Objectives:

What is Chemistry ?

- **Chemistry is the branch of science that deals with the study of matter, its properties, composition, structure, and the changes it undergoes.**
- **It is a fundamental science crucial in understanding the world around us.**

Matter:

❖Matter is anything that has mass and takes up space.

❖Examples of matter : Sand(a solid), water(a liquid), Air(a mixture of gases).

Branches of Chemistry :

The main branches of chemistry are:

❖Physical Chemistry :

is the branch of chemistry that combines principles from physics and chemistry to study the relationship between the physical properties of matter and its chemical composition and behavior.

❖ **Organic chemistry:**

is the study of chemicals containing carbon with hydrogen and their properties, composition, and reactions.

❖ **Inorganic chemistry:**

is the branch of chemistry that studies non-carbon- based compounds and their properties, composition, and reactions.

❖ **Analytical chemistry:**

is the study of the composition of matter. It focuses on separating, identifying, and quantifying chemicals in samples of matter.

❖ **Biochemistry:**

is the study of chemical processes that occur in living things. Research may cover basic cellular processes up to understanding disease states so better treatments can be developed.

- **These branches can be divided further to encompass all of the many areas of study within chemistry.**

• **Environmental Chemistry:** deals with the study of the origin, transport, reactions, effects and fates of chemical species in the environment.

•**Industrial/Chemistry:** Application of chemistry in manufacturing, materials, and technology.

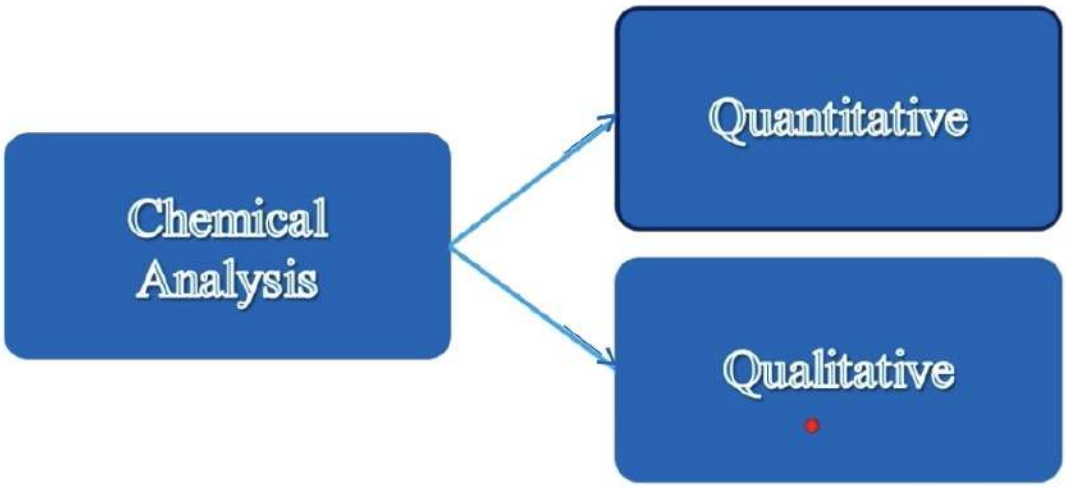
•**Theoretical Chemistry**: Uses mathematics and computer modeling to predict chemical behavior.

•**Nuclear chemistry**: explores radioactivity and nuclear reaction.

Chemical analysis

Chemical analysis consists of two categories:

- **Qualitative analysis**
- **Quantitative analysis**


Chemical Analysis
Quantitative
Qualitative

- **Qualitative analysis : deals with the identification of the constituents of the sample.**
- **Quantitative analysis: is concerned with the amount of substance in the given sample.**

Quantitative analysis

- **Gravimetric analysis.**
- **Titrimetry (volumetric analysis).**
- **Instrumental analysis**

Gravimetric analysis:

The substance being determined is converted into an insoluble precipitate which is collected and weighed using an analytical balance.

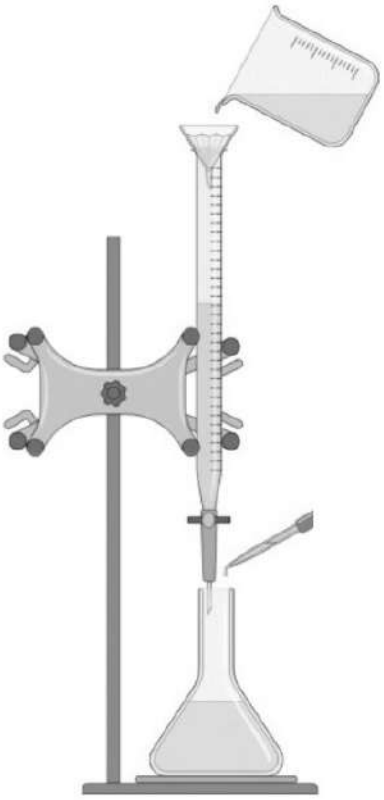
Titrimetry (volumetric analysis):

Based on the accurate measurement of the volume of a standard solution(“titrant”) , a solution of an accurately known concentration, which is required to react quantitatively with a known volume of a solution of the substance to be determined (“analyte”).

- **The concentration of the analyte is calculated from the volume of the standard solution and the known laws of chemical equivalence.**

Titration:

▸ **The process of carefully controlled addition of one solution from the burette to another solution in the conical flask, until the reaction is just complete is called a titration.**



- **The trick is to stop the titration at the point where both reactants have been consumed simultaneously, a condition called:~ the equivalence point of the titration.**

- In a titration we need some means of signaling when the equivalence point is reached.

- There is a technique widely used, in which a very small quantity of a substance added to the reaction mixture changes color at or very near the equivalence point. Such substances are called **indicators**.

- The point at which the solution itself or the indicator gives a clear visual change is **called :~**

the **end point** of **the titration.**

Instrumental analysis:

Scientific instruments are used in analytical chemistry to investigate the analyte.

Methods of Expressing Concentration of Solutions:

When we dissolve a substance in a liquid, we call the substance the solute and the liquid the solvent.

The general term concentration of the solute is the amount of solute dissolved in a standard amount of solution. It may be expressed in several ways:

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Molar concentration or Molarity (M):

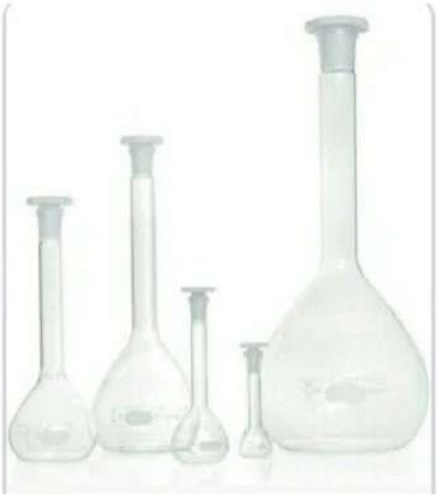
- The molarity of a solution is the number of moles of solute per one liter (cubic decimeter) of solution.
- The molar solution is defined as that solution which contains one mole of the substance dissolved in one liter (dm^3) of solution.

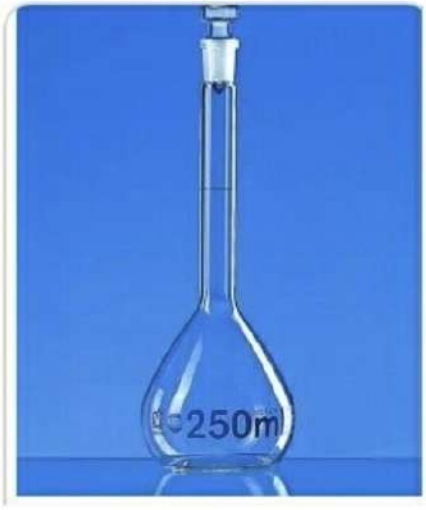
$$\text{Molarity} = \frac{\text{Number of moles of solute}}{\text{Volume L (dm}^3\text{) of solution}}$$

$$\text{Number of moles} = \frac{\text{Weight(g)}}{\text{Molecular weight}}$$

Example1:

A sample of $NaNO_3$ weighing 0.38g is placed in a 50.0mL(cm^3) volumetric flask. The flask is then filled with water to the mark on the neck, dissolving the solid. What is the the molarity of the resulting solution ?





volumetric flasks

Solution:

First, we find the number of moles of $NaNO_3$ in 0.38g : number of moles of $NaNO_3$ =

$$\frac{0.38}{85.00} = 4.47X\ 10^{-3}\ \text{mol}\ NaNO_3$$

0.38g$NaNO_3$ is $4.47X\ 10^{-3}$mol $NaNO_3$

The definition of molarity(M) is:

$$\frac{\text{Number of moles of solute}}{\text{volume of solution(L)}}$$

The volume of solution is 50.0mL, or $50.0X10^{-3}$ L, so the molarity is:

$$\frac{4.47X\ 10^{-3}\ \text{mol}\ NaNO_3}{50.0X10^{-3}\text{L solution}} = 0.089M\ NaNO_3$$

Molality (m) :

The molality of a solution is the number of moles of solute per 1 Kg (1000g)of solvent.

$$\frac{\text{Number of moles of solute}}{\text{mass of solvent(Kg)}}$$

Normality (N):

The normality of a solution is the number of gram equivalent weights of solute per litre of solution.

$$\text{Normality} = \frac{\text{Number of gram equivalent weights of solute}}{\text{Volume L } (dm^3) \text{ of solution}}$$

Mole Fraction(X):

The mole fraction of a component of a solution is the ratio of the number of moles of that component to the total number of moles of all components present in the solution.

The mole fraction of component A in a mixture is given by:

$$X_A = \frac{nA}{nT}$$

Where:

n_A is the number of moles of component A.

n_T is the total number of moles present.

- **The mole fraction is always smaller than one.**

Percent Composition (%):

► %W/W solute = $\frac{\text{mass of solute}}{\text{mass of solution}} \times 100$

► a similar unit that is frequency used to express very small concentration is parts per million (ppm) . It is by volume or by mass:

$$\frac{\text{mass of solute}}{\text{mass of solution}} \times 10^6$$

1ppm = mg/Kg = 1 mg/L

ppb .....

Example 2:

A sample of 0.892 g of potassium chloride (KCl) is dissolved in 54.6 g of water. What is the percent by mass of KCl in the solution?

Solution:

$$\text{Percent by mass of KCl} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100$$

$$\frac{0.892\ \text{g}}{0.892\ \text{g} + 54.6\ \text{g}} \times 100 = 1.61\%$$

Example 3:

A 2-liter sample of water contains 700 mg nitrate ions. Express the concentration in ppm?

Solution:

$$\text{ppm} = \frac{\text{mass of solute(mg)}}{\text{volume of solution(L)}}$$

$$\frac{700\ \text{mg}}{2\text{L}} = 350\text{ppm(mg/L)}$$

Assessment 1

1- What is the difference between molarity and molality ?

2- What is the percent by mass of sugar solution prepared by dissolving 4g of sucrose in 46 g of water ?

3- A homogeneous mixture of two moles of nitrogen, four moles of oxygen and two moles of hydrogen, what is the mole fraction of nitrogen ?