CHEMISTRY

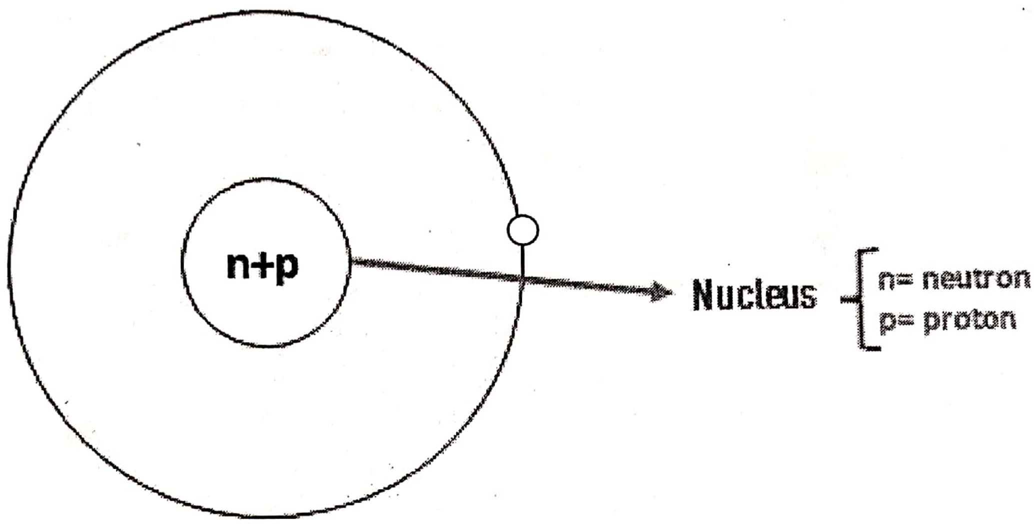


Fig: Structure of a atom

Atomic Number: Atomic Number of an element is equal to the number of protons in the nucleus of atom of that element.

The term atomic number is also referred to as proton number.

Since the atom is a whole is electrically neutral the atomic number (Z) is equal to the number of extranuclear electrons.

Mass Number: Mass Number of an atom is equal to the total number of nucleons in the nucleus of an atom.

The term mass number thus represents the total number of protons and neutrons of an atom. It is expressed by symbol 'A'.

Since electrons have practically no mass the entire atomic mass is due to protons and neutrons each of which has a mass almost exactly one unit therefore, the mass number of an atom can be obtained by rounding of the experimental.

Value of atomic mass or atomic weights to the nearest whole number for example, the atomic mass of sodium and fluorine obtained by experimental is 22.9898 and 26.9815 amu respectively thus their mass number 23 for sodium and 27 for fluorine respectively.

Solve Problem: Uranium has atomic number 92 and atomic weight 238.029. Give the number of electrons, protons, and neutrons is its atom.

Solution:

Atomic number (Z) of Uranium = 92

Number of protons = 92

Number of electrons = 92

We know that Mass Number A = (N + Z) where N= number of neutrons.

$\therefore$ N = A - Z

Mass number (A) is obtained by rounding off the atomic weight = 238.023 = 238

N = 238 – 92 = 146

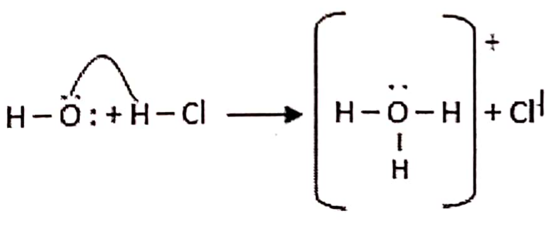
$\therefore$ Thus, Uranium has 92 electrons, 92 protons, and 146 neutrons.

Acid, Base

An acid is a molecule or ion capable of either donating a proton (i,e Hydrogen ion H^+). Known as an Acid (Brønsted Lawry Acid)

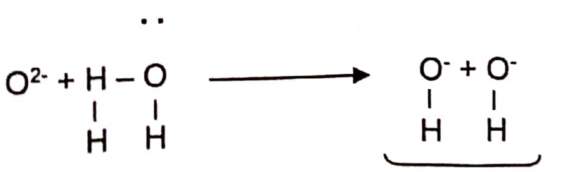
A Base is any molecule or ion that can accept a proton.

For example: When dry HCl gas dissolve in water, each HCl molecule donate a proton to water molecule to produce Hydronium ion.



Hydronium ion

When Calcium oxide is dissolve in water, it is converted to calcium hydroxide, (**$Ca(OH)_2$**) . Here a water molecule donate a proton to oxide ion, O^{2-}, and is a Brønsted acid, the oxide ion accepts a proton and gives $2OH^-$ ions, hence is Brønsted base.



Two OH^- ions

According to ARRHENIUS concept, an acid is a compound that release H^+ ions in water, and base is a compound that release ^-OH ions in water.

For example: HCl is an Arrhenius acid NaOH, is an Arrhenius base.

$$HCl_{(aq)} \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$$

$$NaOH_{(aq)} \longrightarrow Na^+_{(aq)} \; ^-OH_{(aq)}$$

Classes of Acid and Bases (Brønsted)

There are two type of Brønsted Acids:

1. Monoprotic Acid which are capable of donating one proton

$$HCl \longrightarrow H^+ + Cl^-$$

$$H{-}COOH \longrightarrow H^+ + H{-}COO^-$$

2. Polyprotic Acid which are capable of two or more protons

H_2SO_4, H_3PO_4, H_2CO_3, etc.

$$H_2SO_4 \longrightarrow 2H^+ + SO_4^-$$

3. **Amphiprotic base:** Molecules or ions that can act both as Brønsted acid and base are called Amphiprotic substance.

For Example, With HCl, water acts as a base in accepting a proton from the acid.

$$\underset{\text{Acid}}{HCl} + \underset{\text{Base}}{H_2O} \longrightarrow H_3O^+ + Cl^-$$

However, water is an acid while donating a proton to ammonia.

$$\underset{\text{Acid}}{NH_3} + \underset{\text{Base}}{H_2O} \longrightarrow NH_4^+ + OH^-$$

p^H

Hydrogen ion concentration of a solution is called p^H. It is defined as the negative of base – 10 logarithms (log) of H^+ concentration.

Mathematically it may be expressed as

$p^H = -\log [H^+]$

Where $[H^+]$ is the concentration of hydrogen ions in moles per liter.

Alternative and more useful forms of pH definition are:

$p^H = \log \frac{1}{[H+]}$

and $[H^+] = 10^{-PH}$

Measurement of p^H:

p^H can be measured by following ways:

i. p^H indicator
ii. p^H meter
iii. p^H paper

Indicator: When the amount of the base added equals the amount of acid, the end-point or equivalence point is reached. The end-point of a titration is shown by colour change of an indicator previously added to the acid solution.

An acid-base indicator is an organic dye that signals the end-point by visual change in colour.

Methyl orange and phenolphthalein are two common example of acid-base indicators.

Phenolphthalein is pink in base and colourless in acid solution.

Solve Problem:

The pH of a solution of HCl is 2. Find out the amount of acid present in a liter of the solution:

Solution: pH = 2

$-\log [H^+] = 2$ ---------- [By definition]

The dissociation of HCl takes according to equation:

$HCl \longrightarrow K^+ + Cl^-$

One molecule of HCl gives one ions of H^+. therefore,

$[H^+] = [HCl] = 10^{-2}M$

$\therefore \textit{Amount of HCl ion one litre} = 10^{-2} \times \textit{mol mass of HCl}$

$= 10^{-2} \times 36.5$

$= 0.365\ gL^{-1}$

Buffer Solution

In laboratory and industrial processes, it is often necessary to main a certain pH of solution which is achieved with the help of buffer solution or simply buffer.

A buffer solution is one which maintains its pH fairly constant even upon the addition of small amount of acid or base.

Two common types of buffer solution are:

1) A weak acid together with a salt of the same acid with a strong base. These are called Acid buffers CH_3COOH+ CH_3COONa

Solution

A solution is a homogeneous mixture of two or more substance or molecular level.

For example, when a small of sugar (solute) is mixed with water (solvent), a homogeneous solution in water formed. The constituent of the mixture in a smaller amount is called the solute, and the one present in a longer amount is called the solvent.

Concentration of a solution: The amount of solute present in a given amount of solution is called concentration of that solution.

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

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

A solution of relatively low concentration is called Dilute solution. A solution of high concentration is called concentrated solution.

Way of expressing concentration:

There are several ways of expressing concentration of a solution:

a) Percentage by weight
b) Mole fraction
c) Molarity
d) Molality
e) Normality

Mole fraction: Mole fraction (symbol X) of solute is defined as the ratio of the number of moles of solute and total number of moles of solute and solvent. Thus,

$$X\ \text{solvent} = \frac{Mole\ of\ solute}{Moles\ of\ solute + Mole\ of\ solvent}.$$

If n represents moles of solute and N number of moles of solvent.

$$X\ \text{solute} = \frac{n}{n+N}.$$

And Mole fraction of solvent would be

$$X\ \text{solution} = \frac{N}{n+N}.$$

Molarity: Molarity (symbol M) is defined as the number of moles of solute per liter of solution.

If n is the number of moles of solute on U liter the volume of solution,

$$\text{Molarity} = \frac{Mole\ of\ solute}{Volume\ in\ liters}.$$

$$M = \frac{n}{V\ (in\ liter)}.$$

Normality: Normality of a solution (symbol N) is defined as number of equivalents of solute per liter of the solution:

$$\text{Normality (N)} = \frac{Equivalents\ of\ solute}{Volume\ of\ solution\ (in\ liter)}.$$

Thus, if 40g of NaOH (eq.wt =40) be dissolve in one liter of solution, normality of solution is one and the solution is called 1N (One normality).

Solve problem:

5g of NaCl dissolve in 1000g of water. Calculate molarity, normality and mole fraction of the solute, assuming volume of solution is equal to that of solvent.

Solution: Number of moles of NaCl $= \frac{Mass\ of\ NaCl}{Moleculer\ mass\ of\ NaCl}$

$$= \frac{5}{58.5}$$

$$= 0.0854$$

By definition,

$$\text{Molarity} = \frac{Number\ of\ moles\ of\ solute \times 1000}{Mass\ of\ solvent\ in\ grams}$$

$$= \frac{0.0854}{1000} \times 1000$$

$$= 0.0854m$$

$$\text{Volume of the solution} = \frac{Mass\ of\ solution\ in\ grams}{Density\ in\ gram\ per\ ml}$$

$$= \frac{1000+}{0.997}$$

$$= 1008\ ml$$

$$= 1.008\ liter$$

$$\text{Now, Molarity} = \frac{Number\ of\ Moles\ of\ solute}{Volume\ of\ solution\ in\ litres}$$

$$= \frac{0.0854}{1.008}$$

$$= 0.847\ \text{M}$$

$$And,\ Normality = \frac{Number\ of\ gram\ equivalent\ of\ solute}{Volume\ of\ solution\ in\ liters} = \frac{0.0854}{1.008}$$

$$= 0.0847\ \text{N}$$

Colligative properties

Dilute solutions containing non-volatile solutes exhibit the following properties.

1. Lowering of Vapor Pressure.
2. Elevation of Boiling Point.
3. Depression of Freezing Point.
4. Osmosis Pressure.

Above properties are closely related to each other through a common explanation and called colligative properties (Greek colligates - Collected together)

A Colligative property may be termed as one which depends on the number of particles in solution and not in any way on the size of or chemical nature of the particles.

Lowering of Vapor pressure:

Raoult's Law states that: The relative lowering of the vapor pressure of a salute solution is equal to the mole fraction of the solute present in dilute solution.

The vapor pressure of a pure solvent is decreased when a non-volatile solute is dissolved in it. If P Is the VP of the solvent and ps that of the solution,

The lowering of V.P in $P\text{-}P_s$. Thus,

Relative Lowering of V.P = $\frac{P-Ps}{P}$

The according to Raoult's law, Raoult's law can be expressed mathematically in the form:

$$\frac{P - Ps}{P} = \frac{n}{n + N}$$

Here,

n= number of moles of solute.

N = number of moles of solvent.