The chemical reaction must be simple and takes place quantitatively to form known product.
2. The reaction shows some marked changes in some properties at equivalence point.
3. It should be stoichiometric.
4. It should be free from side reactions
5. It should be specific for the substances to be analysed.

6. The end point should be well defined and shows visible change by the use of indicator,
7. The reaction should be relatively fast.

Advantages of volumetric Analysis

1. These analysis required simple apparatus like burette, pipette, conical flask, etc.
2. The analysis process does not involve laborious operations.
3. It can be performed quickly and results obtained readily.
4. This method is more precise and accurate.
5. Depending upon the nature of substances to be analysed different types of titrimetric methods can be used.

Important Terms:

Standard Solution:

Volumetric Analysis depends on the use of at least one standard solution. Standard solution is the solution of known strength. A standard solution is prepared by dissolving an accurate weighted quantity of a highly pure substance.

Primary Standard Solution:

A highly pure substance which is used to which is used to prepare standard solution by direct weighting it, is known as primary standard substance. Standard solution is prepared by dissolving an accurate weighted quantity of a Primary standard substance. Those substances whose solution can not be prepared by direct weighting are not used as a Primary standard solution. These types of substances are called as Secondary standard substances.

Requirements for a substance to be primary standard.(HSEB)

- It must be available in pure form and should be non toxic.
- It should not be hygroscopic(ability to absorb moisture) or deliquescent(turns to solution).
- It should have high molecular weight or equivalent weight so as to minimise the weighing error during weights.
- It should be readily dissolve in water.
- It should be stable. In other words, the composition of substance should not change in solid or in solution state for long time.

Examples of Various Primary Standard used in various kinds of Titrations

a.Acid Base titration:

Sodium carbonate, Potassium Hydrogen phthalate, succinic acid, benzoic acid etc.

b. Oxidation Reduction Titration:

Potassium dichromate, Potassium iodate, Oxalic Acid, Sodium Oxalate, Arsenium oxide, and pure iron.

c. Precipitation Titration:

Silver, silver nitrate, sodium chloride, potassium chloride.

d. Complex formation titration:

Silver, silver nitrate, sodium chloride, Zinc, Magneshium, Lead salts, EDTA disodium salt.

Terms to Express Concentration:

- **Normality**- Number of gram equivalent of solute (Substance) dissolved in one litre (1000 ml) of solution is called as Normality.
- Normality is indicated by **N**

$$\text{Equivalent Weight} = \frac{\textbf{Gram equivalent Weight of Solute}}{\textbf{No. of replaceable } H^+ \textbf{ \& } OH^-}$$

- **Normality Examples- Molecular weight of NaOH (Sodium Hydroxide)=**

  Atomic Weight of Na = 22.99

  Atomic Weight of O = 16

  Atomic Weight of H = 1

  40

- 1N = 40 gm of NaOH is Dissolved in 1000 ml of water (H_2O)
- 0.1 N = 4 gm of NaOH is Dissolved in 1000 ml of water (H_2O)
- 0.01N = 0.4 gm of NaOH is Dissolved in 1000 ml of water (H_2O)

Equivalent Weight :

$$\text{Eq. Wt. of acid} = \frac{\text{Molecular weight}}{\text{Number of replaceable hydrogen ion}}$$

$$\text{Eq. Wt. of Base} = \frac{\text{Molecular weight}}{\text{Number of replaceable hydroxyl ion}}$$

For Ex. Molecular weight of HCL is 36.5g and as it contains one hydrogen atom its equivalent wt. is also 36.5g.

But in case of sulphuric acid H2SO4 molecular weight is 98gm , but Equivalent wt. by above formula is 49 gm.

- **Molarity** - Number of moles of solute (Substance) dissolved in one litre (1000 mL) of Solution is called as Molarity.
- 1 gm in 1000 ml = 1 mol.
- **Molarity** is indicated by **M**

$$M = \frac{\text{Number of moles of Solute}}{\text{1000 mL of Solution}}$$

- **Molarity Examples- Molecular weight of NaOH (Sodium Hydroxide)=**

Atomic Weight of Na= 22.99

Atomic Weight of O= 16

Atomic Weight of H= 1

40

- 1M= 40 gm of NaOH is Dissolved in 1000 mL of water (H_2O)

- 0.1 M= 4 gm of NaOH is Dissolved in 1000 mL of water (H_2O)

- 0.01M= 0.4 gm of NaOH is Dissolved in 1000 mL of water (H_2O)

- **Molarity Examples- Molecular weight of HCl (Hydrochloric acid)=**

Atomic Weight of Cl = 35.5

Atomic Weight of H = 1

36.5

- 1M = 36.5 gm of HCl is Dissolved in 1000 mL of water (H_2O)

- 0.1 M = 3.65 gm of HCl is Dissolved in 1000 mL of water (H_2O)

- 0.01M = 0.365 gm of HCl is Dissolved in 1000 mL of water (H_2O)

- **Molality**- A molal solution contains 1 mole of solute per one kilogram of solution (1 lit. of solvent) is called as **Molality.**
- Molality is indicated by **M**

$$\mathbf{N} = \frac{\textbf{Number of mol. Wt. of substance}}{\textbf{1000 gm of Solution (1Kg)}}$$

- **Molality Examples- Molecular weight of NaOH (Sodium Hydroxide)=**

Atomic Weight of Na = 22.99

Atomic Weight of O = 16

Atomic Weight of H = 1

40

- 1 M = 40 gm of NaOH is Dissolved in 1000 gm of water (H_2O)
- 0.1 M = 4 gm of NaOH is Dissolved in 1000 gm of water (H_2O)
- 0.01 M= 0.4 gm of NaOH is Dissolved in 1000 gm of water (H_2O)
- 1.5 M= 60 gm of NaOH is Dissolved in 1000 gm of water

MOLE FRACTION

- The mole fraction of any component in a mixture is the ratio of the number of moles of it to the total number of moles of all the components present.
- Mole fraction of any component can never be greater then 1 and sum of all mole fractions is equal to 1.
- $xa = \frac{na}{na + nb + nc}$

Percent Composition

- 1. By weight(w/w):
- The percent composition by weight is the number of grams of solute present in 100g of solution.
- 2. By Volume (v/v):
- The percent composition by volume is the volume of solute present in100cc of solution.
- 3. By weight per volume (w/v):
- It is number of solute present in 100cc of solvent.

Problems On Molarity And Normality

Problem No. 1: Calculate the Molarity and Normality of the solution containing 2.0 g of NaOH in 500 cc solution (Mol. Wt. of NaOH = 40 g)

Given: Weight of NaOH = 2g in 500 cc, so

Wt. of NaOH Per dm^3 that is in 1000cc = 4.0 g

Molecular Weight of NaOH = 40 g

To Find: Molarity And Normality

Weight of NaOH in dm^3

Molarity = --------------------------------

Molecular Weight of NaOH

= 4/ 40

= 0.1M

Weight of NaOH in dm^3

Normality = --------------------------------

Equivalent Weight of NaOH

= 4/ 40

= 0.1 N

Hence Molarity of given NaOH solution is 0.1 M and Normality of given NaOH solution is 0.1 N.

Problem No. 2: Calculate the Molarity and Normality of the solution containing 4.9 g of H2SO4 in 500 cc solution (Mol. Wt. of H2SO4 = 98 g)

Given: Weight of H2SO4 = 4.9g in 500 cc, so

Wt. of H2SO4 Per dm^3 that is in 1000cc = 9.8 g

Molecular Weight of H2SO4 = 98g

To Find: Molarity And Normality

Weight of H2SO4 in dm^3

Molarity = --------------------------------

Molecular Weight of H2SO4

= 9.8/ 98

= 0.1M

Weight of H2SO4 in dm^3

Normality = --------------------------------

Equivalent Weight of H2SO4

Equivalent Weight = Molecular weight of Acid/ No. of

Replaceable hydrogen atom

= 98/ 2

= 49 g

Weight of H_2SO_4 in dm^3

Normality = --------------------------------

Equivalent Weight of H_2SO_4

= 9.8/ 49

= 0.2 N

Hence Molarity of given H_2SO_4 solution is 0.1 M and Normality of given H_2SO_4 solution is 0.2 N.

Problem No. 3: Calculate the weight of oxalic acid require to prepare 0.2 N, 1 lit solution. (Mol. Wt. of Oxalic Acid = 126)

Given: Normality of Oxalic Acid = 0.2 N

Molecular Weight of Oxalic Acid = 126g

To Find: Weight of solute per dm^3

Weight of oxalic acid in dm3

Normality = --------------------------------

Equivalent Weight of oxalic acid

Equivalent Weight = Molecular weight of Acid / No. of

Replaceable hydrogen atom

= 126/ 2 = 63 g

Weight of oxalic acid in dm3

Normality = --------------------------------

Equivalent Weight of oxalic acid

0.2 = weight of oxalic acid in dm3 / 63

weight of oxalic acid in dm3 = 0.2 X 63 = 12.6 g

Hence wt. of Oxalic acid reuiered to prepared 0.2 N solution is 12.6 g.

Problem No. 4: Calculate the mole fraction of ethtanol and water if solution contains 6 moles of ethanol and 3 moles of water.

Given: Number of moles of water = 6 moles

Number of moles of ethanol = 3 moles

To Find: Mole fraction of ethanol and mole fraction of water

No. of moles of ethanol

Mole fraction of ethanol = --------------------------------

NO. of moles of ethanol

+ No. of moles of water

No. of moles of ethanol

Mole fraction of ethanol = --------------------------------

NO. of moles of ethanol

+ No. of moles of water

6 6

Mole fraction of ethanol = -------- = --------

6 +3 9

=0.66

$$\text{Mole fraction of water} = \frac{\text{No. of moles of water}}{\text{NO. of moles of ethanol} + \text{No. of moles of water}}$$

$$\text{Mole fraction of water} = \frac{3}{6+3} = \frac{3}{9}$$

$$= 0.33$$

Hence the mole fraction of ethanol is 0.66 and water is 0.33

Problem No. 5: Calculate the number of moles water if solution contains 36 g of water. (mol. Wt. of water = 18)

Given: weight of water= 36 g

Mol. Wt. of water =18

To Find: Number of moles of water

$$\text{No. of Moles of water} = \frac{\text{Weight of water}}{\text{Mol.Wt. of water}} = \frac{36}{18} = 2$$

Hence solution contain 2 moles of water.