WATER

Q.1. What do you mean by hard water and soft water. Explain with examples.

Ans: **Hard water**-water which produce lather with soap solution easily.

Ex: river water, sea water, tap water

Soft water- water which does not produce lather with soap solution.

Ex: distilled water.

Q.2. what is the cause of hardness?

Ans: it is due to presence of following dissolved salts-

(1) Bicarbonate of calcium and magnesium
$Ca(HCO_3)_2$ and $Mg(HCO_3)_2$
(2) Chlorides of calcium and magnesium

$CaCl_2$ and $MgCl_2$

(3) Sulphates of calcium and magnesium

$CaSO_4$ and $MgSO_4$

Q.3. write reaction between soap and water?

Ans: $2C_{17}H_{35}COONa + CaCl_2 \rightarrow (C_{17}H_{35}COO)_2Ca\downarrow + 2NaCl$

$2C_{17}H_{35}COONa + MgCl2 \rightarrow (C_{17}H_{35}COO)_2Mg\downarrow + 2NaCl$

Q.4. Type of hardness of water?

Ans : the hardness of water is of two types-

(1) Temporary hardness : It is due to presence of **bicarbonates of calcium and magnesium salt** in water
$Ca(HCO3)_2$ and $Mg(HCO3)_2$
(2) Permanent hardness : it is due to presence of chlorides and sulphates of calcium and magnesium
$CaCl_2$ and $CaSO_4$, $MgCl_2$ and $MgSO_4$

Q.5. what is the unit of hardness?

Ans : (1) parts per million (ppm)- it is defined as parts of $CaCO_3$ equivalent present per 10^6 parts of water.

Milligram per liter: it is defined as no of milligrams of CaCO3 equivalent present per liter of water.

Q.6. what is the disadvantage of using hard water?

Ans: **(1) problems in domestic use :** it causes harmful effects when used for domestic perposes.

(2) wastage of soap : when hard water is used a large amount of water is wasted.

(3) spoiling clothes : hard water damage silk and nylon fabrics .

(4) cooking: pulses and other vegetables do not cook well in hard water.

Q.7. explain process for removal of temporary hardness ?

Ans: **(1) By boiling :-**Temporary hardness can be removed by boiling as follow

$Mg(HCO3)_2 \rightarrow MgCO3\downarrow + H_2O + CO_2$

$Ca(HCO_3)_2 \rightarrow CaCO3\downarrow + H_2O + CO_2$

(2) By clark's method : (by adding lime)

$Ca(HCO3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3\downarrow + 2H_2O$

$Mg(HCO3)_2 + Ca(OH)_2 \rightarrow 2MgCO_{3\downarrow} + 2H_2O$

Q.8. Explain process for removal of permanent hardness?

Ans **: Ion exchange process :** in this process ions present in hard water get exchanged by ion exchange resin. Ion exchange resin are insoluble, cross linked, long chain organic polymers having ionisable functional group at one end.

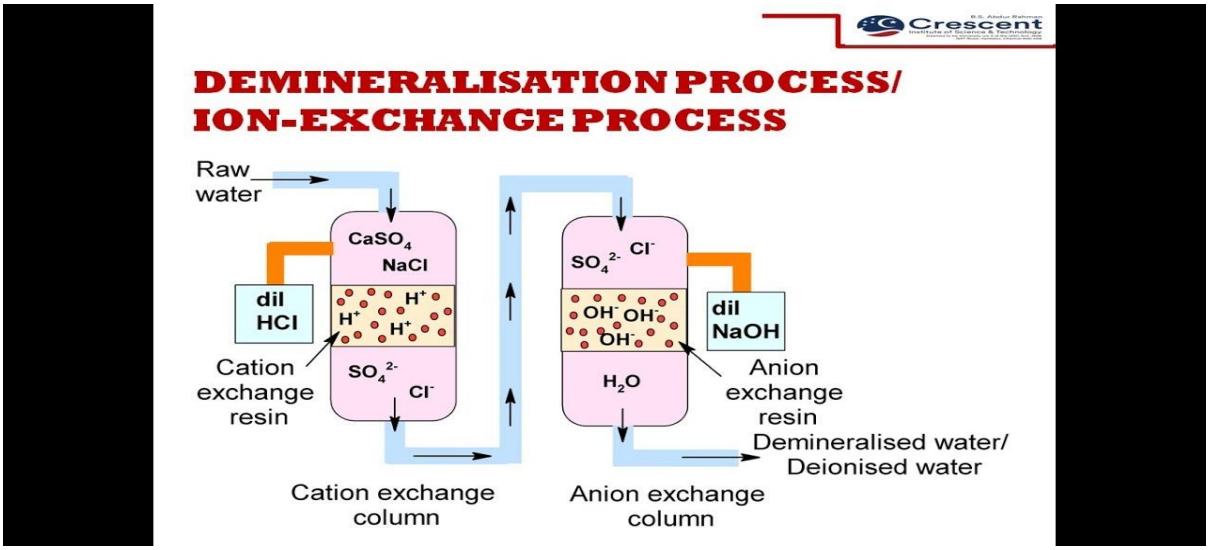
Resin are two types :

(1) **Cation exchange resin:** organic polymers having acidic functional group like –COOH, $-SO_3H$ etc. at one end capable of exchanging their H+ ion with other cation like Ca^{2+} and Mg^{2+}ion present in hard water.

$2RH + Ca^{2+} \rightarrow R_2Ca + 2H^+$

$2RH + Mg^{2+} \rightarrow R_2Mg + 2H^+$

(2) **Anion exchange resin:** organic polymers having basic functional group like –OH, $-NH_2$, at one end capable of exchanging their OH^- groups with other anion like Cl^- and $SO4^{2-}$ present in hard water.



Q.9. what do you mean by caustic embrittlement?

Ans : Cracking of the boilers tubes and plates at the joints when material of the boiler become brittle due to the presence of alkaline substances in boiler.

When water is softened by soda lime process, small amount of free sodium carbonate is left in water which on reaction with water produce NaOH and CO2.

$Na_2CO_3 + H_2O \rightarrow NaOH + CO_2$

Presence of NaOH in water makes water alkaline which flows to hair line cracks present in the inner side of the boilers.

Q.10. what is sterilization process?

Ans : the process used to killing bacteria and germs present in water.

(1) by using chlorine gas :

$Cl2 + H2O \rightarrow HCl + HClO$ (hypochlorous acid)

$HClO \rightarrow HCl + [O]$

Here [O] is nascent oxygen which kills germs and bactria.

(2) By adding bleaching powder :

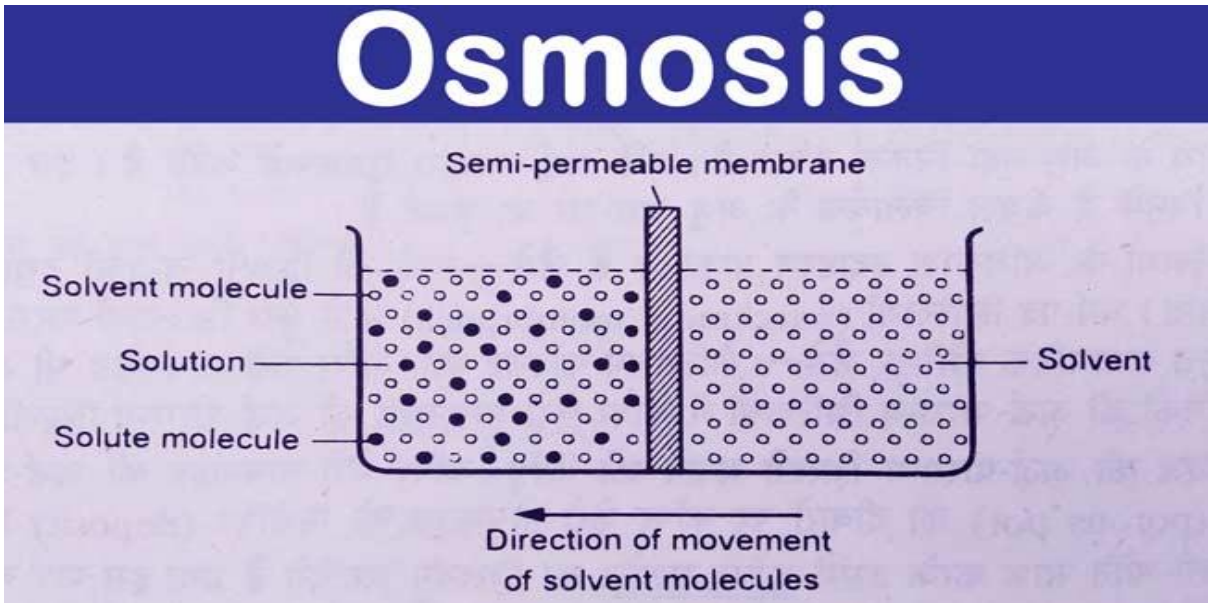
$CaOCl_2 + H_2O \rightarrow Ca(OH)_{2+}Cl_2$

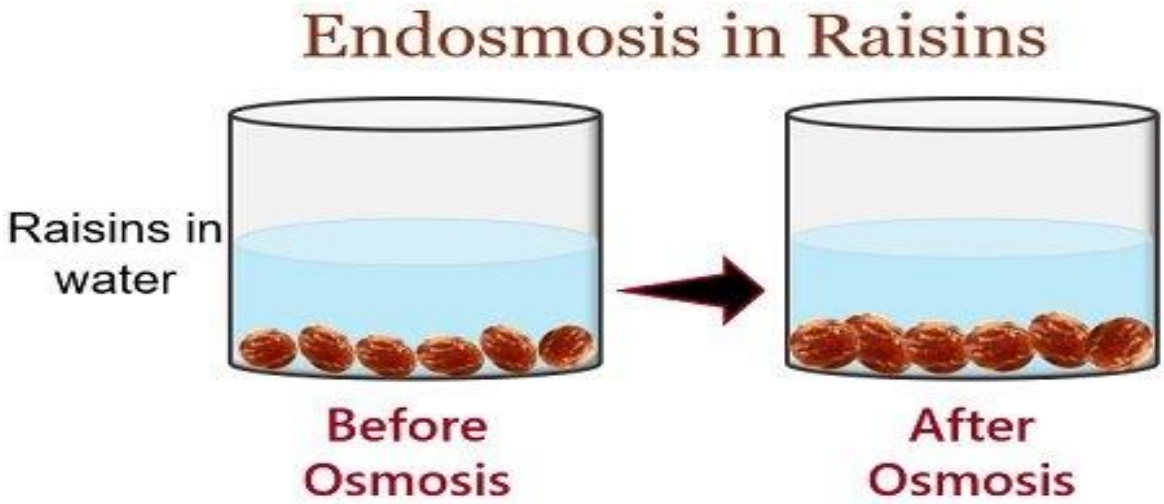
$Cl_2 + H_2O \rightarrow HClO + HCl$

$HClO \rightarrow HCl + [O]$

Q.11. what is reverse osmosis?

Ans: **Osmosis :** movement of solvent molecule from a solution of low concentration towards a solution of high concentration through semipermeable membrane.





Osmotic pressure(π): the external pressure which must be applied on the solution side in order to just stop the flow of solvent into the solution through semi permeable membrane.

Reverse osmosis: pressure greater than osmotic pressure applied on the solution side so that solvent present in the solution side starting move from solution to pure solvent.

Types of semipermeable membrane:(1) Vegetable membranes and animal membranes

(2) parchment paper, cellophane

ASSIGNMENT

Q.1.what types of impurities present in water?

Q.2. define hardness?

Q.3. disadvantage of hard water using in industrial process?

Q.4. general formula of geolite?

Q.5. write note on boiler corrosion?

Q.6.what are the qualities of drinking water?

UNIT-3 ACIDS AND BASES

Q.1. define acid, base and salts with examples?

Ans: acid- an acid is a substance that gives H+ ion when dissolved in water.

Ex: $HCl + H2O \rightarrow H^+ + Cl^-$

$H2SO4 + H20 \rightarrow H^+ + Cl^-$

Base: a base is substance that gives OH- ions when dissolved in water.

Ex: $NaOH + H_2O \rightarrow OH^- + Na^+$

$Ca(OH)_2 + H_2O \rightarrow OH^- + Na^+$

Salt: when an acid reacts with a base. Both are neutralised.

$Acid + base \rightarrow salt + H_2O$

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

Q.2.what is Arrhenius concept of strong acid and strong base. Explain with examples.

Ans: **strong acid-** acids dissolved in water, they dissociated completely into H^+

Ex: HCl,H2SO4,HNO3

Weak acids : acids dissolved in water, they dissociates only to a small extent.

Ex: CH3COOH,H2CO3.

Strong base: bases dissolved in water completely dissociated into OH-

Ex: NaOH, KOH

Weak base: bases dissolved in water, dissociates only to a small extent.

Ex: $Ca(OH)_2$, NH_4OH.

Q.3.explain briefly pH and pH-scale?

Ans: The full form of pH is "**Potential of Hydrogen"**. the meaning of the name pH is explained as power of hydrogen. pH describes the concentration of the hydrogen ions in a solution, which is the indicator of the acidity or basicity of the solution. The pH value on a pH scale varies from 0 to 14.

pH of acid and bases

The pH of the solution ranges from 0 to 14.

- Solutions with a pH value varying from 0 to <7 on the pH scale are called acidic solutions.
- Solution with a pH value ranging from >7 to 14 is known as basic solutions.

- On a pH scale, solutions with a **potential of hydrogen** or a pH value equal to 7 are known as neutral solutions.

$$pH = -\log([H^+])$$

Q.4.calculate the pH of 10^{-3}M HNO_3 solution.

UNIT-3 SOLUTION

Q.1. Define solution?

Ans : A solution is a homogeneous mixture of two or more pure non-reacting substances.

Solute + solvent → solution

Solute: which is present in smaller amount.

Solvent: which is present in larger amount.

Ex: sugar solution, here solute is sugar and solvent is water.

Q.2. define dilute solution and concentrated solution?

Ans: **dilute solution-** A dilute solution is one in which there is relatively small amount of solute dissolved in solution.

Concentrated solution: A solution in which large amount of solute dissolved in solution.

Q.3. define molarity, molality, normality, and ppm?

Ans : **Molarity:** no. of moles of solute dissolved per litre of solution.

Molarity = no. of moles of solute/volume of solution in litre

M = (W2÷M2) × (1000÷V)

Here W2= weight of given solute

M2= molecular mass of solute

V (in ml) is the volume of solution that we Have to prepare.

MOLALITY: no. of moles of solute per 1000gm of solvent.

Molality = no. of moles of solute /weight of solvent

Molality(m) : (W2÷M2) × (1000÷W1)

Here W2= weight of solute

M2= molecular mass of solute

W1= weight of solvent in gms

Normality: no. of gm equivalent of solute dissolved per litre of solution.

No. of gm equivalent = molecular mass /n-factor

n-factor = for acid it is the no of H^+ donated by an acid in water

ex: HCl n-factor is 1, H_2SO_4 n-factor is 2

in case of a base it is the OH^- donated by a base in water

ex: NaOH n-factor is 1 and in case of $Ca(OH)_2$ n-factor is 2

now $N = (W2 \div E2) \times (1000 \div V)$

Here W2 is weight of solute in gm

And E2 is equivalent weight of solute in gm

V is volume of solution in ml.

PPM: Parts per million

1 ppm means 1 part of solute by weight or volume in 1 million parts of solution.

It is generally used for very dilute solution.

ASSIGNMENT

Q.1. A solution is prepared by dissolving 8gm of NaOH to give 500ml of it. calculate the molarity. Given (Molecular mass of NaOH =40gm)

Q.2. Calculate molarity of pure water?

Q.3.Define strength?

Q.4. Prepare a solution of Oxalic acid of Molarity 2M in 250ml.calculate weight of oxalic acid dissolved.

Given MM of oxalic acid is 126gm

Also prepare solution of Normality 2M in 500ml of same compound.

Fuels and Lubricants

Definition of fuel: "Any Combustible substance composed of mainly carbon and hydrogen which on proper burning produces heat that can be used economically for domestically and industrial purposes and in generation of power."

Fuel + O_2--------products + heat

Classification of fuels: On the basis of physical state, the fuels can be divided into three types:

1. Solid fuels
2. Liquid fuels
3. Gaseous fuels

Solid fuels: Wood, Coal, charcoal

Liquid Fuels: Crude oil, petrol, diesel, kerosene oil

Gaseous fuels: Natural gas, bio gas, water gas

Calorific value of a fuel: The calorific value of a fuel a defined as the amount of heat obtained by the complete combustion of a unit mass of the fuel.

Unit of calorific value is Kj/Kg

Characteristics of a good fuels or ideal fuels:

1. High calorific value
2. Low moisture content
3. Moderate ignition temperature
4. Transportation
5. Low storage cost
6. Efficiency
7. Low ash content
8. High suitability
9. Low cost

Advantages of gaseous fuels over other fuels:

1. High calorific value
2. No smoke and poisonous gases
3. Easy transportation
4. Controllable combustion
5. Economical
6. Easily lightened

Scope of hydrogen as future fuels: hydrogen has been widely advocated as an energy carrier for the future. It is use as a fuel has many advantages:

1. It can act as a store of renewable energy from season to season
2. It can provide a transport fuel not dependent on the world's declining reserves of the fuel.
3. Hydrogen is used in large quantities as a feed stock for the chemical industry.

Lubricants: A lubricant may be defined as any substance which when interposed between two relatively sliding or moving surfaces reduces the friction and wear between them.

Function of lubricants:

1. It reduces the loss of energy in the form of heat
2. It increases the efficiency of machines
3. It increases the smooth motion of moving parts.
4. Protects from corrosion
5. It reduces the noise level of the running machines

Classification of lubricants:

#Liquid lubricants:

1. Animal oil: whale oil, seal oil and hard oil
2. Vegetable oil: olive oil, castor oil, palm oil, cotton seed oil.
3. Minerals oil: petroleum
4. Blended or compounded oil: it is prepared by the mixing the minerals oil and vegetable oil or animals oil to improve their properties.
5. Synthetic oil: silicones, poly glycols

Solid Lubricants:

1. Graphites
2. Molybdenum disulphide

Semi-solid lubricants:

1. Sodium soap greases
2. Aluminium soap greases
3. Lithium soap greases

Properties of lubricants:

1. **Viscosity**: it is the property of a liquid or fluid by virtue of which it offers resistance to its own flow.
   Significance: machines moving at slow speed should use more viscous lubricants and machines with high speed use less viscous fluid.
   Effect of temperature on viscosity: viscosity of liquid decreases with increasing temperature and consequently oil becomes thinner as the operating temperature increases.
2. **Flash point:** the lowest temp at which the oil lubricants gives off enough vapors that ignite for a moment, when a tiny flame is brought near it.
3. **Fire point:** the lowest temp at which the vapors of the oil burn continuously for at least five seconds when a tiny flame is brought near it.
4. **Cloud point**: when an oil is cooled slowly the temperature at which it becomes cloudy or hazy in appearance is called pour point
5. **Pour point:** the temp at which the oil ceases to move flow or pour.

UNIT-1

ATOMIC STRUCTURE

Matter is made up of extremely small particles called atoms. John Dalton postulated that atom is indivisible particle of an element that cannot be further divided. But at the end of 19^{th} century various scientific experiments have proved that atom is made up of various sub atomic particles, hence it can be divided. The scientists were able to find the existence of several sub atomic particles, but the three particles namely electron (e), proton (p) and neutron (n) are regarded as the fundamental particles of an atom.

FUNDAMENTAL PARTICLES OF ATOM :

i) **Electron ($_{-1}e^0$):** In 1897, Sir J.J. Thomson discovered a universal sub atomic particle called electron by studying the properties of cathode rays in discharge tube.

a) An Electron carry one unit negative charge (-1.602×10^{-19}C = -1 unit negative charge).

b) It has a mass equal to 1/1837th the mass of one atom of hydrogen (9.1×10^{-31} kg).

c) It is an essential constituent of all atoms. Hence, it is universal particle and represented as $_{-1}e^0$.

ii) **Proton ($_{+1}p^1$):** In 1886, Goldstein discovered protons by studying properties of anode rays in discharge tube. Protons are positively charged sub atomic particles.

a) A Proton has one unit positive charge ($+1.602 \times 10^{-19}$C = +1 unit positive charge).

b) It's mass is nearly equal to the mass of one atom of hydrogen (1.67×10^{-27} kg).

c) It is an essential constituent of all atoms. Hence, it is universal particle and it can be represented as $_{+1}p^1$.

iii) Neutron ($_0n^1$): In 1932, J. Chadwick experimentally concluded the existence of neutral sub atomic particle slightly heavier than proton and by the bombardment of alpha (α) particles on beryllium nucleus.

- Protons and Neutrons are almost of same mass.
- The mass of proton is approximately 1837 times greater than that of an electron.

BOHR'S MODEL OF ATOM:

The main postulates of Bohr's model are:

1. Electrons revolve around the nucleus in certain fixed circular paths called orbits or shells.

2. Each orbit has a definite energy and therefore known as energy level or energy shell.

3. Orbits are numbered as 1,2,3,4….. or designated as K, L, M, N….. starting from the shell next to the nucleus.

4. As long as an electron remains in a particular shell, it neither emits nor absorbs any energy i.e. the energy of an electron in a given orbit is fixed (or quantized). Such orbits are called stationary energy states.

5. An electron can make a transition from a stationary state of higher energy E2 to a stationary state of lower energy E1 and in doing so it emits energy. Similarly, on absorbing the energy, the electron

makes transition from lower energy state E1 to higher energy state E2. Such that, $\Delta E = E1-E2 < 0$ (Transition involve emission of energy)

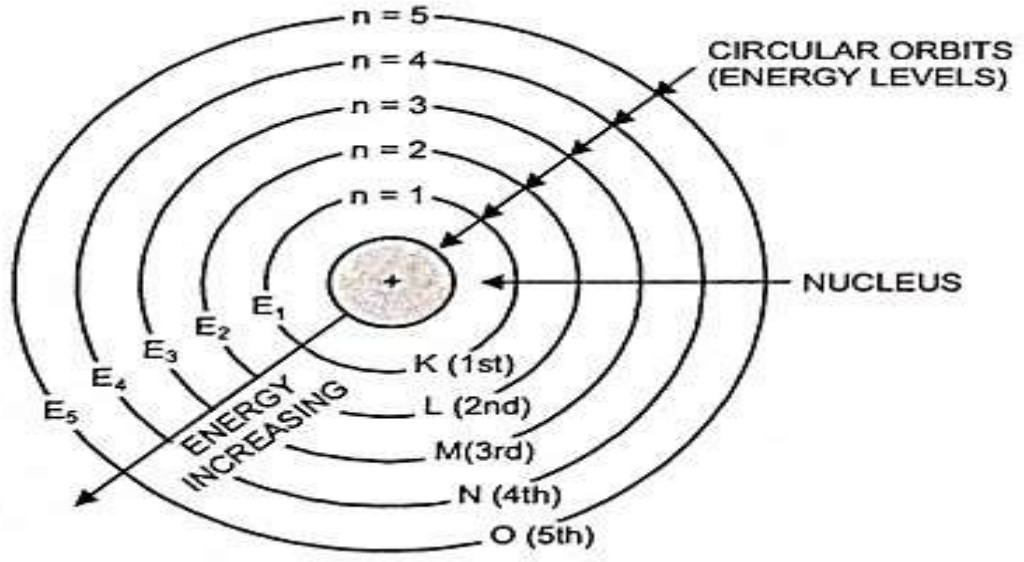
$\Delta E = E1-E2 > 0$ (Transition involve absorption of energy)

$\Delta E = E1-E2 = nh\upsilon$, Where n =1,2,3,….., h = Planck's constant, υ = frequency

6. Only those orbits are allowed for which the angular momentum (mvr) of the electron is integral multiple of $h/2\pi$. Thus,

Angular momentum of electron (mvr) = $nh/2\pi$, Where n=1,2,3,4……..

As per the Bohr's model, an orbit indicates the exact position of electron in an atom. So, orbit is defined as" the definite circular path around the nucleus of an atom in which the electron revolves without losing any energy." It is circular in shape and represents the two dimensional motion of electron. Orbits are used to determine the energy levels of electrons in an atom.



Important terms

Mass number: Mass number of the element is the sum of number of neutrons and protons.

Atomic number: it is the number of protons present in the nucleus. It is also termed as nuclear charge.

For a neutral atom, number of proton = number of electron

Isotopes: Isotopes are atoms of those elements which possess same atomic number but different mass number. Example: $_{17}Cl^{35}$ and $_{17}Cl^{37}$

Isobars: Isobars are atoms of those elements which possess same mass number but different atomic number. Example: $_{1}H^{3}$ and $_{2}He^{3}$

Isotones: Isotones are atoms of different elements with same number of neutrons. Example: $_1H^3$ and $_2He^4$; number of neutrons for H = 3-1 =2 and for He = 4 – 2 = 2

Isoelectronic species: Isoelectronic species are atoms or molecules with similar number of electrons. Example: Cl- and Ar possess 18 electrons respectively.

Orbits and Orbitals :

Orbits	Orbitals
An orbit is a fixed path on which electrons revolve around the nucleus.	An orbital is the probable area of finding the maximum density of electrons in an atom.
An orbit is a planar representation, i.e., a two dimensional representation.	An orbital is a three dimensional representation.
An orbit is non-directional in nature	While an orbital can describe the shape of an atom thus is directional in nature.
An orbit does not follow the theory of Heisenberg's Uncertainty Principle.	An orbital follows the theory of Heisenberg's Uncertainty Principle.
An orbit can accommodate $2n^2$ electrons where n represents the number of the orbit or the shell.	An orbital can accommodate the maximum of two electrons only in its sub-levels.

What are quantum numbers?

The set of numbers used to describe the position and energy of the electron in an atom are called quantum numbers. There are four quantum numbers, namely, principal, azimuthal, magnetic and spin quantum numbers.

Principal Quantum Number :-

Principal quantum numbers are denoted by the symbol 'n'. They designate the principal electron shell of the atom.

Azimuthal Quantum Number (Orbital Angular Momentum Quantum Number) :-

The azimuthal (or orbital angular momentum) quantum number describes the shape of a given orbital. It is denoted by the symbol 'l'.

Magnetic Quantum Number :-

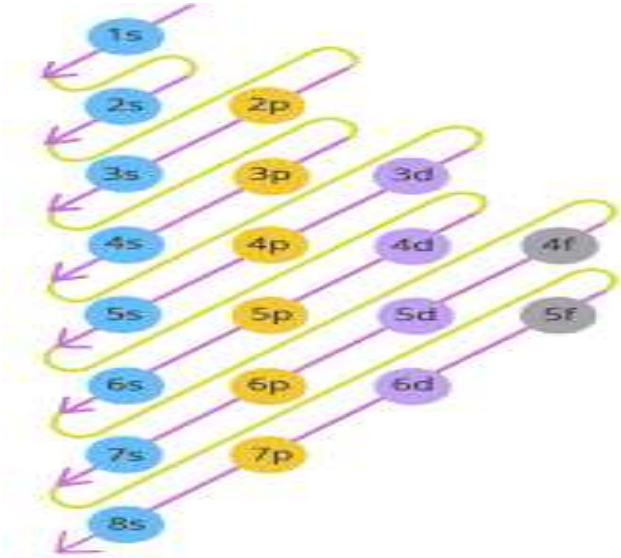
The total number of orbitals in a subshell and the orientation of these orbitals are determined by the magnetic quantum number. It is denoted by the symbol 'ml'.

Electron Spin Quantum Number :-

The electron spin quantum number is independent of the values of n, l, and ml. The value of this number gives insight into the direction in which the electron is spinning, and is denoted by the symbol ms.

PRINCIPLES OF FILLING ELECTRONS IN VARIOUS ORBITALS :-

Aufbau principle : The principle states that "In the ground state of atom electrons are filled in the increasing order of energy of orbitals. "The increasing order of energies of various orbitals in the ground state is 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d, …….



Pauli's exclusion principle :

According to this principle, An orbital can have maximum of two electrons with opposite spin. The electron with clock wise spin is represented by +½ or ↑ and that with anticlock wise spin is represented by-½ or ↓.

Hund's rule of maximum multiplicity:

It states that "the pairing of electrons in the orbitals of same subshell does not take place until each orbital of the subshell has got one electron."