Analytical chemistry

Analytical chemistry has been important since the early days of chemistry, providing methods for determining which elements and chemicals are present in the object in question.

Analytical Chemistry: is concerned with the chemical characterization of matter, both qualitative and quantitative. It is important in nearly every aspect of our lives because chemicals make up everything we use.

Deals with the methods for the identification of one or more of the components in sample of matter and determination of the relative amount of each

Analytical chemistry consists of:

1- classical methods:

(A) Qualitative analysis which deals with the identification of elements, ions, or compounds present in a sample (tells us what chemicals are present in a sample).

(B) Quantitative analysis which is dealing with the determination of how much of one or more constituents is present (tell us how much amounts of chemicals are present in a sample). This analysis can be divided into three branches:

(1) Volumetric analysis (Titrimetric analysis): The analyte reacts with a measured volume of reagent of known concentration, in a process called titration.

(2) Gravimetric analysis: usually involves the selective separation of the analyte by precipitation, followed by the very selective measurement of mass (of the precipitate).

2-Instrumental methods : They are based on the measurement of a physical property of the sample, for example, an electrical property or the absorption of electromagnetic radiation. Examples are spectrophotometry (ultraviolet, visible, or infrared), fluorimetry, atomic spectroscopy (absorption, emission), mass spectrometry, nuclear magnetic resonance spectrometry (NMR), X-ray spectroscopy (absorption, fluorescence).

Solution

Solution: Homogeneous mixture of two or more substance produce from dissolved (disappeared) solute particle (ions, atoms, molecules) (lesser amount) between solvent particle (larger amount).

Solute (lesser amount) + Solvent (larger amount) Solution

$NaCl(s) + H_2O(l) \rightarrow$ Salt Solution

Concentrated Solution has a large amount of solute.

Dilute Solution has a small amount of solute.

The concentration of a solution is defined as : the amount of solute present in a given amount of solution.

Concentration is generally expressed as the quantity of solute in a unit volume of solution.

$$\text{Concentration} = \frac{\text{Quantity of solute}}{\text{Volume of solution}}$$

A solution containing a relatively low concentration of solute is called Dilute solution. A solution of high concentration is called Concentrated solution.

The constituent of the mixture present in a smaller amount is called the Solute.

the one present in a larger amount is called the Solvent.

For example, when a smaller amount of sugar (solute) is mixed with water (solvent), a homogeneous solution in water is obtained. In this solution, sugar molecules are uniformly dispersed in molecules of water. Similarly, a solution of salt (Na+ Cl–) in water consists of ions of salt (Na+,Cl–) dispersed in water.

TYPES OF SOLUTIONS

The common solutions that we come across are those where the solute is a solid and the solvent is a liquid. *In fact, substance in any three states of matter (solid, liquid, gas) can act as solute or solvent. Thus there are seven types of solutions whose examples are listed in Table .1.

TABLE 14.1. TYPES AND EXAMPLES OF SOLUTIONS

State of Solute	State of Solvent	Example
1. Gas	Gas	Air
2. Gas	Liquid (Carbonated drinks)	Oxygen in water, CO_2 in water
3. Gas	Solid	Adsorption of H_2 by palladium
4. Liquid	Liquid	Alcohol in water
5. Liquid	Solid	Mercury in silver
6. Solid	Liquid	Sugar, Salt
7. Solid	Solid (Steel)	Metal alloys : Carbon in iron

Classification of solutions according to amount of solute:

(1) Unsaturated solutions: if the amount of solute dissolved is less than the solubility limit, or if the amount of solute is less than capacity of solvent.

(2) Saturated solutions: is one in which no more solute can dissolve in a given amount of solvent at a given temperature, or if the amount of solute equal to capacity of solvent.

(3) Super saturated solutions: solution that contains a dissolved amount of solute that exceeds the normal solubility limit (saturated solution). Or a solution contains a larger amount of solute than capacity of solvent at high temperature

Classification of solution based on solute particle size:

(1) True solution: A homogeneous mixture of two or more substance in which substance (solute) has a particle size less than 1 nm dissolved in solvent. Particles of true solution cannot be filtered through filter paper and are not visible to naked eye (NaCl in water).

(2) Suspension solution: heterogeneous mixtures which settles on standing and its components can be separated by filtrating (Amoxcycilline Antibiotics), particle of solute visible to naked eye.

(3) Colloidal solution: homogeneous mixture which does not settle nor are their components filterable, solute particle visible with electron microscope (milk).

Standard Solutions

• A solution that contains a known concentration of an analyte.

• It is prepared by dissolving accurately weighed quantity of highly pure material called Primary Standard material.

• The primary standard material should includes the following requirements:

1. It should be *100.00% pure*, although 0.01 to 0.02% impurity is tolerable if it is accurately known.
2. It should be *stable to drying* temperatures, and it should be stable indefinitely at room temperature. The primary standard is always dried before weighing.[3]
3. It should be *readily available* and fairly inexpensive.
4. Although not necessary, it should have a *high formula weight*. This is so that a relatively large amount of it will have to be weighed to get enough to titrate. The relative error in weighing a greater amount of material will be smaller than that for a small amount.
5. If it is to be used in titration, it should possess the *properties required for a titration* listed above. In particular, the equilibrium of the reaction should be far to the right so that a very sharp end point will be obtained.

Preparation of standard solutions

Standard solutions are prepared in two ways:

1. Direct method (Primary standard solution) a primary standard compound is carefully weighed and dissolved in an exactly known volume of solution. The direct method is the best method to be utilized.

2. Indirect method-Standardization (Secondary standard solution)

Preparation of standard solutions

Electrolytes

An electrolyte is a substance that produces an electrically conducting solution when dissolved in a polar solvent, such as water. The dissolved electrolyte separates into cations and anions, which disperse uniformly through the solvent.

A substance that dissociates into ions in solution and acquires the capacity to conduct electricity.

Sodium, potassium, chloride, calcium, and phosphate are examples of common electrolytes

A strong electrolyte is a solution/solute that completely, or almost completely, ionizes or dissociates in a solution. These ions are good conductors of electric current in the solution.

Originally, a "strong electrolyte" was defined as a chemical that, when in aqueous solution, is a good conductor of electricity. With a greater understanding of the properties of ions in solution, its definition was replaced by the present one.

Electrolytes

A species that completely dissociates into ions in solution is called a strong electrolyte. When any ionic compound dissolves in water, it will completely dissociate into ions. For example:

$$NaCl(s) \xrightarrow{H_2O} Na^+(aq) + Cl^-(aq) \quad (1)$$

$$K_2SO_4(s) \xrightarrow{H_2O} 2\,K^+(aq) + SO_4^{2-}(aq) \quad (2)$$

When dissolved in water, some acids (called *strong* acids) completely dissociate into ions:

$$HBr(g) \xrightarrow{H_2O} H^+(aq) + Br^-(aq) \quad (3)$$

Similarly, strong bases will also completely dissociate in water to produce hydroxide ions.

$$LiOH(s) \xrightarrow{H_2O} Li^+(aq) + OH^-(aq) \quad (4)$$

Electrolytes

Other acids and bases only partially ionize in solution. They are called *weak* acids and bases and are examples of **weak electrolytes**:

$$HCN(aq) \rightleftharpoons H^+(aq) + CN^-(aq) \quad (5)$$

$$CH_3NH_2(aq) \rightleftharpoons CH_3NH_3^+(aq) + OH^-(aq) \quad (6)$$

Notice how these reactions are written with a double arrow (instead of a single arrow). This indicates that at the end of the reaction (at equilibrium) species on both sides of the equation still exist in solution.

Not all species produce ions when dissolved in solution. Most covalently-bonded (molecular) compounds are **nonelectrolytes**, meaning they do not form any ions in solution. For example:

$$CO(NH_2)_2(s) \xrightarrow{H_2O} CO(NH_2)_2(aq) \quad (7)$$

Classification of Solutes in Aqueous Solutions

Type of Solute	Dissociation	Particles in Solution	Conducts Electricity?	Examples
Strong electrolyte	Complete	Ions only	Yes	Ionic compounds such as NaCl, KBr, $MgCl_2$, $NaNO_3$; NaOH, KOH; HCl, HBr, HI, HNO_3, $HClO_4$, H_2SO_4
Weak electrolyte	Partial	Mostly molecules and a few ions	Yes, but poorly	HF, H_2O, NH_3, $HC_2H_3O_2$ (acetic acid)
Nonelectrolyte	None	Molecules only	No	Carbon compounds such as CH_3OH (methanol), C_2H_5OH (ethanol), $C_{12}H_{22}O_{11}$ (sucrose), CH_4N_2O (urea)

• Gram atomic weight (gAw some time Awt): Is the weight of a specified number of atoms of that element (contains exactly the same number of atoms of that element as there are carbon atoms in exactly 12g of carbon 12 (this number is Avogadro's number = 6.022x1023 atoms).

• Gram molecular weight (gMw some times M.wt): Defined as the sum of the atomic weight of the atoms that make up a molecular compound.

• Gram formula weight (gFw some time F.wt): The sum of the atomic weight of the atoms that make up an ionic formula.

(is the more accurate description for substances that do not exist as molecules but exist as ionic compounds e.q strong electrolytes-acids, bases, salts). Sometimes use the term molar mass (Molecular weight, M.wt) in place of gram formula weight, gFw).

Example :-Calculate the number of grams in one mole of CaSO4.7H2O (calculate gram molecular or formula weight).

Solution: One mole is the formula weight expressed in grams.

The formula weight is (Ca=40.08; S=32.06; O=16.00; H=1.01)

CaSO4.7H2O=40.08+32.06+(16.0×4)+7[(2×1.01)+16.00]=262.25 g/mol

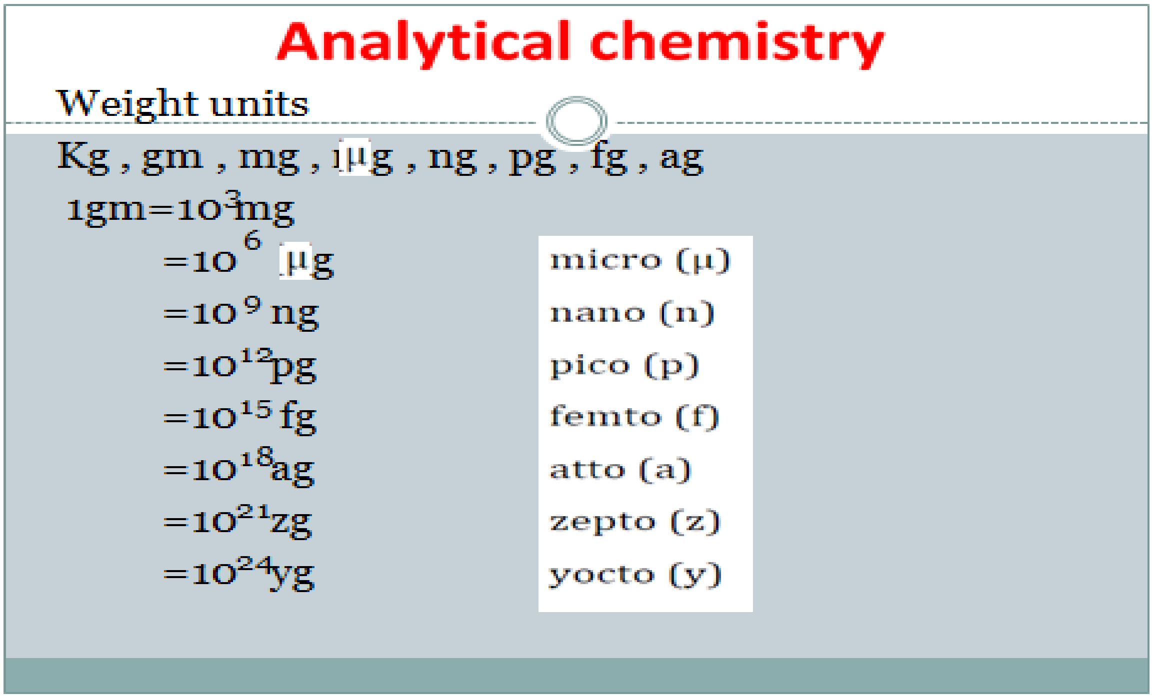
Mole Concept:-Mole: which is Avogadro's number (6.022x1023) of atoms, molecules, ions or other species. Numerically: it is the atomic, molecular, or formula weight of a substance expressed in grams

$$\text{Mole} = \frac{\text{weight (g)}}{\text{formula weight } \left(\frac{\text{g}}{\text{mole}}\right)}$$

$$\text{mMole} = \frac{\text{weight (mg)}}{\text{formula weight } \left(\frac{\text{mg}}{\text{mmole}}\right)}$$

Example :-Calculate the number of moles in 500 mg Na2WO4.

Solution:---------H.W



UNITS OF CONCENTRATION

* There are many ways to express concentrations. Concentration may be expressed several different ways and some of the more common concentration units are:

1. Equivalent weight
2. Molarity
3. Molality
4. Normality
5. Percent solution (weight/weight)
6. Percent solution (weight/volume)
7. Percent solution (volume/volume)