

MAHARASHTRA AGRICULTUREAL UNIVERSITIES
AGRICUTURE POLYTECHNIC
(LOWER AGRICULTURAL EDUCATION)

Course Title: General Science – I (Chemistry – I)

First Year

Lecture No.	Chapter No.	Topic to be covered	Weightage (%)
Physical and inorganic chemistry			
1	1	Basic concept of chemistry - Importance, Role, Definition. Branches of chemistry	3
2 & 3	2	Fundamental and derived units and their SI units - Systems of units Fundamental basic units, Avogadro's law, Avogadro's number, Molecular weight	2
4 -- 6	3	State of matter - Introduction, States of matter, Ideal gas equation. Liquid state. Qualitative description of vapour pressure, surface tension Viscosity, Classification of solid and their types	3
7 ---10	4	Atomic structure – Introduction. Rutherford's nuclear model Planks quantum theory, Bohr's atomic model Idea of shells, sub shells and orbitals Electronic configuration of elements	2
11--12	5	Periodic table – Modern periodic table. Classification of elements on basis of electronic configuration Periodic trend, Properties, Atom, Radius, Screening effective nuclear charges	2
13--14	6	Redox Reaction – Introduction, Classical concept of oxidation and reduction, Electron transfer concept Oxidizing agent and reduction agent, Difference between oxidation and reduction	3
15	7	Chemical equilibrium – Introduction, Types of chemical reaction, difference between reversible and irreversible reaction, Chemical equilibrium, Law of mass action, Mass law equation	4
16	8	Adsorption – Introduction, Definition, Phenomenon, Difference between adsorption and absorption, Force between adsorbent and adsorbate, Types of adsorption, Factors affecting on adsorption, Freundlich adsorption Isotherm	4
17--18	9	Nature of chemical bond - Introduction, Electronic theory of valency, Postulates .Octate rule. Limitation, Types of bond, Valence bond theory	3
Organic and inorganic chemistry			
19 --21	10	Chemistry of carbon compounds – Introduction, impotence of organic chemistry. General characteristics of organic compound, Classification of organic compounds. Homologous series,. Empirical and molecular formula	3
22	11	Alkanes – Introduction, Structure of methane and ethane, Classification of alkanes isomerism in alkanes. Nomenclature Physical properties of alkanes chemical properties, Uses.	3
23	12	Alkenes – Introduction, Structure of ethane, Isomerism, Nomenclature, Classification, Physical and chemical properties, Uses.	2
24	13	Alkynes – Introduction, Structure of acetylene, Nomenclature, Physical and chemical properties (Only enlist), Uses	2
25	14	Aromatic compounds – Introduction, Characteristics difference between aliphatic and aromatic compounds, Benzene structure, Physical and chemical properties.	4

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Sr. No.	Topic	Name Reference Book	Page No.
Physical and inorganic chemistry			
1	Basic concept of chemistry - Importance, Role, Definition. Branches of chemistry	Chem. Class XI Nikita	1,2,3
2	Fundamental and derived units and their SI units - Systems of units Fundamental basic units, Avogadro's law, Avogadro's number, Molecular weight	Publication, Latur	3,4,6,9,18
3	State of matter - Introduction, States of matter, Ideal gas equation. Liquid state. Qualitative description of vapour pressure, surface tension Viscosity, Classification of solid and their types		52,59,65,67,68,70,71
4	Atomic structure – Introduction. Rutherford's nuclear model Planks quantum theory, Bohr's atomic model Idea of shells, sub shells and orbitals Electronic configuration of elements		100,101,103,106,113
5	Periodic table – Modern periodic table. Classification of elements on basis of electronic configuration Periodic trend, Properties, Atom, Radius, Screening effective nuclear charges		123,126,131,
6	Redox Reaction – Introduction, Classical concept of oxidation and reduction, Electron transfer concept Oxidizing agent and reduction agent, Difference between oxidation and reduction		143,144,145,150
7	Chemical equilibrium – Introduction, Types of chemical reaction, difference between reversible and irreversible reaction, Chemical equilibrium, Law of mass action, Mass law equation		163,165,166,168,169
8	Adsorption – Introduction, Definition, Phenomenon, Difference between adsorption and absorption, Force between adsorbent and adsorbate, Types of adsorption, Factors affecting on adsorption, Freundlich adsorption Isotherm		193,194,195,197
9	Nature of chemical bond - Introduction, Electronic theory of valency, Postulates .Octate rule. Limitation, Types of bond, Valence bond theory		205,208,209
Organic and inorganic chemistry			
10	Chemistry of carbon compounds – Introduction, impotence of organic chemistry. General characteristics of organic compound, Classification of organic compounds. Homologous series,. Empirical and molecular formula		308,309,316,321

11	Alkanes – Introduction, Structure of methane and ethane, Classification of alkanes isomerism in alkanes. Nomenclature Physical properties of alkanes chemical properties, Uses.		335,336,344,350,
12	Alkenes – Introduction, Structure of ethane, Isomerism, Nomenclature, Classification, Physical and chemical properties, Uses.		355,365,357,359,364,371
13	Alkynes – Introduction, Structure of acetylene, Nomenclature, Physical and chemical properties (Only enlist), Uses		375,378,379,384
14	Aromatic compounds – Introduction, Characteristics difference between aliphatic and aromatic compounds, Benzene structure, Physical and chemical properties.		388,390,391,392,

Chapter No. - 1

Some Basic Concepts of Chemistry

Chemistry:- “It is the branch of science deals with study of matter, its composition, its properties and the changes it undergoes, accompanied by energy changes during various processes.” According to Linus Pauling, “chemistry is the science of substances their properties, their structures and transformations.”

Chemistry plays very significant role in almost every aspects of our life. Some of the major contribution of chemistry to the life in modern world are as given below.

1. Chemistry in medicines: Modern chemistry discoveries have done a lot to totally remove diseases and to improve health.

1. Life saving drugs like taxol and cisplatin (used in cancer therapy); azidothymidine (AZT) used for AIDS victims.
2. Prophylactics (disease preventing screen and vaccines).
3. Anesthetics and antiseptics.
4. Disinfectant and germicides.

2. Chemistry in Industry: Some important industrial manufactures are,

1. Synthetic fibers like rayon, nylon, dacron, orlon.
2. Plastics like bakelite, teflon, polythene, etc.
3. Paints, varnishes, enamel, dyes, etc
4. Cement, glass, ceramics, fuels, metal alloys, extraction of metals Ag, Mg, Au, Fe

3. Chemistry in Agriculture: The major contribution in the field of agriculture is the use of

1. Chemical fertilizers like urea, ammonium sulphate, calcium nitrate, for better cropping yield.
2. Insecticides such as DDT, gammexane, methoxychlor for the protection of crops from insects and safe storage of food-grains.
3. Preservatives like sodium benzoate, Sodium meta bisulphate and salicylic acid for better preservation of food.

4. Chemistry in comfort, convenience and pleasure: Chemistry helped us in getting a number of requirements.

1. Domestic needs such as paper, fabrics, soaps, cosmetics, oils, flavoring essences, dyes and perfumes.
2. Air conditioning made by the use of chemicals like liquid ammonia or liquid sulphur dioxide.

5. Chemistry in Energy resources: The energy resources of the world are Petroleum, coal, wood, nuclear fuels. Attempts are being made by the chemists to utilize the nuclear energy, solar energy and hydrogen from sea water to overcome energy crises due to limited coal and petroleum.

6. Branches of chemistry: For convenience and better understanding of the subject, chemistry has been divided into different branches such as,

- 1. Organic chemistry:** This branch deals with the study of carbon compounds, especially hydrocarbons and their derivatives, except carbonates, bicarbonates, cyanides, isocyanide, carbides and oxides of carbon.
- 2. Inorganic chemistry:** This branch deals with the study of all other elements and their compounds except organic compounds. It mainly studies material obtained from, air, sea and soil (minerals found in earth crust)
- 3. Physical Chemistry:** This branch deals with physical properties and constitution of matter, fundamental principles, laws and theories governing chemical combinations and reactions.
- 4. Analytical chemistry:** This branch deals with physical and chemical methods in qualitative and quantitative analysis of various substances.

Chapter No. – 2

Fundamental and derived units and their SI units

The Value of a physical quantity is meaningful only when expressed as its numerical and unit e.g. volume of a liquid is 2.5 lit, where 2.5 is numerical and lit is unit.

Thus, “A unit is the standard of reference chosen to measure or express any physical quantity.”

Systems of units:

A complete set of units (both fundamental and derived) for all kinds of physical quantities is called a system of units.

The common systems are given below.

- 1. The British or FPS system:** The system uses the foot, the pound and the second for length, mass and time respectively. It is not used nowadays.
- 2. MKS system:** The system uses the meter, the kilogram and the second for length, mass and time respectively. This is a decimal system.
- 3. CGS system:** The system uses the centimeter, the gram and the second for length, mass and time respectively. It is also a decimal system.
- 4. International system of units:** (French name, system international i.e. SI units) (1960)
The system uses the meter, the kilogram and the second for length, mass time respectively. It is modification of metric system (1960) and now worldwide accepted.

Fundamental (basic) unit:-

It is an independent unit and it cannot be derived from any other units e.g. a fundamental SI unit of length is meter that of time is second and mass is kilogram, etc. Gram, liter and atmosphere are accepted SI units.

Table: Fundamental S.I. units

Sr.No.	Physical quantity	Fundamental SI unit	Symbol
1	Length	Meter	M
2	Mass	Kilogram	Kg
3	Time	Second	S
4	Temperature	Kelvin	K
5	Electric current	Ampere	A
6	Light intensity	Candela	Cd
7	Amount of substance	Mole	mol

A derived unit:

It is obtained by combination (division or multiplication) of one or more fundamental (basic) units.

Ex. 1. Area = length X breadth

$$= m \times m$$

$$= m^2$$

Thus, derived SI unit of area is m^2

2. Speed = Distance traveled / time

$$= m/S$$

Thus, derived SI unit of speed is m/S

Table: Some common derived SI units

Sr.No.	Physical quantity	SI unit	Expression in basic unit
1	Area	Square meter	M^2
2	Volume	Cubic meter	M^3
3	Density	Kilogram m^{-3}	$Kg m^{-3}$
4	Speed	Meter per sec	Ms^{-1}
5	Acceleration	Meter per sec ²	Ms^{-2}
6	Force	Newton	$Kg ms^{-2}$
7	Newton	Pascal	Nm^{-2}
8	Pressure	Joule	$Kg m^2 s^{-2}$
9	Energy (Work)	Watt	Js^{-1}
10	Electric charge	Coulomb	As
11	Electric potential	Volt	$JA^{-1}S^{-1}$
12	Frequency	Hertz	Cycle s^{-1}
13	Heat capacity	Joule/Kelvin	JK^{-1}
14	Concentration	Mole/Volume	Mol/dm^3
15	Electrochemical equivalent	Kilogram/Coulomb	Kg/C

2.1 Avogadro's law

In 1808 John Dalton stated that, "Whenever elements combine, they do so in simple ratio of their atoms." In 1809 Gay Lussac stated that, "Whenever gases combine, they do so in simple ratio by volume."

Avogadro related these two and stated that, "there are two kinds of particles of matter namely an atom and a molecule." When a substance takes part in chemical reaction, its molecules and not atoms are actually involved.

Atom: It is the ultimate particle of an element which can take part in chemical reaction and it may or may not have free existence.

Molecule: It is the smallest particle of a substance (either an element or a compound) which can have free existence.

Statement: "Equal volumes of all gases under the same conditions of temperature and pressure, contain the same number of molecules."

OR "Equal numbers of molecules of all gases occupy the same volume under the same condition of temperature and pressure."

Mathematical expression:

If 'V' is the volume occupied by a gas containing 'n' number of molecules at a given temperature and pressure, then according to Avogadro's law,

$$V \propto n$$

Explanation: Avogadro's hypothesis explains different gaseous chemical reactions correctly. It explains the concept of molecule with the help of formation of hydrogen chloride as,

At a given temperature and pressure,

$$(1 \text{ volume of hydrogen}) + (1 \text{ volume of chlorine}) = (2 \text{ volume of hydrogen chloride})$$

According to Avogadro's hypothesis, assuming 1 volume contains 'n' particles for each gas,

$$(n \text{ molecules of hydrogen}) + (n \text{ molecules of chlorine}) = (2n \text{ molecules of hydrogen chloride})$$

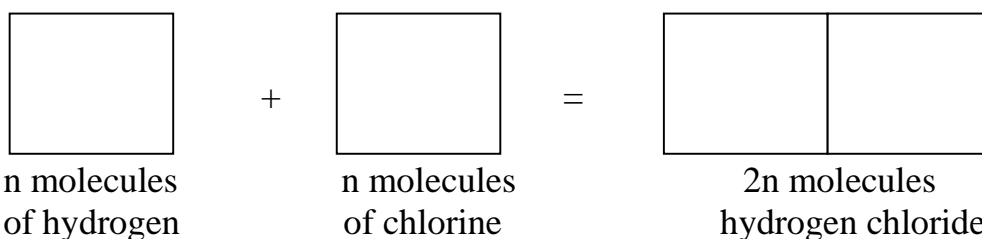
If, $n = 1$

$$(1 \text{ molecules of hydrogen}) + (1 \text{ molecules of chlorine}) = (2 \text{ molecules of hydrogen chloride})$$

$$(1/2 \text{ molecules of hydrogen}) + (1/2 \text{ molecules of chlorine}) = (1 \text{ molecule hydrogen chloride})$$

But, 1 molecule of hydrogen chloride gas contains at least 1 atom of hydrogen and 1 atom of chlorine which are derived from half a molecule of hydrogen and half a molecule of chlorine respectively. It means 1 molecule of hydrogen and 1 molecule of chlorine must contain at least two atoms of hydrogen of hydrogen and two atoms of chlorine respectively.

A diagrammatic representation of this example is shown below.



Applications of Avogadro's law:

In determination of atomicity of elementary gases: "Atomicity of an elementary gas is the number of atoms present in its 1 molecule."

It has already been shown that, 1 molecule of hydrogen chloride i.e. hydrochloric acid is made up of half a molecule of hydrogen and half a molecule of chlorine.

Hydrochloric acid is found monobasic, means its 1 molecule contains only one atom of hydrogen. Therefore, it follows that,

$$1/2 \text{ molecule of hydrogen} = 1 \text{ atom of hydrogen}$$

$$1 \text{ molecule of hydrogen} = 2 \text{ atoms of hydrogen}$$

Hence atomicity of hydrogen gas is 2.
Similarly, atomicity of chlorine gas is 2.

In determination of molecular formula: It is also possible to find molecular formula of gas by applying Avogadro's law as.

Hydrogen	+	Oxygen -----	Water vapour
2 vol.		1 vol.	2 vol.
2 n molecules		n molecules	2n molecules
2 molecules		1 molecule	2 molecules
1 molecule		½ molecule	1 molecule

So, 1 molecule of water contains 1 molecule of hydrogen (2 'H' atoms) and half molecule of oxygen (1 'O' atom) Hence molecular formula of water is H₂O.

2.2 Avogadro's number (N_A)

Significance of Avogadro's number: According to Avogadro's law.

- One mole of any gas occupies 22.4 lit at N.T.P.
- At a given temperature and pressure say N.T.P., same volume, i.e. 22.4 lit of all gases contain same number of molecules.

This number of molecules has been found to be 6.023×10^{23} and known as Avogadro's number. Thus, there are 6.023×10^{23} molecules in 2×10^{-3} kg hydrogen, 32×10^{-3} kg oxygen, 71×10^{-3} kg chlorine, 16×10^{-3} kg methane, 4×10^{-3} kg helium or 12×10^{-3} kg carbon etc.

Definition of Avogadro's number: "It is the number of carbon atoms present in exactly 12 gram of C¹² isotope."

As the number of carbon atoms present in exactly 12 gram (1 mole) of C¹² isotope were found 6.023×10^{23} by Avogadro.

Avogadro's number (N_A) = 6.023×10^{23} particles per gm mole.

2.3 Molecular weight

Like atom, absolute weight of a molecule is also very small such as,

$$\begin{aligned} \text{H}_2 &= 3.34 \times 10^{-27} \text{ kg} \\ \text{O}_2 &= 53.2 \times 10^{-27} \text{ kg} \\ \text{Cl}_2 &= 117.8 \times 10^{-27} \text{ kg} \\ \text{H}_2\text{O} &= 29.94 \times 10^{-27} \text{ kg} \end{aligned}$$

Therefore, mass of molecule is expressed in relative terms called molecular weight.

Definition: "Molecular weight is the average relative weight of one molecule of the compound as compared to (1/12)th weight of one carbon atom whose mass is taken as 12."

OR

"It is the sum of atomic weights of all atoms presenting in one molecule of a substance."

$$\text{Molecular weight} = \frac{\text{Weight of one molecule of compound}}{(1/12)^{\text{th}} \text{ weight of one C}^{12} \text{ atom}}$$

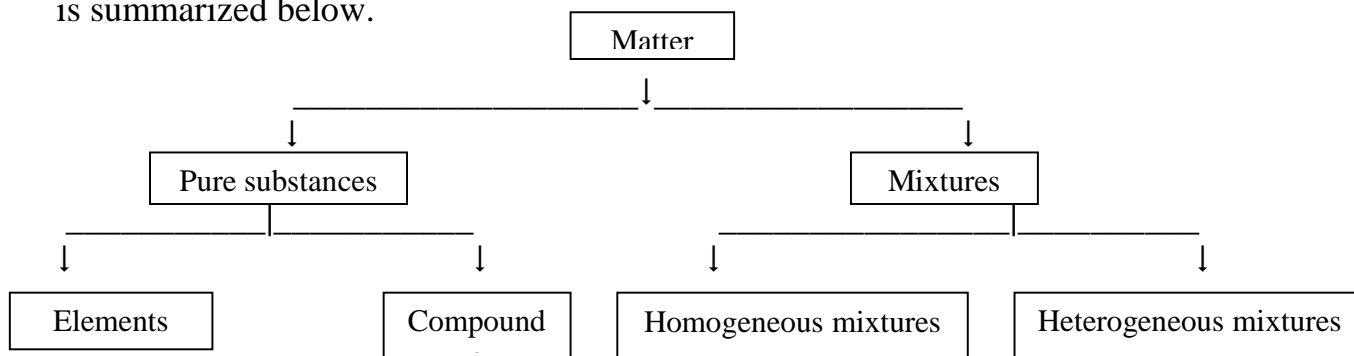
Thus molecular weight is only a number and has no unit e.g. molecular weight of 'H₂O' is 18.

Chapter No. – 3

States of Matter

3.1 Introduction

Matter is everything which has mass and occupies space. The classification of matter is summarized below.



States of matter

Matter mainly exists in three states,

1. **Solid state:** It is a state of matter in which matter has definite volume as well as definite shape e.g. wood, ice, stone, etc.
2. **Liquid state:** It is a state of matter in which matter has definite volume but no definite shape e.g. milk, oil, water, etc.
3. **Gaseous state:** It is a state of matter in which matter has neither definite volume nor definite shape e.g. oxygen, air, steam, etc.

Recent research has led to the discovery of fourth and fifth states of matter as,

4. **Plasma state:** It is super heated gaseous state consisting of mixture of electrons and cations with unusual properties. It is found at extremely high temperature and intense electric field.
5. **Fifth state:** It is super cooled solid state in which all atoms get condense and behave like a single super atom.

In this topic, we will study the three main states of matter, gas, liquid and solid.

Comparative properties of solids, liquids and gases :

Sr.No.	Property	Solids	Liquids	Gases
1	Volume	Definite	Definite	Not definite
2	Shape	Definite	Not definite	Not definite
3	Packing	Close	Loose	Very loose
4	Molecular attraction	Strong	Weak	Negligibly weak
5	Freedom of movement to molecules	Absent	Less	Maximum

3.2 Boyle's Law: [1662]:

Statement: "At constant temperature, volume of a given mass of a gas is inversely proportional to (varies inversely with) pressure on it." OR "The product of pressure and

volume for a gives mass of a gas is always constant when temperature is kept constant.”

3.3 Charle’s Law [1787]

Statement: “At constant pressure, the volume of a gives mass of a gas increases or decreases by 1/273 of its volume at 0°C for each degree Celsius rise fall of temperature .

3.4 Ideal gas equation

Normal Temperature Pressure (N.T.P.) condition (Standard Temperature Pressure (S.T.P.) condition) : It is the ideal condition of temperature 273 K and pressure 1.013 X 10⁵ pa at which on mole of any gas occupies same volume i.e. 22.4 dm³.

Standard temperature: It is the temperature which is equal to 273 K or 00C.

Standard pressure: It is the pressure which is equal to 1.013 X 10⁵ pa or 1 atm.

General (ideal or combined) gas equation: It is the mathematical expression which relates pressure, volume, number of mole, gas constant and absolute temperature for a gas.

It is obtained by combining Boyle’s law, charle’s law and Avogadro’s law. It is also known as ‘Equation of state’.

Derivation:

According to Boyel’s law

$$V \propto \frac{1}{P} \quad \text{----- (1)}$$

According to Charle’s law,

$$V \propto T \quad \text{----- (2)}$$

According to Avogadro’s law

$$V \propto n \quad \text{----- (3)}$$

Combining relations (1), (2), and (3)

$$V \propto \frac{nT}{P}$$

$$V = \frac{RnT}{P}$$

Rearranging,

$$\mathbf{P V = n R T}$$

This is general gas equation.

Where, P = Pressure of gas
 V = Volume of gas
 n = Number of mole of gas
 R = Gas constant
 T = Absolute temperature of gas

Rearranging, general gas equation,

$$P V$$

$$\frac{P V}{T} = n R$$

For a given mole of a gas, $n R$ is constant, we get,

$$\frac{P V}{T} = \text{Constant}$$

i.e. $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$ OR $\frac{P_1 V_1}{T_1} = \frac{P_0 V_0}{T_0}$

These are applied forms of general gas equation.

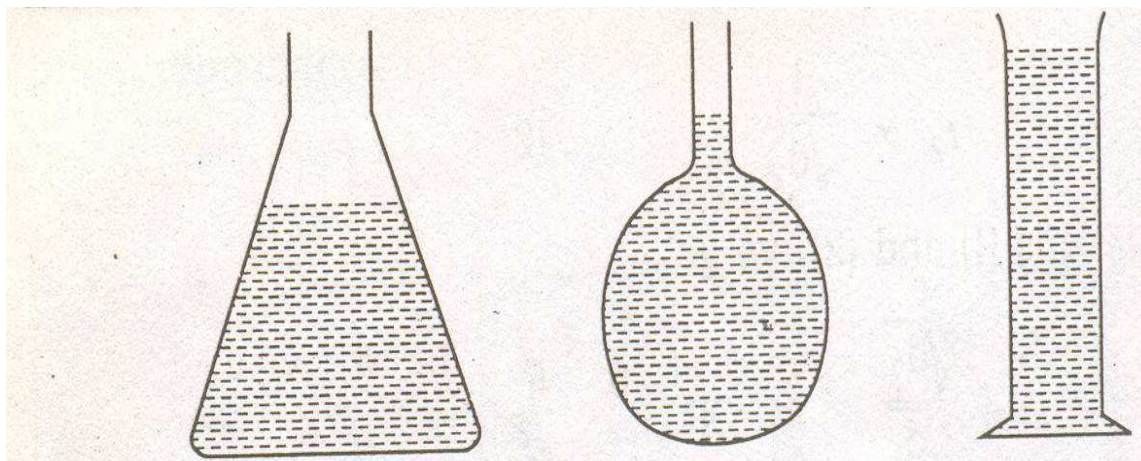
3.5 Liquid state:

Properties of liquid

- 1. Shape:** Liquid have no shape of their own but assume the shape of container and remain confined to the lower part of container.
- 2. Volume:** Unlike gases, liquid have a definite volume irrespective of shape and size of container. In liquids due to strong intermolecular forces of attraction, molecules are quite close. Therefore, they are not free to occupy the whole space available, as that is observed in gases.

As the molecules are free to move with in the boundaries, the liquid will take up the shape of bottom of container of large size as shown in the figure below.

Fig. Page no.66 (Chemistry XI) Nikita Puplication Latur



3. Density: The density of liquid is about thousand times greater than that of gas due to closer approach of molecules in liquid e.g. densities of liquid and vapour of water at 373 K and 1 atm are 0.958 gm/cm^3 and 0.000588 gm/cm^3 respectively.

4. Compressibility: Liquids are much less compressible than gases, due to very little free space available in liquid e.g. at 2.5°C , increase in pressure from 1 atm to 2 atm, decreases the volume of liquid water by 0.0045 % and decreases the volume of an ideal gas by 50%.

5. Diffusion: Liquid diffuse slowly in comparison to gases, due to less space and less velocities in liquid molecules.

6. Evaporation:

1) Certain fraction of molecules at the surface will have K.E. large enough to overcome attractive forces of neighboring molecules and to escape into the space above the liquid surface.

2) If a liquid is in open container, evaporation will continue until no liquid remains.

3) During evaporation, molecules with high energy escape and molecules with less energy remain behind. This explains, the common experience that temperature (proportional to K.E.) falls when liquid evaporate e.g.

a) Cool sensation on the skin due to evaporation of a drop of ether or spirit or chloroform.

b) Effective cooling by a ‘desert – cooler’ on a hot – dry summer day.

4) Evaporation depends upon following factors,

a) Nature of liquid:

$$\text{Rate of evaporation} \propto \frac{1}{\text{Strength of intermolecular attractions}}$$

e.g. rate of evaporation increases as,

Water < Alcohol < Ether

b) Surface area:

Rate of evaporation \propto Surface area

Larger the surface area, greater is the opportunity of the molecules to escape.

c) Rate of evaporation \propto Temperature

Greater the temperature, greater is the K.E. and opportunity of molecules to escape as well.

d) Blowing the current of air across the surface of liquid: The flow of air, helps the molecules to go away (lift) from the surface of liquid and increases rate of evaporation e.g. desert cooler.

7. Heat of vaporization: “The amount of heat required to convert 1 mole of a liquid into gas at a constant temperature is known as heat of vaporization.”



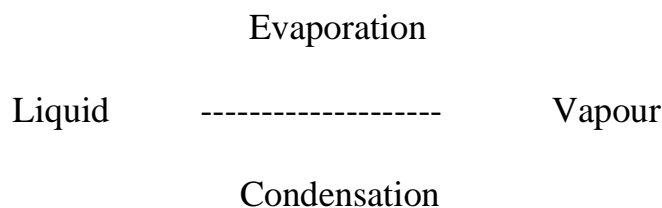
(Heat of vaporization Of a liquid) \propto (The strength of intermolecular forces of attraction)

The value of heat of vaporization generally decreases with increase in the temperature.

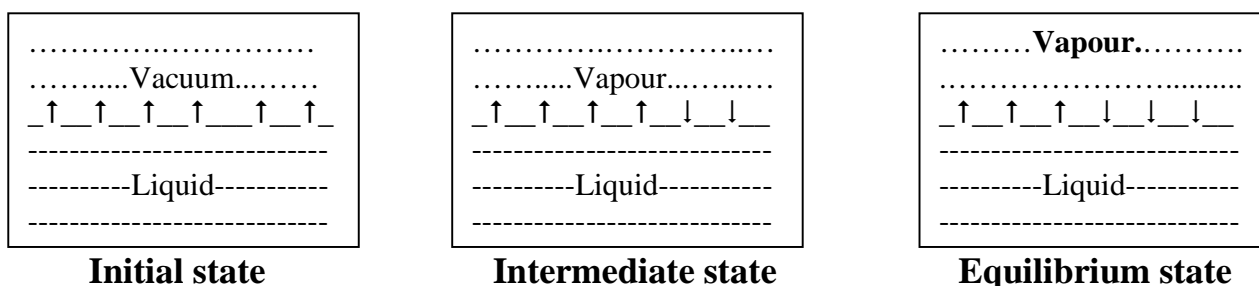
3.6 Qualitative description of vapour pressure, surface tension and viscosity

Vapour pressure:

When a liquid is taken in a close container surface molecules escape in the form of vapours, Some vapours condense back into liquid. At some state, in closed container equilibrium between evaporation and condensation is attained.



The amount of liquid and vapour in closed container at equilibrium remain constant. The vapour above liquid, exerts a pressure at a given temperature as shown in the figure below.



Initial state

Intermediate state

Equilibrium state

Definition: “At a constant temperature, the vapour pressure of a liquid is the pressure exerted by the vapours of the liquid in equilibrium with liquid.”

As temperature increases, the vapour pressure increases.

Boiling point is the temperature at which the vapour pressure of the liquid becomes equal to the atmospheric pressure and bubbles of vapour begin to form below surface of the liquid.

The boiling point of a liquid, thus depends upon external atmospheric pressure. The boiling point of liquid at 1 atmospheric pressure, is called ‘Normal or standard boiling point’. At lower atmospheric pressure at high altitude (mountains) boiling point is reduced and thereby takes longer time to cook food. Similarly higher the external pressure, higher the boiling point.

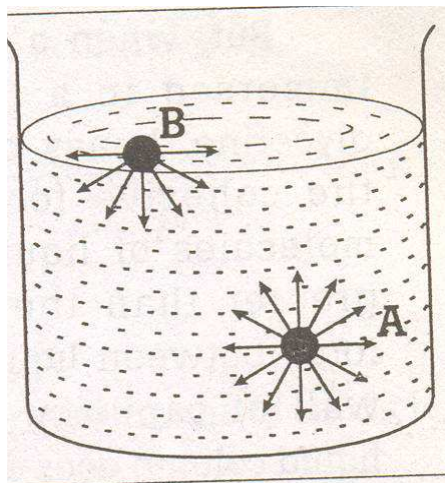
Difference between evaporation and Boiling point:

Evaporation		Boiling point	
1.	It takes place of this surface of liquid.	1.	It takes place by formation of bubble even below surface of liquid.
2.	It is a slow.	2.	It is rapid.
3.	It occurs spontaneously at all temperatures.	3.	It occurs only at a certain temperature at which vapour pressure is equal to imposed external pressure.

Surface tension:

Every molecule well within the bulk (interior) of the liquid is uniformly attracted in the directions by the neighbouring molecules. Therefore, the net force acting on such a molecule is almost zero, as shown by, ‘A’ molecule in the figure.

However, every molecule at the free surface has no molecules from upper side to participate in attraction. Thus the molecules at the surface experience a resultant inward pull and the surface behaves as a stretched membrane or were under tension. As a result of unbalanced forces at the surface, the liquid tend to contract and minimise the surface area. This effect is called ‘surface tension’, as shown by ‘B’ molecule in the figure.



Definition: “The surface tension is a measure of the inward force on the surface of liquid which acts downwards perpendicular to the plane of surface.”

The unit of surface tension is dyne cm^{-1} or N/m . The surface tension is the force in dyne acting on the surface at right angle to any line of unit length e.g. surface tension of water is $72.75 \times 10^{-3} \text{ N/m}$ and that of mercury is $475 \times 10^{-3} \text{ N/m}$.

The intermolecular forces and thereby surface tension decrease with increase temperature of liquid.

Many common phenomenon can be explained with the help of surface tension.

- a) The surface tension, tries to minimize the surface area and for a given volume, a sphere has minimum surface area. Therefore, drops of liquid acquire a spherical shape.
- b) The surface tension makes the surface to behave like a stretched elastic membrane and therefore insects can walk on the surface of water without drowning.
- C) Soap and detergent solutions due to their lower surface tension, penetrate into the fiber greasy substances and wash of away.
- d) Force of adhesion between water molecules and molecules of glass capillary tube are greater than the force of cohesion between water molecules. Due to this surface of water in a glass capillary tube becomes concave (curves upwards) and the water climbs up to such a height that the weight of water column is just balanced by force of surface tension.

But when a capillary is immersed in a liquid like glycerin, honey or mercury the cohesive force among molecules of liquid become greater than the adhesive force between liquid and the wall of capillary tube. The liquid column goes down in the capillary and upper surface becomes convex (curves downward)

Viscosity :

Some liquids such as honey, custor oil, glycerine etc.flow slowly,whereas others like water, petrol ,ethanol etc. flow rapidly. It means, every liquid has some internal resistance to flow.

Definition:

“It is the internal resistance or friction which one part of liquid offers to another part”

The resistance to flow is directly related to strength of intermolecular forces .when temperature (K.E)is raised, strength of intermolecular forces will decreased and hence viscosity will also get decreased.

3.7. Classification of solids

Solids are mainly classified into two types as,

1. **Amorphous solids:** In this type of solids, arrangement of particles is irregular, so that they do not have definite geometry.
2. **Crystalline solids:** In this type of solids, arrangement of particles is regular in three dimensional pattern, so that they have definite geometry with flat faces and sharp edges.

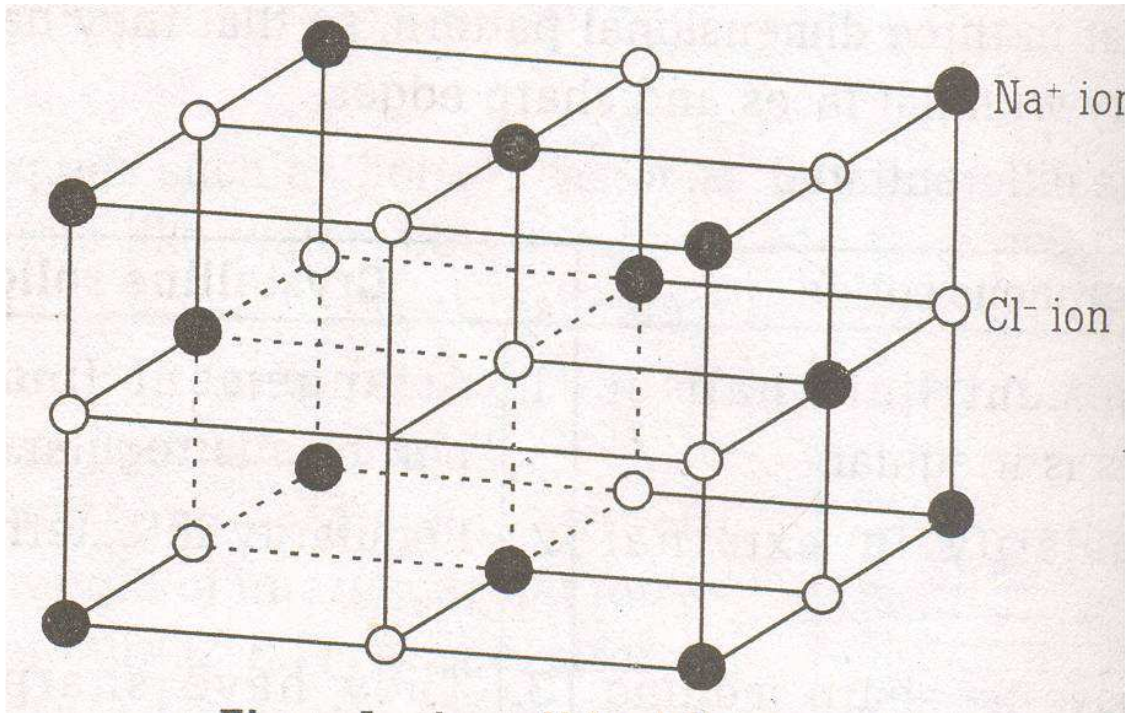
Amorphous solids		Crystalline solids	
1	Arrangement (internal) of particles is irregular.	1	Arrangement (internal) of particles is regular
2	No regularity in external forms	2	Regularity in external forms.
3	They have no sharp milting point	3	They have sharp melting point.
4	Give irregular cut.	4	Give regular cut.
5	No characteristic ‘heat of fusion’.	5	Characteristic ‘heat of fusion’.
6	Are regarded as psedo - solids or super cooled liquids.	6	Are regarded as true or perfect solids.
7	Are isotropic, i.e. physical properties R.I., conductivity, thermal expansion are same in all directions.	7	Are anisotropic, i.e. physical properties R.I., conductivity, thermal expansion are different in different directions.
8	They have no definite geometry.	8	They have definite geometry with the flat faces and sharp edges.
9	e.g. CaCO ₃ , glass, rubber, plastic.	9	e.g. NaCl, diamond, sugar, CuSO ₄

Type of crystalline solids:

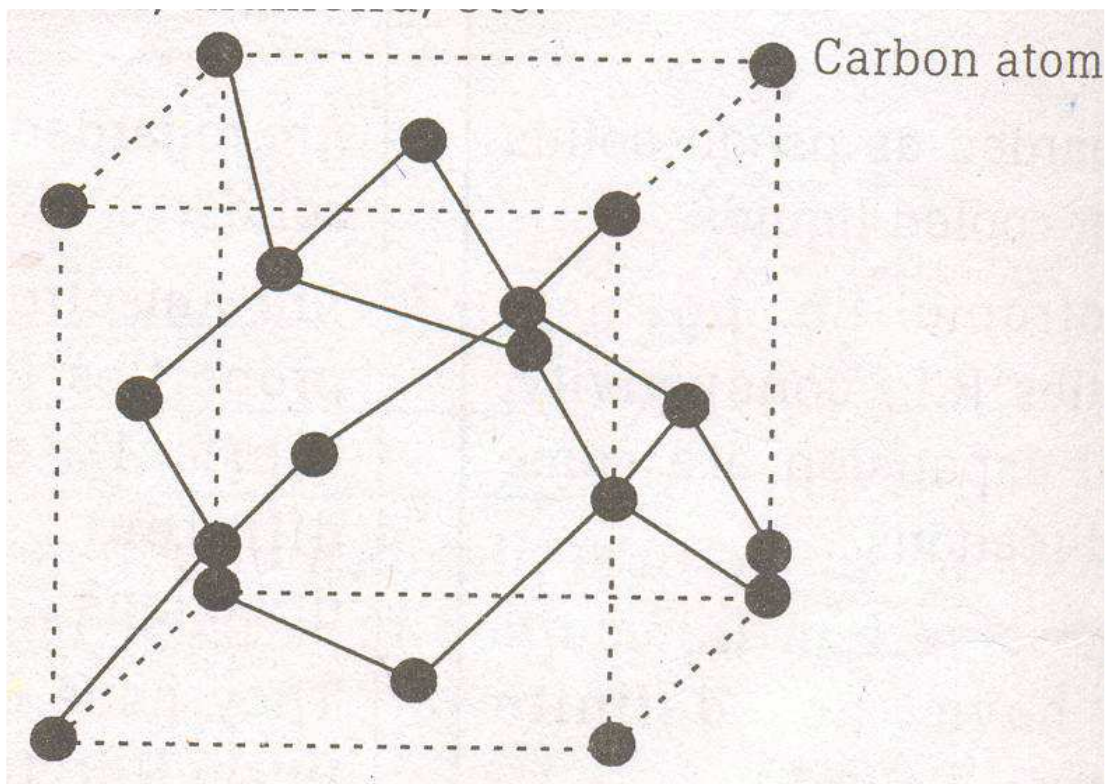
In crystalline solids, the particles are either ions, atoms or molecules. The nature of bonding which hold the particles within the solid are either ionic, metallic, covalent of Vander Waal.

Thus, depending upon nature of particles and nature of bonding between them in crystalline solids, they are of four types as,

- 1. Ionic solid:** “It is the type of crystalline solids in which lattice points are occupied by cations and anions held with the help of electrostatic force.”
e.g. NaCl, CsCl, ZnS.



- 2. Covalent solid:** “It is type of crystalline solids in which lattice points are occupied by atoms held with the help of covalent bonds.”
e.g. Silicon, carbon, diamond, etc.



3. Metallic solid: “It is type of crystalline solids in which lattice points are occupied by metal cations held with the help of metallic bonds.”
e.g. Na, Mg, Al, etc.

Fig. Page no.73 (Chemistry XI) Nikita Puplication Latur

4. Molecular solid: “It is type of crystalline solids in which lattice points are occupied by molecules held with the help of Vander Waals forces.”
e.g. dry ice [solid CO_2], solid phosphorus, solid sulphure, etc.

Chapter No. - 4

Atomic Structure

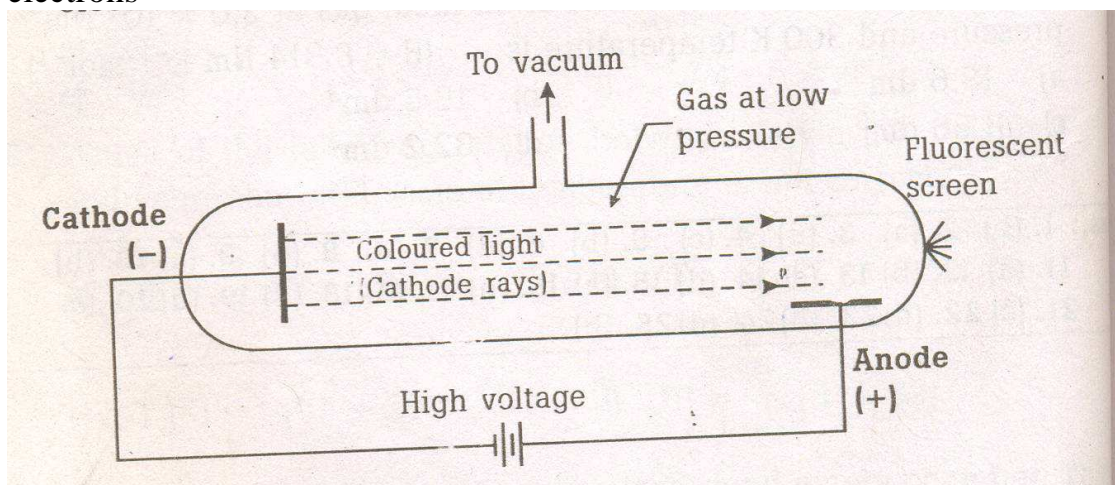
Modern concept of structure of atom:

In 1808, John Dalton proposed that, atom was the smallest indivisible particles of matter

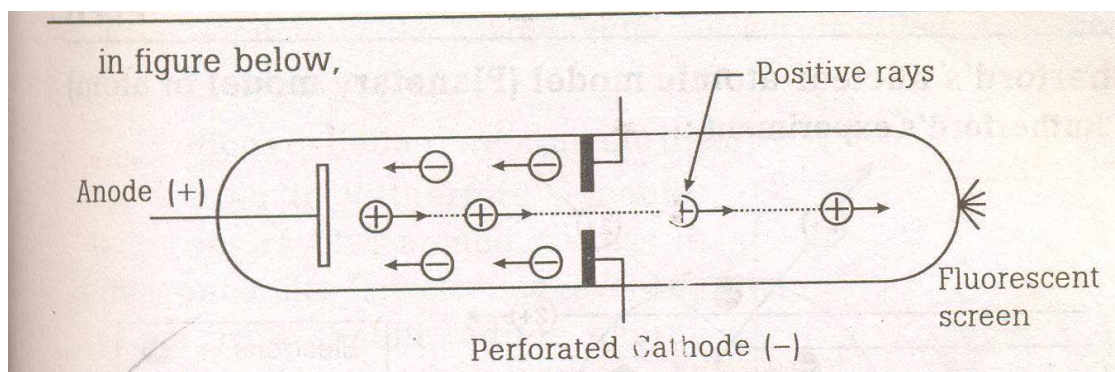
Later on many scientists established that, atom was made up of still smaller particles like electrons, protons and neutrons, called 'fundamental particles of atom.

In this topic, we will study the discoveries and nature of these fundamental particles, followed by their arrangement in atom viz. Rutherford atomic structure and Bohr's atomic structure.

1. **Discovery of electrons (J.J.Thomson):** When a very high voltage (5000 -10,000 V) was applied to a gas at low pressure (10^{-4} to 10^{-2} atm) in the discharge tube, a beam of rays moved in straight line from cathode (-) to anode (+). These rays were named cathode rays. Which are made up of negatively charged light particles named electrons

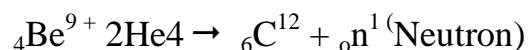


2. **Discovery of proton (Goldstein):** When perforated metal disc was used as cathode, luminous rays moved away in straight line from anode to hole of cathode. These rays were named canal of positive or anode rays which are made up of positively charged particles named protons as shown in figure below.



3. **Discovery of neutron (Chadwick):** When particles were bombarded on beryllium, a very high penetrating radiation was obtained. The radiation was made up of neutral particles named neutrons.

4.



5. **Discovery of X-ray (Rontgen):** When cathode rays were bombarded on the solid metal, very highly penetrating radiations were coming out of the discharge tube, these radiations were very high frequency electromagnetic waves named X-.

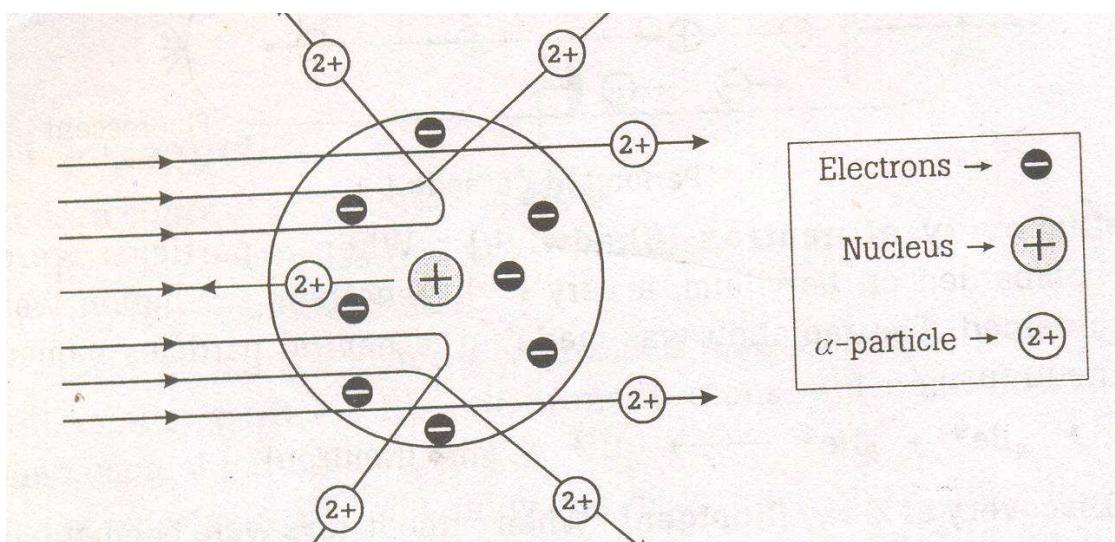
6. **Atomic number (Moseley):** When Moseley obtained X-rays of different frequencies using different metallic elements, he related the square root of frequency directly with number of proton present (Z) in the nucleus of metal atom as, $\nu = a(Z - B)$. This number Z is characteristic of an element and known as 'atomic number'

7. **Mass number:** This mass number (A) of an atom is equal to the total number of nucleons (protons and neutrons) in the nucleus of that atom.

8. **Atomic model:** It is the model showing probable arrangement of fundamental particles in atom of an element.

Rutherford's nuclear atomic model (Planetary model of atom)

a) Rutherford's experiment :



1. Rutherford performed an experiment of scattering of α - particles by thin gold foil.
2. He observed that majority α particles passed through the foil straight.
3. Few α particles were deflected by an angle less than 90° .
4. Very few α - particles out of 20,000 were deflected by an angle 90° or more such as about 180° .

on the basis of these observations, he gave some conclusions regarding structure of atom as follows.

B) Postulates of Rutherford's atomic theory:

1. There should be large number of small empty spaces (gaps) inside the atom.
2. There should be positively charged nucleus at the centre the atom.
3. Electrons are revolving around nucleus in different orbits with high speed such that electrostatic force of attraction between electrons and nucleus is balanced by centrifugal force acting on electron.
4. The atom as a whole is electrically neutral. Since, number of electrons is equal to number of positive charges, present inside the nucleus.
5. Most of the mass and all the positive charge of an atom is concentrated in a very small region called nucleus. Radius of nucleus is of the order of 10^{-15} m; where as radius of atom is of the order of 10^{-10} m.
6. The magnitude of the charge on the nucleus is different for atoms of different elements.

c) Limitations of Rutherford's atomic theory

1. According to Rutherford's theory electrons revolve around nucleus in different orbits. But, electron revolving in an orbit should radiate energy continuously, being a charged body. As a result, a radius of orbit of electron become smaller and smaller so that finally electron will fall into the nucleus.

Hence, this atomic model failed to explain stability of atom.

2. It could not explain the discontinuous (line or band) atomic spectrum. Since, Rutherford's atomic model, expected continuous atomic spectra.
3. It could not explain the position, energy and distribution of electrons around the nucleus.

Plank's quantum theory:

Wave nature of radiation: Electromagnetic radiations (waves) are obtained either from electrons or from a moving charged body as well as an oscillation magnet to and fro in magnetic field.

According to plank's quantum theory, energy is absorbed or emitted by a body in the discontinuous form of small packets (bundles) called 'quanta' and not in a continuous manner. In case of light, the 'quantum' is called 'photon'. Each quantum has a definite energy (E) = $h\nu$.

Energy is emitted or absorbed in a quantum or whole number multiple of quantum i.e. as $1h\nu$, $2h\nu$, $3h\nu$. etc.

There are four important properties of wave motion.

1. Wavelength (λ): It is distance between two successive troughs or crests of wave. It is expressed in terms of centimeter or Angstrom unit, where $1 \text{ \AA} = 10^{-10} \text{ m}$.
2. Frequency (ν): It is the number of waves passing at a point in one second. It is expressed in terms of cycles per second (cps) or Hertz (Hz).
3. Velocity (c): It is the distance traveled by the wave in one second .It is expressed in terms of centimeter per second (cm/s).
Where, $c = \lambda \times \nu$
4. Wave number ($\bar{\nu}$): it is the reciprocal of wavelength. It is expressed in terms of cm^{-1} i.e. $\bar{\nu} = 1/\lambda$.

Atomic spectra (pattern of radiation):

1. The hot element or compound emits energy in the form of light radiation contains different wavelengths. e.g. copper vessel on heating on gas flame, gives beautiful characteristic green flame.
2. A spectroscope is a device which separates out a light (radiation) into its components of different wavelength. This pattern of different wavelengths obtained is called spectrum e.g. sunlight when passed through a prism, it splits into seven colour pattern VIBGYOR. This is a kind of continuous spectrum e.g. rainbow.
3. The spectrograph or spectrum is found discontinuous i.e. either lines or bands. The line or atomic spectrum obtained for each element is different from other.
4. The production of line spectra by atoms of different elements reveals that, an atom can radiate only certain energies and not any energies. In other words, electron of an atom which emits energy, has specific energy. The energy is emitted in certain fixed amount and not continuously.

Bohr's atomic model

Postulates:

1. Rutherford's atomic model is accepted.
2. Nearly whole mass of atom is concentrated in the positively charged nucleus.
3. The electrons of an atom are revolving around the nucleus. In certain fixed circular paths called 'stationary orbits'.
4. An electron revolving in a particular orbit has angular momentum (mvr) in the integer multiple of $h/2$

$$\text{i.e. } mvr = n \frac{h}{2}$$

Where, $n = \text{integer } 1, 2, \dots$ i.e. orbit number.

5. Radius of orbit(r) can be given as,

$$R = \frac{n^2 \times a_0}{Z}$$

6. An electron revolving in a particular orbit is associated with certain fixed amount of energy (E), which is given as,

$$E = \frac{2 mZ^2 e^4}{n^2 h^2}$$

7. As we move away from the nucleus, energy of electron increases from near orbit to farther orbit as $K < L < M < N \dots$
8. So long as an electron revolves in a permitted orbit, it doesn't absorb or radiate energy.
9. Energy is absorbed only when an electron from lower orbit jumps to higher orbit.
10. Energy is radiated only when an electron from higher orbit jumps to lower orbit.

Limitation:

1. It couldn't explain atomic spectrum of elements other than H and He.
2. It couldn't explain the fine structure of spectral line.
3. When atomic source radiation is kept in magnetic field, every spectral line splits up into number of closely spaced lines. This effect is known as "Zeeman effect".
4. Similar splitting of spectral line can be observed in electric field. Which is known as 'stark effect'. Bohr couldn't explain this effect.
5. According to Bohr model, circular orbits of electrons are planar, but X – ray studies Show three dimensional geometry of atom.
6. Concept of well defined Bohr's orbit is invalid, in the light of 'Uncertainty principle' i.e. 'position and velocity of an electron are difficult to measure at a time'.
7. Bohr couldn't explain the wave particle dual nature of electron.
8. Bohr couldn't explain arrangement of electrons in atom.

4.2 Idea of shells, sub shells and orbital

Shells or orbits or main energy levels (n):

Bohr's stationary orbits are now called energy levels or shells. From near to nucleus and lowest energy, the shells are numbered as 1,2,3,4,etc. These shells are also denoted as K,L,M,N respectively on the basis of X-ray spectra.

Definition: "It is fixed circular path in which electrons of an atom are revolving around the nucleus" (On the basis of Bohr's atomic theory)

Sub shells (Sub energy levels):

The fine structure of spectral line indicates the presence of close grouping of sub energy levels in a main energy level. These sub energy levels are called sub-shells.

Orbitals:

These are regions of space around the nucleus where probability of finding the electron is maximum.

Fig. Fig. Page no.106,107 (Chemistry XI) Nikita Pulpication Latur

Depending upon directional characters (orientations) of these regions, there are four type of orbitals.

- i) s – orbital (sharp – orbital)
- ii) p – orbital (principal – orbital)
- iii) d – orbital (diffused – orbital)
- iv) f – orbital (fundamental – orbital)

The fixed orbits of Bohr are now replaced by orbitals.

Sub Shell s – A single orbital s - orbital

Sub Shell p – A set of three p – orbitals of equal energies

Sub Shell d – A set of five d – orbitals of equal energies

Sub Shell f – A set of seven f – orbitals of equal energies

4.3 Shapes of s and p-orbital

S-orbital

Definition: “It is the spherically symmetrical region in space around the nucleus in which chance of finding the electrons is maximum”.

Features

1. Each orbit contains one s - orbital.
2. s - orbital is spherically symmetrical in shape.
3. The size of s-orbital increases with increase in orbit number e.g. 2s-orbital is having bigger size than 1s-orbital.
4. s-orbital is spherically symmetrical and non directional.
5. s-orbital is having less energy and more stability.
6. s-orbital can contain maximum two electrons.

P-orbital

Definition: “It is dumb – bell shaped region in space around the nucleus in which chances of finding the electrons is maximum”

Features

1. Except first orbit (n=1), each orbit contains a set of three p-orbital.
2. These three p-orbital are designated as p_x , p_y and P_z are depending upon their orientation along the axes of usual coordinate system.
3. Each p-orbital is dumb –bell shaped with atomic nucleus in between.
- 4-All the three p-orbital p_x , p_y and P_z have equal energy.
5. The p-orbital can contains maximum 6 electrons altogether.
6. In between two lobes of a p-orbital i.e. in the nucleus probability, of finding electron is practically zero and is nodal plane.

4.4. Electronic configurations of elements

(The electronic configuration from atomic number 1 to 30)

Electronic configuration of an element is the arrangement showing distribution of electrons in its different orbital.

An electronic configuration of an element should be written on the basis of Auf-bau principle, Pauli's principle, Hund's rule as.

Sr. No.	Name of element	Symbol and At.No.	Electronic configuration
1	Hydrogen	${}^1\text{H}$	1S^1
2	Helium	${}^2\text{He}$	1S^2
3	Lithium	${}^3\text{Li}$	$1\text{S}^2 2\text{S}^1$
4	Beryllium	${}^4\text{Be}$	$1\text{S}^2 2\text{S}^2$
5	Boron	${}^5\text{B}$	$1\text{S}^2 2\text{S}^2 2\text{P}_x^1$
6	Carbon	${}^6\text{C}$	$1\text{S}^2 2\text{S}^2 2\text{P}_x^1 2\text{P}_y^1$
7	Nitrogen	${}^7\text{N}$	$1\text{S}^2 2\text{S}^2 2\text{P}_x^1 2\text{P}_y^1 2\text{P}_z^1$
8	Oxygen	${}^8\text{O}$	$1\text{S}^2 2\text{S}^2 2\text{P}_x^2 2\text{P}_y^1 2\text{P}_z^1$
9	Fluorine	${}^9\text{F}$	$1\text{S}^2 2\text{S}^2 2\text{P}_y^2 2\text{P}_z^1$
10	Neon	${}^{10}\text{Ne}$	$1\text{S}^2 2\text{S}^2 2\text{P}_x^2 2\text{P}_y^2 2\text{P}_z^2$
11	Sodium	${}^{11}\text{Na}$	$1\text{S}^2 2\text{S}^2 2\text{p}^6 3\text{S}^1$
12	Magnesium	${}^{12}\text{Mg}$	$1\text{S}^2 2\text{S}^2 2\text{P}^6 3\text{S}^2$
13	Aluminum	${}^{13}\text{Al}$	$1\text{S}^2 2\text{S}^2 2\text{P}^6 3\text{S}^2 3\text{P}_x^1$
14	Silicon	${}^{14}\text{Si}$	$1\text{S}^2 2\text{S}^2 2\text{P}^6 3\text{S}^2 3\text{P}_x^1 3\text{P}_y^1$
15	Phosphorus	${}^{15}\text{P}$	$1\text{S}^2 2\text{S}^2 2\text{P}^6 3\text{S}^2 3\text{P}_x^1 3\text{P}_y^1 3\text{P}_z^1$
16	Sulphur	${}^{16}\text{S}$	$1\text{S}^2 2\text{S}^2 2\text{p}^6 3\text{S}^2 3\text{P}_x^2 3\text{P}_y^1 3\text{P}_z^1$
17	Chlorine	${}^{17}\text{Cl}$	$1\text{S}^2 2\text{S}^2 2\text{p}^6 3\text{S}^2 3\text{P}_x^2 3\text{P}_y^2 3\text{P}_z^1$
18	Argon	${}^{18}\text{Ar}$	$1\text{S}^2 2\text{S}^2 2\text{p}^6 3\text{S}^2 3\text{P}_x^2 3\text{P}_y^2 3\text{P}_z^2$
19	Potassium	${}^{19}\text{K}$	$1\text{S}^2 2\text{S}^2 3\text{p}^6 3\text{s}^2 3\text{p}^6 4\text{s}^1$
20	Calcium	${}^{20}\text{Ca}$	$1\text{s}^2 2\text{s}^2 2\text{p}^6 3\text{s}^2 3\text{p}^6 4\text{s}^2$
21	Scandium	${}^{21}\text{Sc}$	$1\text{s}^2 2\text{s}^2 2\text{p}^6 3\text{s}^2 3\text{p}^6 4\text{s}^2 3\text{d}^1$
22	Titanium	${}^{22}\text{Ti}$	$1\text{s}^2 2\text{s}^2 2\text{p}^6 3\text{s}^2 3\text{p}^6 4\text{s}^2 3\text{d}^2$
23	Vanadium	${}^{23}\text{V}$	$1\text{s}^2 2\text{s}^2 2\text{p}^6 3\text{s}^2 3\text{p}^6 4\text{s}^2 3\text{d}^3$
24	Chromium	${}^{24}\text{Cr}$	$1\text{s}^2 2\text{s}^2 2\text{p}^6 3\text{s}^2 3\text{p}^6 4\text{s}^1 3\text{d}^5$
25	Manganese	${}^{25}\text{Mn}$	$1\text{s}^2 2\text{s}^2 2\text{p}^6 3\text{s}^2 3\text{p}^6 4\text{s}^2 3\text{d}^5$
26	Iron	${}^{26}\text{Fe}$	$1\text{s}^2 2\text{s}^2 2\text{p}^6 3\text{s}^2 3\text{p}^6 4\text{s}^2 3\text{d}^6$
27	Cobalt	${}^{27}\text{Co}$	$1\text{s}^2 2\text{s}^2 2\text{p}^6 3\text{s}^2 3\text{p}^6 4\text{s}^2 3\text{d}^7$
28	Nickel	${}^{28}\text{Ni}$	$1\text{s}^2 2\text{s}^2 2\text{p}^6 3\text{s}^2 3\text{p}^6 4\text{s}^2 3\text{d}^8$
29	Copper	${}^{29}\text{Cu}$	$1\text{s}^2 2\text{s}^2 2\text{p}^6 3\text{s}^2 3\text{p}^6 4\text{s}^1 3\text{d}^{10}$
30	Zinc	${}^{30}\text{Zn}$	$1\text{s}^2 2\text{s}^2 2\text{p}^6 3\text{s}^2 3\text{p}^6 4\text{s}^2 3\text{d}^{10}$

Chapter No. - 5

Periodic Table

5.1 Introduction

Before the beginning of eighteenth century, only a very few elements were known. Therefore, it was quite easy to study and remember their individual properties. Due to rapid discoveries of large number of elements in later years (115 elements known today), the scientists felt need of some simple method to study and remember the properties of various elements and their compounds. It has been done by arranging elements such that, elements with similar properties were grouped together and elements with different properties were separated. This is known as classification of elements.

The classification of elements led to the formation of periodic table “Periodic table is the tabular arrangement of all the known elements according to their properties such that, similar elements fall within a same vertical column and dissimilar elements is separated”.

Many attempts of systematic classification of elements were made. In 1829, Dobereiner, observed some relationship between the atomic weights and their properties. He classified elements having similar properties in a group of three, called ‘triads’. In 1863, Newland, arranged elements in the increasing order of their atomic weights and suggested that, on every 8th elements from a given one, the properties are repeated called ‘Newland’s law of octave’s. Lothar Meyer in 1869, plotted a graph of atomic volumes against atomic weights and stated that, elements with similar properties, occupy similar positions on the curve.

In 1869, Mendeleev a Russian scientist stated periodic law as, “The physical and chemical properties of elements are the periodic functions (properties recur at regular intervals i.e. periods) of their atomic weights ” On the basis of atomic weight of elements, Mendeleev prepared a short form of periodic table containing 7 periods and 8 groups.

In 1912, Moseley was found that, atomic number is more fundamental property of an element than its atomic weight. He gave a modern periodic law as, “the physical and chemical properties of elements are the periodic function of their atomic numbers and not atomic weights.” He prepared a periodic table which was then extended by Bohr by arranging the elements on the basis of their electronic configuration (atomic number). Bohr table is derived from the Mendeleev table by extending each of the long period and separating sub groups and therefore is called long form of periodic table or modern periodic table.

5.2 Modern periodic Table

It is a periodic table in which elements are arranged according to their atomic numbers.

Features of modern periodic table:

1. Elements are arranged in increasing order of their atomic numbers.
2. The elements of which are placed in a same group show similar chemical properties and same valence.

3. It contains seven horizontal rows called 'periods' and eighteen vertical columns called 'groups'
4. The first period is shortest containing just 2 elements. The second and third period contain 8 elements each. The fourth and fifth periods contain 18 elements each. The sixth period is longest containing total 32 elements. The seventh period is incomplete (in progress) containing 26 elements.
5. The elements of group IA → VIIA are called normal elements.
6. The elements of group IB → VIIB and VIII are called transition elements.
7. The elements of group IA are called 'alkali metals'
8. The elements of group IIA are called 'alkaline earth metals'.
9. The elements of O group are called 'Inert or noble or rare gases'.
10. The series of 14 elements each belong to 6th period and 7th period, which are placed separately at the bottom of main periodic table are called 'Lanthanides' and 'Actinides' respectively.
11. The elements of second period are called 'bridge elements'.
12. The elements of third period are called 'typical or representative elements'.
13. The main defect in the table is position of hydrogen, as it shows similarities with both IA and VIIA elements.

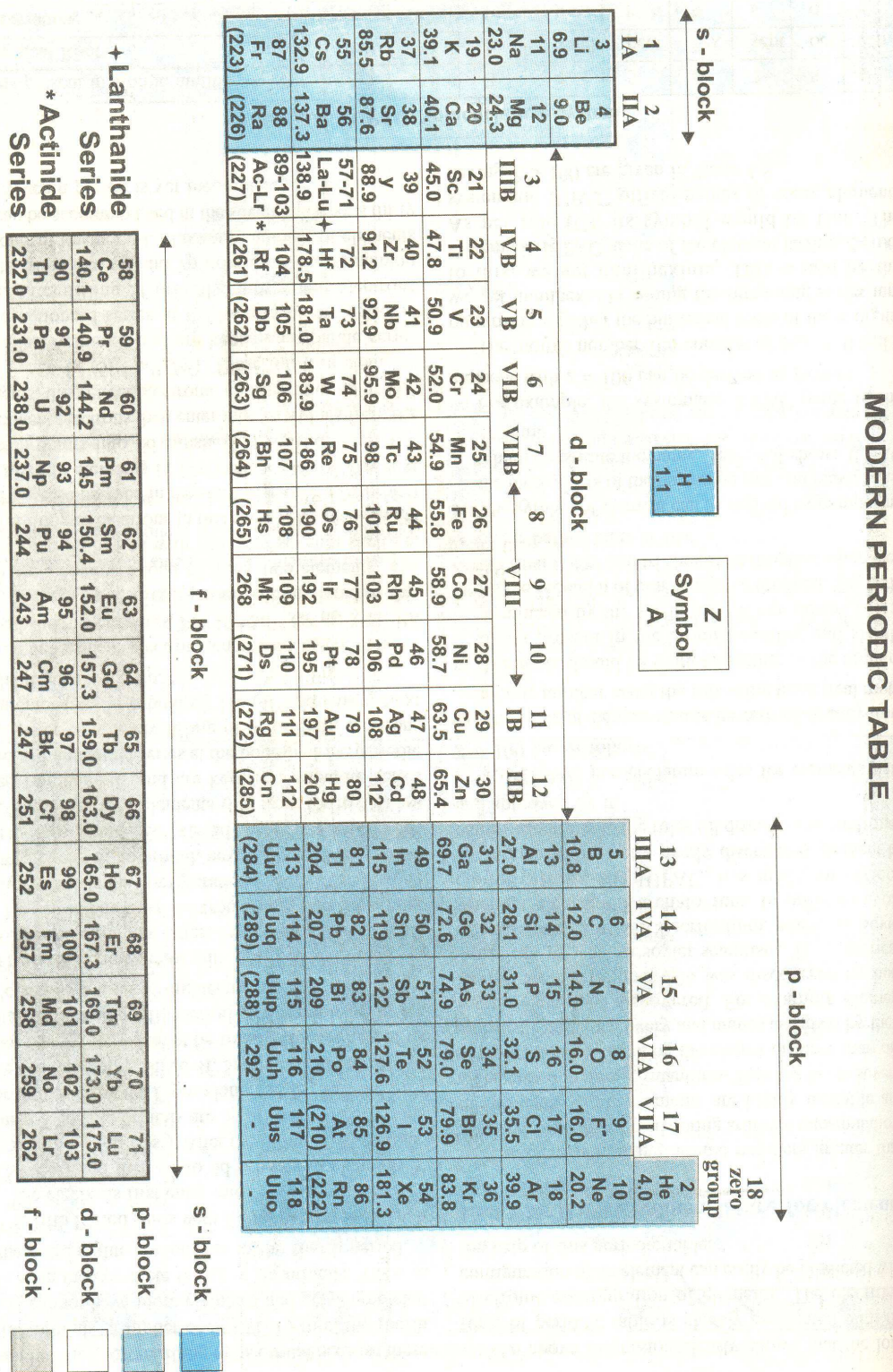


Fig. 4.2 Modern periodic Table

5.3. Classification of elements on the basis of electronic configuration

On the basis of electronic configurations, the elements are classified into four different electronic types. The actual criteria of classification are the complete and incomplete shells.

1. **Noble elements (Inert gases):** In outermost shell of these elements (except 'He'), eight electrons are present. Each atom of these elements have fulfilled and p sub shell. They have outer electronic configuration $ns^2 np^6$. They are chemically inert (in fact, noble). They are placed in zero group of table.
2. **Normal elements:** In atom of these elements, only the outermost shell is incomplete and is getting progressively filled. Their outer electronic configuration is $ns^{1 \text{ or } 2}$ to $ns^2 ns^5$. They are placed in IA to VIIA groups. They have been further divided as,
 - i) **s-block elements:**
 - a) This block contains elements of groups IA and IIA
 - b) They are called 's' block elements because in their atom the last electron enters in 's' orbital of outermost shell.
 - c) They have general electronic configuration ns^1 and ns^2 for elements of IA and IIA respectively. (Where n is outermost shell number).
 - ii) **p-block elements:**
 - a) This block elements of groups IIIA to VIIA and zero.
 - b) They are called 'p' block elements because in their atom the last electron is present in p-orbital of outermost shell.
 - c) They have general electronic configuration ns^2, np^{1-6} for elements of IIIA → VIIA and zero respectively.

3. Transition elements (d-block elements):

- a) In atom these elements, the last two shells are incompletes.
- b) This block contains elements of groups IB → VIIB and VIII.
- c) They are called 'd' block elements because, the last electron enters in the 'd' orbital of penultimate (last but one) shell.
- d) As they are placed in between s-block and p-block elements i.e. in the middle part of periodic table, known as 'transition elements'.
- e) These elements have outer electronic configuration, $ns^{1 \text{ or } 2} (n-1) d^{1-10}$

4. Inner transition elements (f-block elements) :

- a) In atom of these elements, last three shells are incomplete.
- b) This block contains 14 elements each of lanthanides and actinides series.
- c) They are called f-block elements because; the last electron enters in the 'f' orbital of antepenultimate (last but two) shell.
- d) As f-orbital is still inner orbital as compared to d-orbital, they are known as 'inner transition elements'
- e) These elements have general electronic configuration $ns^2 (n-1)^{0 \text{ or } 1}, (n-2)^{0-14}$.

5.4 Periodic trend in properties

Properties of the elements recur at regular intervals in the periodic table. This repetition of properties in elements is called periodicity or periodic trends in properties.

Properties of an element are governed by,

- a) Atomic radius: "It is a distance between center of nucleus and outer most electronic shell of an atom." Smaller the atomic radius, greater is the attraction between

nucleus and valence electrons and vice –versa. It decreases along period and increases down group.

- b) Screening (Shielding) effect: “It is the property of inner shell electrons to repel away the valence electrons, so that valence electrons experience less attraction with nucleus.” Greater the number of inner shell electrons, more will be shielding effect and smaller attractive force is exerted by the nucleus on the valence electrons. It decreases along is exerted by the nucleus on the valence electrons .It decreases along period and increases down group.
- c) Effective nuclear charge: “It is the actual positive charge of nucleus experienced by the valence electrons in presence of screening effect.” Greater the positive charge of nucleus and less shielding effect, more is the effective nuclear charge (attractive force) that experienced by the valence electrons. It increases along period and decreases down group.

1. Atomic size (Radius) :

It is a distance between center of nucleus and outer most electronic shell of an atom

Units : It is expressed in the terms of Angstrom or meter.

$$\text{Where, } 1\text{A}^0 = 10^{-10}\text{m}$$

Trend along period : In period from left to right atomic size gradually decreases.

This is because ,

- i) Atomic number i.e. nuclear charge increases.
- ii) New electrons get added in the same shell. The number of inner shell electrons i.e. screening effect remains same.
- iii) Effective nuclear charge increases and therefore valence shell is attracted by nucleus firmly.
- iv) Thus, distance between nucleus and valence shell i.e. atomic size goes on decreasing.

Trend down a group : In a group from top to bottom atomic size increases.

This is because.

- i) Atomic number i.e. nuclear charge increases but new electrons get added into new shell so that number of shells increases.
- ii) The number of inner shell electrons increases and screening effect increases.
- iii) Effective nuclear charge decreases and valence shell is held less firmly by nucleus.
- iv) Thus, distance between nucleus and valence shell i.e. atomic size goes on increasing.

2. Ionic radii:

It is the distance from nucleus of ion upto which it has influence on its electron cloud in the ionic bond.

Explanation: A positive ion (cation) is formed by the loss of one or more electrons by the atom, whereas a negative ion (anion) is formed by the gain of one or more electrons by the atom. These ions are held together in ionic compound. The internuclear distance between cation and anion in the compound can be determined by x-ray analysis. This distance is

taken as sum of the ionic radii of two ions. By knowing radius of one ion, the radius of other ion can be calculated.

- a) The size (pm) of cation is smaller than that of parent atom. Since, same nuclear charge acts upon less number of electrons. The increase in nuclear charge per electron, causes contraction in the size.

Al → 143	Na → 190	Mg → 136
Al ³⁺ → 50	Na ⁺ → 95	Mg ²⁺ → 65

- b) The size (pm) of anion is large than the parent atom. Since, same nuclear charge acts upon more electrons. The decrease in nuclear charge per electron, causes expansion in the size.

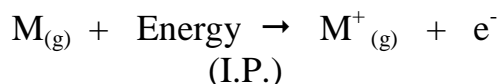
Cl → 99	O → 73	Mg → 136
Cl ⁻ → 181	O ²⁻ → 140	N ³⁻ → 171

Trend along a period: In a period from left to right, ionic radii follow the same trend to that of atomic size and therefore ionic radii gradually decrease.

Trend down a group: In a group from top to bottom, ionic radii follow the same trend to that of atomic size and therefore ionic radii gradually increase.

3. Ionization potential:

It is amount of energy required to remove the most loosely bound electron from the isolated gaseous atom of element.



Units : It is expressed in the terms of meV or eV. It has S.I. unit J or kJ.

Trend along period: In a period from left to right, Ionization potential gradually increases.

This is because.

- Atomic size decreases as effective nuclear charge increases.
- The last electron is held more firmly by nucleus.
- Therefore, more amount of energy is required to remove last electron and I.P. increases.

Element of 3 rd period	Na	Mg	Al	Si	P	S	Cl	Ar
First I.P. in eV	5.1	7.6	6.0	8.1	11.0	10.4	13.0	15.8

Trend down a group : In a group from top to bottom ionization potential gradually decreases.

This is because,

- Though nuclear charge increases due to increase in screening effect, atomic size increases.
- The last electron is held less firmly by nucleus.
- Therefore, less amount of energy is required to remove last electron, and ionization potential decreases.

Element of Group I A	H	Li	Na	K	Rb	Cs
I.P. in eV	13.5	5.4	5.1	4.3	4.2	3.9

4. Electron affinity:

It is amount of energy released, on addition of an electron into the isolated gaseous atom of element.



Units: It is expressed in the terms of meV or eV and S.I . units is J/kj

Explanation: Greater the ease of addition of electron into the atom, greater will be amount of energy released i.e. electron affinity and vice- versa.

Trend along period: In a period from left to right electron affinity of elements increases.

This is because,

- Atomic size i.e. distance between nucleus and valence shell decreases.
- Addition of extra electron into the isolated gaseous atom becomes easy.
- On addition of electron, more amount of energy is liberated i.e. electron affinity increases.

Element of 2 nd period	Li	Be	B	C	N	O	F
Electron affinity eV	1.0	1.5	2.0	2.6	3.05	3.5	4.0

Trend down a group: In a group from top to bottom electron affinity of elements decreases.

- Atomic size i.e. distance between nucleus and valence shell increases.
- Addition of electron into the isolated gaseous atom becomes difficult i.e. less easier.
- On addition of extra electron. less amount of energy is liberated i.e. electron affinity decreases.

Element of VII A group	F	Cl	Br	I
Electron affinity in KJ	349.29	365.69	343.50	316.48

5.5 Electronegativity:

It is the ability of atom of element to attract the shared pair of electrons towards itself within a molecule.

Explanation: When a covalent bond between two dissimilar atoms is formed the shared pair of electrons doesn't present exactly at the mid point of two nuclei. But, the shared pair of electron is found to be to shifted towards one atom.

This is because, that one atom attracts the shared pair of electrons towards it self, to a greater extent than another atom. This ability of atom of the element is termed as 'electronegativity'.

The electronegativity of different elements are expressed on Pauling scale as relative numbers.

Trend along period: In a period from left to right, electronegativity of elements increases.

This is because,

- i) Atomic size i.e. distances between nucleus and valence shell decreases.
- ii) The distance between nucleus of atom and shared pair of electrons also decreases.
- iii) Hence, ability of atom of the element to attract shared pair of electrons towards itself i.e. electronegativity increases.

Element of I A group	Li	Be	B	C	N	O	F
Electronegativity	1.0	1.5	2.1	2.5	3.0	3.5	4.0

Trend down a group : In a group from top to bottom, electronegativity of element decreases.

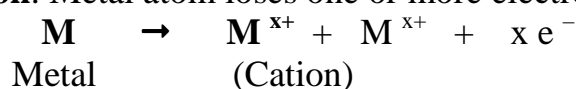
- i) Atomic size i.e. distances between nucleus and valence shell increases.
- ii) The distance between nucleus of atom and shared pair of electrons also increases along with screening effect.
- iii) Hence, the ability of atom of the element to attract shared pair of electrons towards itself within a molecule i.e. electronegativity decreases.

Element of I A group	Li	Na	K	Rb	Cs	Fr
Electronegativity	1.0	0.9	0.8	0.79	0.70	0.69

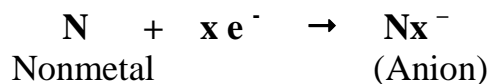
5.6 Metallic and nonmetallic Character:

Metallic character is the property of atom of the element to lose electrons to form cation and non metallic character is the property of atom of the element to gain electrons to form anion.

Explanation: Metal atom loses one or more electrons to form respective cation as,



Nonmetal atom gains one or more electrons to form respective anion as,



Trend along a period: In a period from left to right, metallic character of element decreases and nonmetallic character increases.

This is because.

- i) Atomic size decreases.
- ii) Both I.P. and electron affinity increases.
- iii) Valence electrons are getting firmly held by the nucleus.
- iv) Hence, the property of atom of element to lose electron i.e. metallic character decreases and at the same time the property of atom of element to gain electron i.e., nonmetallic character increases.

Trend down a group: In a group from top to down, metallic character of element increases and nonmetallic character decreases.

This is because.

- i) Atomic size increases.
- ii) Both I.P. and electron affinity decreases.
- iii) Valence electrons are getting loosely held by the nucleus.
- iv) Hence, property of atom of element to lose electron i.e. metallic character increases and at the same time the property of atom of element the to gain the electron i.e. nonmetallic character decreases.

Chapter No. – 6

Redox Reaction

6.1 Introduction

Many types of chemical reactions, we come across. Oxidation and reduction, is one of the important class of reactions.

Earlier oxidation was considered as, the reaction involving addition of oxygen such as, rusting of iron, burning of coal. While reduction was considered as reaction involving addition of hydrogen such as hydrogenation, extraction of metal from its oxide. Generation of electricity in batteries and many industrial processes such as manufacture of caustic soda, potassium permanganate, extraction of metals, involve both oxidation and reduction reactions.

6.2 Old concept of oxidation and reduction

1. Oxidation

Definition: “It is a process of addition of oxygen or any other electronegative element or removal of hydrogen or any other electropositive element.”

Ex. :

- i) $C + O_2 \rightarrow CO_2$ [Addition of oxygen]
- ii) $Zn + S \rightarrow ZnS$ [Addition of electronegative element]
- iii) $H_2S + Br_2 \rightarrow 2HBr + S$ [Removal of hydrogen]
- iv) $2KI + Cl_2 \rightarrow 2KCl + I_2$ [Removal of electropositive element]

Oxidizing agent: It is a substance which helps in oxidation of another substance. e.g. O_2 , $KMnO_4$, etc.

2. Reduction:

Definition: “It is process of addition of hydrogen or any other electropositive element or removal of oxygen or any other electronegative element.”

Ex. :

- i) $Br_2 + H_2 \rightarrow 2HBr$ [Addition of hydrogen]
- ii) $2FeCl_2 + Fe \rightarrow 3FeCl_2$ [Addition of electropositive element]
- iii) $ZnO + C \rightarrow Zn + Co$ [Removal of oxygen]
- iv) $SiCl_4 + 4K \rightarrow Si + 4KCl$ [Removal of electronegative element]

Reducing agent: It is a substance which helps in reduction of another substance. e.g. H_2 , $H_2C_2O_4$, etc.

6.3 Electron transfer concept

1. Oxidation

Definition: "It is process loss of electrons by an atom or ion which causes the increase in positive charge or decrease in negative charge.

Ex.:

- i) $\text{Na} \rightarrow \text{Na}^+ + 1e^-$ [Increase in positive charge]
- ii) $\text{Zn} \rightarrow \text{Zn}^{+2} + 2e^-$ [Increase in positive charge]
- iii) $\text{Fe}^{2+} \rightarrow \text{Fe}^{+3} + 1e^-$ [Increase in positive charge]
- iv) $2\text{I}^- \rightarrow \text{I}_2 + 2e^-$ [Decrease in negative charge]
- v) $\text{MnO}_4^{2-} \rightarrow \text{MnO}_4^- + e^-$ [Decrease in negative charge]

By loss of electrons, negative charge decreases and position charge increases.

2. Reduction:

Definition: "It is a process of gain of electrons by on atom or ions which causes the increase in negative charge or decrease in positive charge.

Ex. :

- i) $\text{Cl}_2 + 2e^- \rightarrow 2\text{Cl}^-$ [Increase in negative charge]
- ii) $[\text{Fe}(\text{CN})_6]^{3-} + e^- \rightarrow [\text{Fe}(\text{CN})_6]^{4-}$ [Increase in - ve charge]
- iii) $\text{S} + 2e^- \rightarrow \text{S}^{2-}$ [Increase in negative charge]
- iv) $\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu}$ [Decrease in positive charge]
- v) $\text{Sn}^{4+} + e^- \rightarrow \text{Sn}^{2+}$ [Decrease in positive charge]

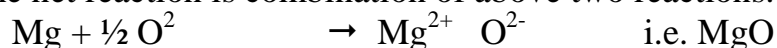
By gain of electrons, negative charge increases and positive charge decreases.

Oxidation and reduction as electron transfer reaction:

Oxidation involves loss of electrons, while reduction involves gain of electrons. Therefore, electrons are transferred from species undergoing oxidation to species undergoing reduction. It means, oxidation and reduction reactions go hand in hand i.e. simultaneously e.g. when magnesium wire is burnt in oxygen, powder of magnesium oxide is formed as.

- i) $\text{Mg} \rightarrow \text{Mg}^{2+} + 2e^-$ [Oxidation]
- ii) $\frac{1}{2} \text{O}_2 + 2e^- \rightarrow \text{O}^{2-}$ [Reduction]

The net reaction is combination of above two reactions.



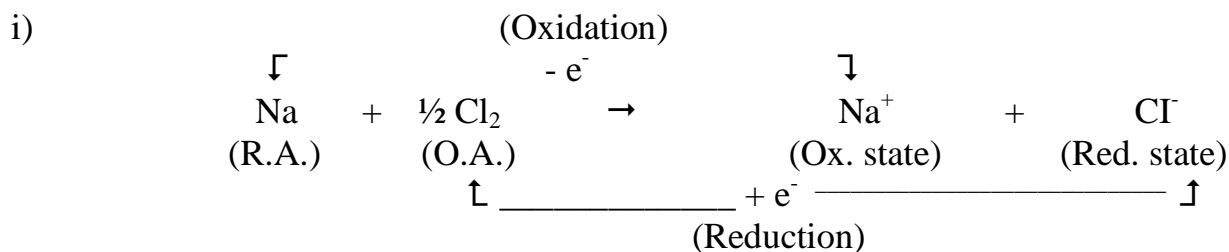
Thus, oxidation and reduction are electron transfer reactions.

6.4 Oxidizing agent and reduction agent

Oxidizing agent (Oxidant): It is a substance which helps in oxidation of another substance by gaining electrons e.g. F_2 , Cl_2 , O_2 , Fe^{3+} , HNO_3 , MO_2 , $\text{K}_2\text{Cr}_2\text{O}_7$ etc.

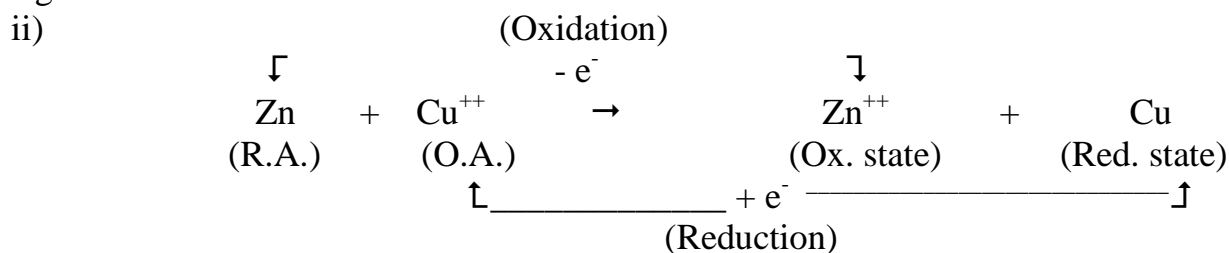
Reducing agent (Reductant): It is a substance which helps reduction of another substance by losing electrons. e.g. Mg , H_2 , C , Fe^{2+} , SnCl_2 , etc.

Explanation with suitable example:



In above reaction Cl helps in oxidation of Na by gaining electron. Therefore, Cl acts as oxidizing agent.

While Na helps in reduction of Cl by losing electron therefore Na acts as reducing agent.



Difference between oxidation and reduction:

Oxidation		Reduction	
1	It involves addition of oxygen or an electronegative element.	1	It involves removal of oxygen or an electronegative element.
2	It involves removal of hydrogen or an electropositive element.	2	It involves addition of hydrogen or an electropositive element
3	It is loss of electrons by an atom or ion.	3	It is gain of electrons by an atom or ion.
4	It causes increase in positive charge or decrease in negative charge.	4	It causes increase in negative charge or decrease in positive charge.
5	It involves increase in oxidation number.	5	It involves decrease in oxidation number.
6	It is helped by oxidizing agent.	6	It is helped by reducing agent.
7	Substance undergoing oxidation, reduces other and therefore, acts as reducing agent.	7	Substance undergoing reduction, oxidises other and therefore, acts as oxidizing agent.
8	Example: (a) $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$ (b) $\text{Na} \rightarrow \text{Na}^+ + 1 e^-$	8	Example: (a) $\text{CuO} + \text{H}_2 \rightarrow \text{Cu} + \text{H}_2\text{O}$ (b) $\frac{1}{2} \text{Cl}_2 + 1 e^- \rightarrow \text{Cl}^-$

Chapter No. - 7

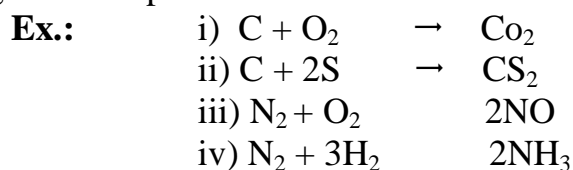
Chemical Equilibrium

7.1 Introduction

In a chemical change (reaction), substances (reactants) get converted to new substances (products). Generally, chemical reactions are accompanied by evolution or absorption of heat called exothermic and endothermic reaction respectively. In some chemical reactions called irreversible reactions, reactants get completely converted into products. But, in most of the chemical reactions. When carried out in closed vessel, the reactants do not get completely converted into products. This is because, the formed products can also react with each other to produce the original reactants. These reactions are called reversible reactions.

In this topic we will discuss many aspects of reversible reactions.

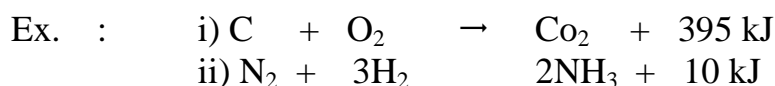
Chemical reaction: It is a process in which the reactant undergoes a chemical change to form products.



Types of Chemical reaction:

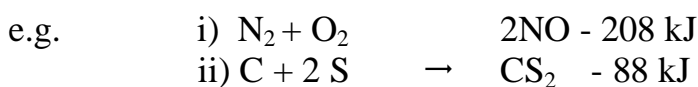
1. Exothermic reactions:

Definition: "It is a chemical reaction which is accompanied by evolution of heat."



2. Endothermic reactions:

Definition: "It is a chemical reaction which is accompanied by absorption of heat."



Difference between exothermic and endothermic reaction:

Exothermic reaction		Endothermic reaction	
1	Heat is evolved.	1	Heat is absorbed
2	Products are more stable.	2	Products are less stable.
3	It is spontaneous.	3	It is nonspontaneous.
4	It is slow.	4	It is fast.
5	It is favoured by low temperature.	5	It is favoured by high temperature.
6	e.g. C + O ₂ → CO ₂ + 395	6	e.g. C + 2 S → CS ₂ - 88 kJ

	kJ		
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Difference between reversible reaction and irreversible reaction:

Reversible reaction		Irreversible reaction	
1	The formed products can react with each other to produce the original reactants.	1	The formed products can not react with each other to produce the original reactants.
2	Complete conversion of reactants into products, is not possible.	2	Complete conversion of reactants into products, is possible.
3	Products are less stable.	3	Products are more stable.
4	It is slow.	4	It is fast.
5	The symbol \rightleftharpoons is written between reactants and products.	5	The symbol \rightarrow is written between reactants and products.
6	It proceeds in both forward and backward directions.	6	It proceeds in only forward directions.
7	“Law of mass action’ is applicable.	7	“Law of mass action’ is not applicable.
8	Equilibrium is attained.	8	Equilibrium is not attained.
9	Reaction never goes to completion.	9	Reaction goes to completion.
10	$N_2 + O_2 \rightleftharpoons 2NO$	10	$C + O_2 \rightarrow CO_2$

7.2 Chemical Equilibrium

When a reversible reaction is arranged in a closed vessel, at some stage the forward and backward reaction proceed with same rate. There will be no net change in concentration of substances after this stage. This state of system is known as ‘chemical equilibrium’

Definition: “It is the state of reversible reaction at which, rates of forward and backward reactions are exactly equal.”

“It is the state of reversible reaction at which, there is no net change in concentrations of reactions and products with time.”

Explanation with suitable example:

Consider, a reversible reaction started with N_2 and H_2 in a closed vessel,



The forward reaction is,



According to ‘law of mass action’, the rate of forward reaction can be given as,

$$r_f \propto [N_2]^1 \times [H_2]^3$$

The backward reaction is,



According to 'law of mass action', the rate of backward reaction can be given as,

$$r_b \propto [\text{NH}_3]^2$$

In the beginning, the rate of forward reaction is rapid. Due to maximum concentration of N_2 and H_2 in the reactor. But, the rate of backward reaction is zero due to absence of NH_3 .

When reaction proceeds with time, N_2 and H_2 will get converted into NH_3 . The rate of forward reaction decreases, due to decreases in concentration of N_2 and H_2 . At the same time, the rate of backward reaction increases of due to increases in concentration of NH_3 . If this is continued, at some stage, the rate of forward reaction and rate of backward reaction will become exactly same. This state of reversible reaction is known as 'state of chemical equilibrium'. At this stage, as concentration of reactants and products do not change, the reaction appears to have stopped.

Graphical representation:

Fig. Page no.167 (Chemistry XI) Nikita Puplication Latur

7.3 Chemical equilibrium

When a reversible reaction is arranged in a closed vessel, at some stage the forward and backward reaction proceed with same rate. There will be no net change in concentration of substances after this stage. This state of system is known as 'chemical equilibrium'.

Definition: "It is the state of reversible reaction at which, rates of forward and backward reactions are exactly."

"It is the state of reversible reaction at which, there is no net change in concentration of reactions and products with time."

7.4 Law of mass action (Guldberg and Waage, 1867)

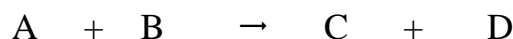
Statement: "The rate of a chemical reaction is directly proportional to the product of active masses of reactants present at that instant with each concentration term raised to the power equal to the number of molecules of respective reactants in the chemical reaction."

Explanation with suitable example:

Consider, a general reversible reaction,



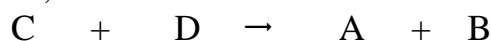
Where, the forward reaction is,



According to 'law of mass action' the rate of forward reaction can be written as,

$$r_f \propto [A] \times [B]$$

The backward reaction is,



According to 'law of mass action', the rate of backward reaction can be given as,

$$r_b \propto [C] \times [D]$$

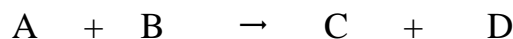
Mass law equation (Equilibrium equation)

Definition: "It is the equation obtained for a reversible reaction by applying 'law of mass action' at equilibrium."

Derivation: Consider, a general reversible reaction,



Where, the forward reaction is,

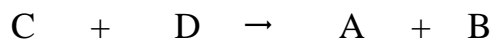


By applying law of mass action, the rate forward reaction can be given as,

$$r_f \propto [A] \times [B]$$

$$\text{i.e. } r_f = K_f [C] [D] \quad \dots\text{(i)}$$

The backward reaction is,



By applying law of mass action, the rate of backward reaction can be given as,

$$r_b \propto [C] \times [D]$$

$$\text{i.e. } r_b = K_b [C] [D] \quad \dots\text{(ii)}$$

But, at equilibrium, rates of forward & backward reactions are equal,

$$r_f = r_b \quad \dots\text{(iii)}$$

Keeping equation (i) and (ii) in equation (iii)

$$K_f [A] [B] = K_b [C] [D]$$

Rearranging,

$$\frac{K_f}{K_b} = \frac{[C] [D]}{[A] [B]}$$

Replacing, (K_f/K_b) by another constant K_c finally we get, the “mass law equation’ as

$$K_c = \frac{[C] [D]}{[A] [B]} \quad \text{(When substances are solutions.)}$$

OR

$$K_p = \frac{P_C \times P_D}{P_A \times P_B} \quad \text{(When substances are gases.)}$$

Where, K_c or K_p = Equilibrium constant

[C] = Active mass (mol/dm^3) of C

[D] = Active mass of D

[A] = Active mass of A

[B] = Active mass of B

$$\frac{[C] [D]}{[A] [B]} = \text{Equilibrium quotient } (Q_c)$$

Chapter No. - 8

Adsorption

8.1 Introduction

In 1776, **Scheele** observed accumulation of gases on charcoal. This is the phenomenon of adsorption, which was further studied by H. Kayser in 1881. Substance such as charcoal, silica gel and some colloidal substance such as $\text{Fe}(\text{OH})_3$, $\text{Al}(\text{OH})_3$ have tendency to collect other substance on their surfaces, when come in contact.

The molecules on the surface of a solid or a liquid are in unbalanced and higher energy state. When such a solid or liquid comes in contact with another liquid or a gas, the liquid or gas are held on the surface. A number of processes in chemistry are based on this phenomenon.

Adsorption: "It is the phenomenon of collection (accumulation) of one substance mainly on the surface of other substance." **OR**

"It is the phenomenon of attracting and retracting the molecules of a liquid or gas mainly on the surface of a solid or liquid, result into higher concentration of the molecules on the surface than in the bulk."

While the phenomenon of removal of adsorbed molecules away from the surface, on which they were adsorbed, is known as desorption. This is reverse of adsorption can be brought about by increasing temperature or decreasing the pressure.

Adsorption usually takes place when two immiscible i.e. heterogeneous phases are brought in contact.

There are three cases of adsorption,

- i) Gas – Solid system e.g. adsorption of hydrogen gas on charcoal.
- ii) Liquid – Solid system e.g. adsorption of acetic acid on charcoal.
- iii) Gas – Liquid system e.g. adsorption of oxygen gas on mercury.

Adsorption as surface phenomenon

- i) The molecules present in the bulk (B) of adsorbent (solid or liquid) are attracted by other molecules from all sides. Hence they are in balanced state.
- ii) But the molecules present at the surface (S) of adsorbent are only attracted by other molecules from inside. Therefore they are in unbalanced state. So, as to attain balance state, the surface molecules hold molecules of other substance from outside as shown in figure. This also helps to decrease surface tension.
- iii) The molecules on the surface of solid or liquid are in higher energy state than the molecules in bulk. These molecules on surface hold molecules of another liquid or gas with release of surface energy.
- iv) Thus, adsorption takes place mainly on the surface and slightly into the bulk of adsorbent and hence it is surface phenomenon.

Fig. Page no.192 (Chemistry XI) Nikita Puplication Latur

Adsorption: “It is phenomenon of penetration of a substance (Adsorbate) through the surface and its uniform distribution into the bulk of another substance (Adsorbent).” e.g. soaking of water (Adsorbate) by sponge (Adsorbent), absorption of ink by a chalk piece or blotting paper and absorption of tea by bread etc.

The two substances i.e. phases involved in adsorption are termed as,

1. **Adsorbate:** “It is substance which gets collected on the surface of another substance.”
2. **Adsorbent:** “It is substance which collects another substance on its surface.”

Example:

Sr.No	Adsorbate	Adsorbent	Reaction
1	N ₂ and H ₂	Iron	N ₂ + 3 H ₂ → 2 NH ₃
2	CO and H ₂	ZnO or Cr ₂ O ₃	CO + 2 H ₂ → CH ₃ OH
3	SO ₂ and O ₂	Platinised asbestos	2 SO ₂ + O ₂ → 2SO ₃
4	Oil and H ₂	Nikel	Oil + H ₂ → Fat
5	Colour particles	Charcoal	Decolourisation of sugar solution
6	Different cations or amino acids	Silica gel or Al ₂ O ₃	Chromatography

8.2 Difference between adsorption and absorption

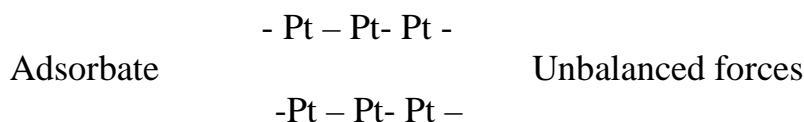
Adsorption		Absorption	
1	It is surface phenomenon.	1	It is bulk phenomenon.
2	A substance gets collected on the surface of other substance.	2	A substance gets penetrated through out the body of other substance.
3	It depends upon the surface area.	3	It is independent upon the surface area.
4	It depends upon temperature and pressure.	4	It is independent of temperature and pressure.
5	Heat is evolved.	5	Heat is neither evolved nor absorbed.
6	It may be reversible.	6	It may be irreversible.
7	It may be selective (specific).	7	It is non selective (universal).
8	It is fast process.	8	It is gradual process.
9	e.g. adsorption of H ₂ gas on charcoal.	9	e.g. adsorption of water by sponge.

Forces between adsorbent and adsorbate:

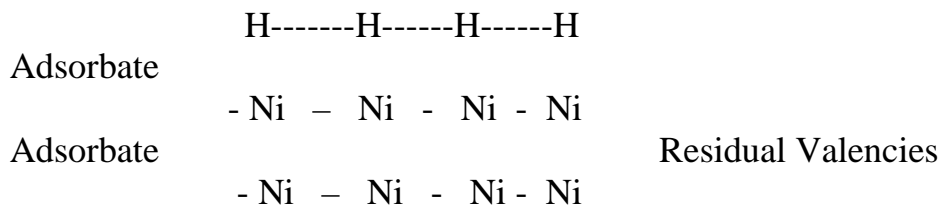
The adsorbate molecules are held by the surface particles of adsorbent by two forces.

1. Vander Waal’s forces: At low temperature, the surface particles of adsorbent are not chemically activated. Therefore, they hold molecules of adsorbate by weak mutual nuclei electrons attraction (Vander Waal’s forces). Thus, unbalanced Vander Waal’s forces will be balanced by holding adsorbate molecules as shown in the figure below.





2. Chemical forces: At high temperature, the surface particles of adsorbent get chemically activated. Therefore, they hold molecules of adsorbate by strong chemical forces (bonds). Thus, residual valencies are fulfilled by holding atoms from adsorbate molecules as shown in the figure below.



8.3 Types of adsorption: Physical & Chemical adsorption

1. Physical or Van der Waal’s adsorption: “It is type of adsorption in which, adsorbate molecules are held on the surface of adsorbent by **weak Van der Waal’s forces i.e. physical forces** due to unbalanced intermolecular forces at the surface.” This adsorption is also called as physisorption.

e.g. i) adsorption of NH₃ gas on charcoal.

2. Chemical or Activated adsorption: “It is type of adsorption in which adsorbate molecules are held on the surface of adsorbent by stronger chemical bonds due to residual valence forces.” This adsorption is also called as chemisorption.

e.g. i) adsorption of O₂ gas on tungsten (W).

Difference between Physical and Chemical adsorption

Physical adsorption		Chemical adsorption	
1	Adsorbate molecules are held on the surface of adsorbent by Van der Waal’s forces.	1	Adsorbate molecule are held on the surface of adsorbent by Chemical forces.
2	Multimolecular layer of adsorbent is formed on surface of adsorbent.	2	Monomolecular layer of adsorbate is formed on surface of adsorbent.
3	Heat evolved is low. [20 – 40 kJ/mol of adsorbate].	3	Heat evolved is high. [40 – 400 kJ/mol of adsorbate].
4	It is reversible.	4	It is irreversible.
5	It is fast.	5	It is slow.
6	It is non specific (non selective).	6	It is specific (selective).
7	It takes place at low temperature.	7	It takes place at high temperature.
8	It has low activation energy.	8	It has high activation energy.

8.4 Factors affecting adsorption

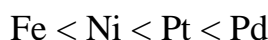
1. Temperature: Adsorption is exothermic process. According to Le-Chatelier's principle, after optimum temperature, the rate of adsorption decreases with increase in temperature vice versa.. Adsorption is favoured by low temperature. Thus, adsorption is inversely proportional to temperature as shown in the graph.

In physisorption, rate of adsorption decreases with increases in temperature. But in chemisorptions, the rate first increases and then decreases with increase in temperature due to high activation energy.

Fig. Page no.195 (Chemistry XI) Nikita Publication Latur

2. Pressure: The increase in pressure causes strengthening of Vander Waal's forces. This helps the adsorbate molecules to get adsorbed quickly. At constant temperature, rate of adsorption increases with increase in pressure. But at a certain high pressure, the whole surface area of adsorbent is jam covered by adsorbate molecules. If pressure is still increased, then further increases in rate of adsorption is not possible. Thus, adsorption is directly proportional to pressure but upto certain limit.

3. Nature of adsorbent: The substance having porous nature and rough surface, are found adsorbents. The substances having more free valencies and unbalanced forces at the surface, are found good adsorbents. The adsorbent may be selective for adsorbate e.g. from the mixture of ethylene and coal gas, activated charcoal adsorbs only ethylene. The adsorption of H₂ gas on metals, increases in the following order,



4. Nature of adsorbate: Physisorption depends upon B.P. of liquid adsorbate. The gases are adsorbed more than liquids or solids. The easily liquefiable and highly water soluble gases get adsorbed more e.g. NH₃, Cl₂, SO₂. The gases with high molecules weights get absorbed more e.g. SO₂ is adsorbed more than CO₂. The adsorbate may be selective for adsorbent e.g. adsorbate O₂ gas is selected by tungsten.

5. Concentration of adsorbate: The rate of adsorption increases with increase in concentration of adsorbate solution but, upto certain limit.

6. Surface area of adsorbent: Adsorption is surface phenomenon. So, greater the total surface area of adsorbent, greater is adsorption. Hence porous substance, substance with and finely powdered substances, provide more surface area and more unbalanced forces for greater adsorption e.g. charcoal powder adsorbs more than the charcoal block of same mass.

8.5 Freundlich Adsorption Isotherm (1909)

Adsorption Isotherm: "It is the relation between rate of adsorption and pressure of concentration of adsorbate at constant temperature."

Freundlich adsorption Isotherm: “It is an empirical equation given by Freundlich, showing effect of pressure or concentration of adsorbate on rate of adsorption at constant temperature over a limited range of pressure.”

$$\left(\frac{x}{m}\right) = K P^{1/n} \quad \text{(For gas – solid system)}$$

$$\left(\frac{x}{m}\right) = K C^{1/n} \quad \text{(For liquid – solid system)}$$

(Condition: $0 < 1/n < 1$)

where, x – Mass of gas adsorbed,
 m – Mass of solid adsorbent

$$\left(\frac{x}{m}\right) - \text{Rate of adsorption}$$

P – Pressure of gas

C – Concentration of solution.

K – Constant for the given system.

n – Constant for the given system which is more than 1.

Graphical representation of Freundlich adsorption isotherm:

It (x/m) values are plotted against P value the following curve is obtained.

Fig. Page no.198 (Chemistry XI) Nikita Publication Latur

i) At low pressure range: The rate of adsorption (x/m) increases rapidly with increase in pressure i.e. $(x/m) \propto P$.

ii) At moderate pressure range: The rate of adsorption increases but less rapidly with increase in pressure. i.e. $(x/m) \propto P^{1/n}$
 (Where $n > 1$)

iii) At high pressure range: The rate of adsorption attains a maximum value and becomes independent of pressure i.e. $(x/m) \propto P^0$
 But, $P^0 = 1$, therefore $(x/m) = \text{constant (K)}$

Evaluation of K and n: The value of constants K and n , depend upon nature of adsorbent, nature of adsorbate and temperature.

The Freundlich adsorption isotherm is,

$$\left(\frac{x}{m}\right) = K^{1/n}$$

Taking log on both sides of above equation, we get an equation for straight line. Thus, it holds good at moderate pressure only.

$$\left(\log \frac{x}{m}\right) = n (\log P) + (\log K)$$
$$y = m(x) + C$$

$\left(\log \frac{x}{m}\right)$ values are plotted against $(\log P)$ values, a straight line curve is obtained. The slope line gives the value of 'n' and Y-straight line gives the value of log 'K'. Thus, K and n are evaluated.

Fig. Page no.199 (Chemistry XI) Nikita Puplication Latur

Chapter No. – 9

Nature of Chemical Bond

9.1 Introduction

Atoms of noble elements (inert gases) have free existence. Since, they have complete octet of electrons and stable outer electronic configuration i.e. ns^2, np^6 . But, atoms of other elements are unstable and therefore they combine with one another in different ways and form stable molecules. Thus, a molecule is a cluster of atoms, where atoms are bonded by chemical bonds.

Chemical bond: “It is the force of attraction which binds (holds) two atoms within a molecule.”

Electronic theory of valency (Octet theory)

In 1916, W. Kossel and G.N. Lewis proposed this theory, which was then modified by Langmuir in 1919. It is based on electronic concept of valency and octet of elements and therefore known as ‘Electronic theory of valency or octet theory.’

Postulates:

1. The outermost electronic shell of atom is called valence shell and electrons present in it, are called valence electrons
2. The valence electrons of an atom can only take part in bond formation. Therefore, valency of an element depends upon number of valence electrons.
3. The noble elements contain eight electrons in their valence shell and therefore they are stable. They have stable outer electronic configuration ns^2, np^6 .
4. The other elements do not contain eight electrons in their valence shell. Therefore, they have tendency to lose, gain or share electrons, to attain electronic configuration of nearest noble element (inert gas).

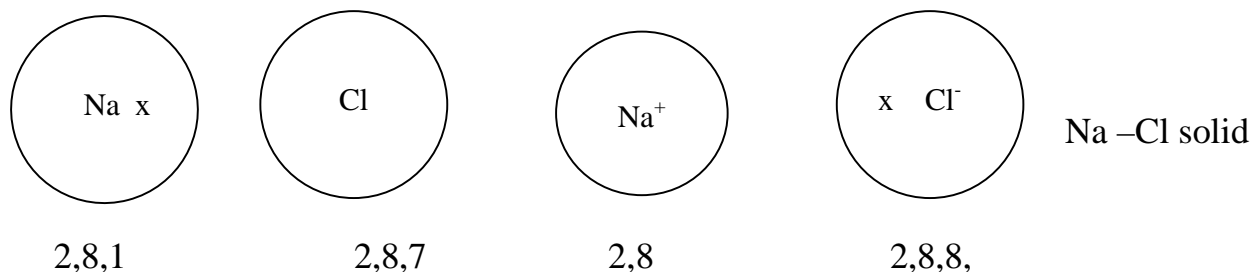
Octet Rule:

“In forming a chemical bond, atoms lose, gain or share electrons so that, their valence shell contain 8 electrons just like nearest noble element.”

Explanation with example: (Formation of NaCl molecule)

- i) Na has bigger atomic size and Cl has smaller.
- ii) Na has loosely held only 1 electron and Cl has firmly held 7 electrons in their valence shell.
- iii) Na loses 1 electron, while Cl gains that 1 electron to complete their octet.

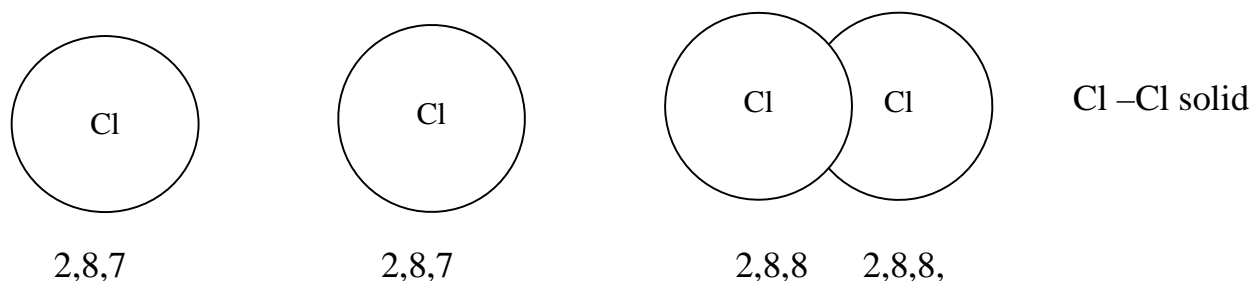
- iv) Thus, Na forms Na^+ ion and Cl forms Cl^- ion. Sodium attains electronic configuration of nearest inert gas Neon i.e. $1s^2 2s^2 2p^6$ and Chlorine attains electronic configuration of nearest inert gas Argon i.e. $1s^2 2s^2 2p^6 3s^2 3p^6$. Many Na^+ and Cl^- are held together by electrostatic force of attraction i.e. ionic bond to form NaCl ionic solid.



2. Covalent bond: “It is bond which is formed by the mutual (equal) sharing of electrons between two atoms.

Explanation with example: (Formation of Cl_2 molecule)

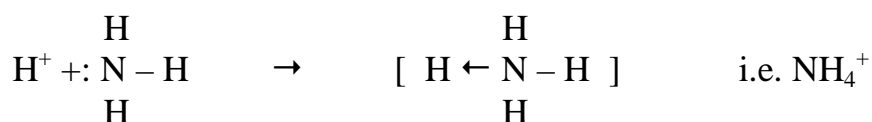
- Cl has smaller atomic size
- Each Cl atoms has firmly held 7 electrons in its valence shell.
- Each Cl atoms needs only one electron to complete octet.
- Hence, two Cl atoms mutually share an electron to complete their octet. Chlorine attains electronic configuration of nearest inert gas Argon i.e. $1s^2 2s^2 2p^6 3s^2 3p^6$. Thus, Cl_2 molecules is formed by covalent bond.



3. Co-ordinate (Dative) bond: “It is bond which is formed by the sharing of electron pair between two atoms, where both the electrons are contributed by only one atom.”

Explanation with example: (Formation of NH_4 molecule)

- N atom from NH_3 donates its a pair of electrons to H^+ ion.
- Hence, a pair of electrons is shared between these two or form a co-ordinate bond (\leftarrow) as shown below.



4. Van der Waal's forces: “It is the mutual attraction between nuclei and electrons of molecules by which the molecules are held together.”

Explanation with example: This attraction is a result of instantaneous dipole and

induced dipole due to elliptical path of electrons around the nucleus of atom.

Ex. [Formation of molecular solid of phosphorous]

Each P atom gets covalently bonded with other three P atom to form P₄ molecule. Many P₄ molecules are held together by Van der Waal's forces to form molecular solid phosphorous.

Difference between Ionic bond and Covalent bond:

Ionic bond		Covalent bond	
1	It is formed by transfer of electrons from one atom to another atom.	1	It is formed by mutual sharing of electrons between two similar or dissimilar atom.
2	It is generally formed between metal and non metal.	2	It is generally formed between two non metals.
3	Cations and anions are held together in bulk.	3	Atoms are held together in a molecule.
4	It is a polar directional.	4	It is directional.
5	It is a polar bond.	5	It may be polar or non polar.
6	Electronegativity diff. between atoms is more than 1.8	6	Electronegativity diff. between atoms is less than 1.8

9.2 Valence Bond Theory (V.B.T.)

This theory was first put forth by W. Heitler and F. London in 1927. It was further extended by Pauling and J.Slater in 1931 introducing concept of hybridization. It has following postulates.

- Mechanism of bond formation:** A covalent bond between two atoms is formed by the overlapping of their atomic orbitals containing an unpaired electron each.
- Spin of electrons:** The atomic orbitals taking part in overlapping should contain an unpaired electron with opposite (antiparallel) spins.
- Energy of orbitals:** The atomic orbitals of two atoms taking part in overlapping should have nearly same energy.
- Binding force:** The spin of electrons get mutually neutralized and pairing of electrons takes place in overlapped region between the two nuclei to avoid the nuclear repulsion.
- P.E. change of system:** During the course of overlapping potential energy of system decreases.
- Extent of overlap:** The extent of overlapping is limited, since then repulsive forces increases.
- Strength of bond :** The strength of bond is directly proportional to extent of overlapping
- Valency:** The number of covalent bonds formed by an atom i.e. its valency is equal to number of unpaired electrons present in its valence shell.
- Geometry of molecules:** The geometry and shapes of overlapping orbitals of atom, decide the geometry of resulting molecule.

10. Stability of bond: There is maximum possible orbital overlap and minimum possible energy of system to form stable covalent bond.

Necessary conditions for bond formation:

1. The two atoms should have one unpaired electron each with opposite spin.
2. When the two atoms approach within internuclear distance, forces of attraction should be greater than forces of repulsion and P.E. should decrease.
3. The atomic orbitals of two atoms containing one unpaired electron each should overlap to maximum possible extent at minimum energy.

Chapter No. – 10

Chemistry of carbon Compounds

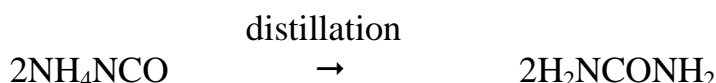
10.1 Introduction

In 18th century organic compounds are obtained from living organisms (Plants and animals). These compounds included sugar, oils, formic acid, lactic acid, ethyl, alcohol, citric acid, etc.

According to **Lavoisier** all compounds derived from living organism have similar elements, i.e. C, H, O. These compounds are called as organic compounds.

Berzleius in 1815 proposed vital force theory. According to this theory organic compounds can not be prepared in laboratory, these are obtained from only living organism due to their magic force.

Vital force theory comes to an end in 1828 when **wholer** prepared first organic compound urea from distillation of ammonium cyanate



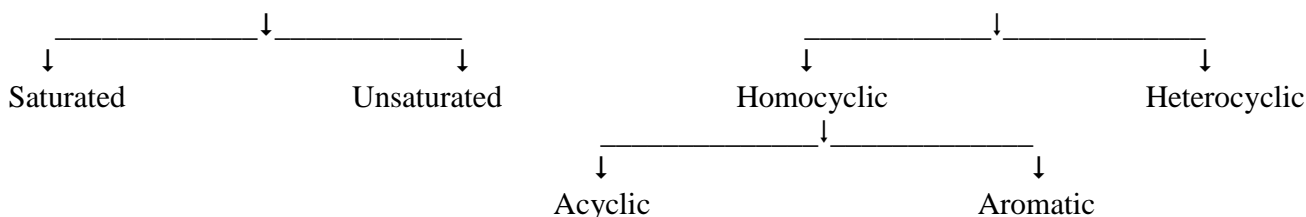
In 1845 **Kolbe** prepared acetic acid from carbon, hydrogen and oxygen and **Hennel** prepared ethyl alcohol from same elements.

It was then concluded that organic compound contain carbon is the main element. Thus now a day organic chemistry is defined as. "It is a branch of chemistry which deals with study of covalently bonded carbon and hydrogen compounds".

10.2 Importance of organic chemistry

Organic compounds play an important role in daily life. The food that we eat is a organic compound, The cloth that we wear all are organic compounds. The following list clearly shows the importance of organic compounds.

1. **Foods:** carbohydrates, Proteins, oils, fats, vitamins, enzymes, etc.
2. **Clothes:** Cotto, wool, silk, nylon, ryon, Dacron etc.
3. **Medicines :** Antibiotics (penicillin, streptomycin, chloromycetin), analgesic (bruffin, aspirin), antipyretic (paracetamol, aspirin) etc,
4. **Fuels:** Wood, petrol, gas (LPG, CNG), coal, etc.
5. **Explosives:** Nitroglycerin, nitrocellulose, 2-4-6 trinitro toluene (TNT), 1-3-5 trinitro benzene (TNB), RDX (research department explosive), etc.
6. **Dyes:** Indigo, cangored, methyl red, phenolphthalein, malachite green etc.
7. **Insecticide:** Dichloro diphenyl trichloro ethane (DDT), difluoro diphenyl trichloro ethane (DDFT), chloropicrin, BHC, malathion, etc.
8. **Common articles:** Soap, perfumes, cosmetics paper, rubber, ink, paints, films, leather, resin (Adhesive) etc.



Organic compounds are mainly divided into two types.

- a) Open chain compounds
- b) Closed chain compounds

10.4 Homologous series

Definition : It is a series of organic compounds having same general formula and functional group but two successive members differ by CH_2 (methylene) group

e.g. i) Homologous series of alkanes, General formula $\text{C}_n\text{H}_{2n+2}$

Methane	CH_4	CH_2
Ethane	C_2H_6	CH_2
Propane	C_3H_8	CH_2
Butane	C_4H_{10}	CH_2
Pentane	C_5H_{12}	CH_2
Hexane	C_6H_{14}	

ii) Homologous series of alcohol. General formula $\text{C}_n\text{H}_{2n+1}\text{OH}$

Methyl alcohol	$\text{CH}_3\text{-OH}$
Ethyl alcohol	$\text{CH}_3\text{-CH}_2\text{-OH}$
n-propyl alcohol	$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-OH}$
n-butyl alcohol	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{-OH}$

Characteristics of homologous series:

1. Molecules in homologous series contain same elements and same functional group.
2. Molecules in homologous have same general formula.
3. These are prepared from similar methods.
4. They have same chemical properties.
5. They have gradual change in physical properties according to their increasing molecular weight.
6. Two successive members differ in their formula by CH_2 group (methylene group) or by atomic mass 14.

10.5 Empirical and molecular formula

Empirical formula

Definition: Empirical formula represents smallest atomic ratio of various atoms present in molecule.

e.g. i) Molecular formula of benzene is C_6H_6

Empirical formula show smallest atomic ratio.

Hence empirical formula of benzene is CH

ii) Molecular formula of glucose is $C_6H_{12}O_6$

Empirical formula is CH_2O

Formula	C	H	O	Smallest ratio	Empirical formula
C_6H_6	6	6	-	1:1	CH
$C_6H_{12}O_6$	6	12	6	1:2:1	CH_2O

Empirical weight: It is the sum of atomic weight of atoms present in empirical formula.

Molecular formula:

Definition: Molecular formula represents actual number of atoms present in one molecule.

e.g. i) Molecular formula of phenol is C_6H_6O

ii) Molecular formula of ethyl alcohol is C_2H_6O

iii) Molecular formula of acetic acid is $C_2H_4O_2$

Molecular weight: It is the sum of atomic weight of atoms present in molecular formula.

Disadvantages of molecular formula: It does not show actual attachments of atoms from one another in a molecule and it does not distinguish isomers.

Structural formula

Definition: It shows the actual attachment of atoms or groups from one another in a molecule. **OR** arrangement of groups of atoms in a space is known as structural formula.

e.g. Molecular formula C_2H_6O has two structures



Chapter No. – 11

Alkanes

11.1 Introduction

Alkanes are simplest compounds made from only carbon and hydrogen. In alkanes carbon atom is attached to another carbon atom by single covalent bond and carbon atom again attached to hydrogen atom by single covalent bond.

Alkanes are chemically inert (less reactive) hence named as **paraffins** (parum-little, affines-affinity). In latin known as parumaffines (little attraction)

Definition : Alkanes are open chain saturated hydrocarbons.

Alkanes have general formula C_nH_{2n+2} where 'n' is the number

First ten members of alkanes,

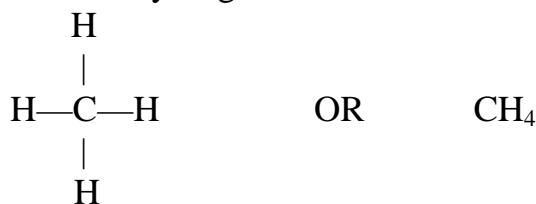
1. CH_4	Methane	6. C_6H_{14}	Hexane
2. C_2H_6	Ethane	7. C_7H_{16}	Heptane
3. C_3H_8	Propane	8. C_8H_{18}	Octane
4. C_4H_{10}	Butane	9. C_9H_{20}	Nonane
5. C_5H_{12}	Pentane	10. $C_{10}H_{22}$	Decane

13/2 Structure of methane (CH_4) and ethane (C_2H_6)

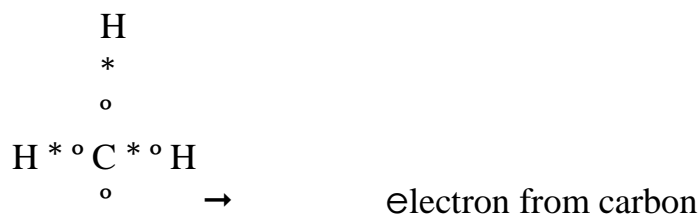
Structure of methane (CH_4)

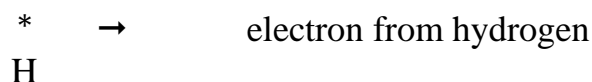
Methane molecule is formed from one carbon atom and four hydrogen atom.

1. In methane central atom is carbon, atomic number six and arrangement of electron in shell is 2,4. Carbon contains four unpaired electrons in outermost orbit hence it is tetravalent. Carbon requires another four electrons to complete its octet.
2. During formation of methane molecule carbon shares four unpaired electrons with electrons of four hydrogen atoms to form carbon hydrogen single covalent bond.



Electron dot structure of methane:



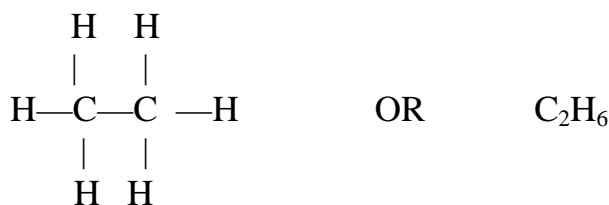


Structure of ethane (C₂H₆)

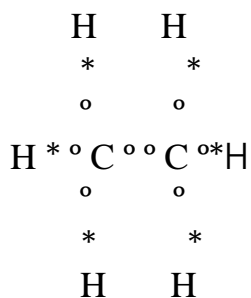
Ethane molecule is formed from two carbon atom and six hydrogen atoms

1. In ethane central atom is carbon, atomic number six and arrangement of electron in shell is 2,4. Carbon contains four unpaired electrons in outermost orbit hence it is tetra valent. Carbon requires another four electrons to complete its octet.
2. During formation of ethane molecule carbon shares one electrons with another carbon atom to form C-C single covalent bond, and remaining electrons of each carbon atoms are shares with electrons of hydrogen atoms to form single covalent bond.

Electron dash structure of ethane :



Electronic or lewis structure of ethane



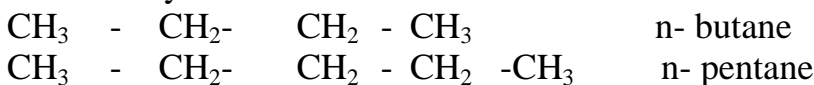
11.2 Classification of alkanes

Alkanes are classified on the basis of arrangement of carbon atoms in their molecule.

These are classified as

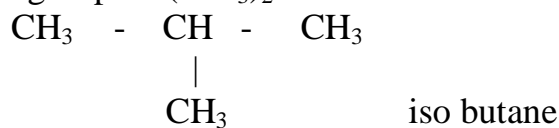
1. Normal alkanes(Straight chain alkanes)
2. Branched alekanes

1. **Normal alkanes:** In shch types of compounds carbon atoms are arranged in straight chain in which no any carbon atom is attached to mere than two carbon atoms. These are indicated by 'n'

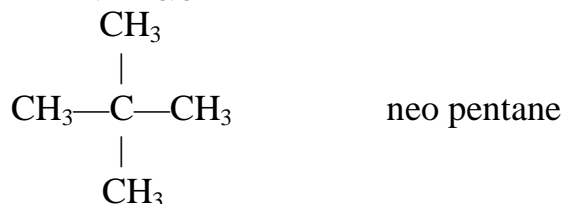


2. **Branched alkanes:** In such types of compounds carbon atoms are arranged in branch, in which atleast one carbon atom is attached to more than two carbon atoms. These are indicated by iso, neo.

Prefix iso is used in that compounds in which last but one carbon atom carries one methyl group i.e. $(\text{CH}_3)_2\text{CH}-$



Prefix neo is used in that compounds in which last but one carbon atom carries two methyl groups i.e. $(\text{CH}_3)_3\text{C}-\text{CH}_2-$



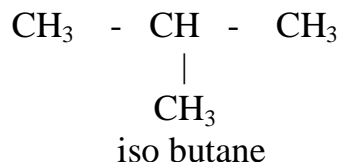
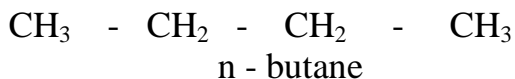
11.3 Isomerism in alkanes

Alkanes shows chain and optical isomerism and higher alkane shows position isomerism, in which position of alkyl group is different in same carbon chain.

Organic compound having same molecular formula but different arrangement of carbon atoms are known as chain isomers and phenomenon is known as chain isomerism.

First three members of alkanes i.e. methane, ethane and propane does not show isomerism. Remaining alkanes shows isomerism.

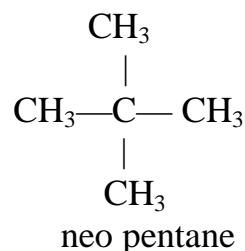
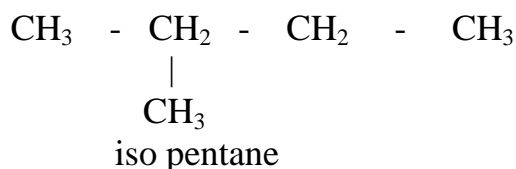
e.g. **1. Isomers of butane (C_4H_{10})**



2. Isomers of pentane (C_5H_{12})



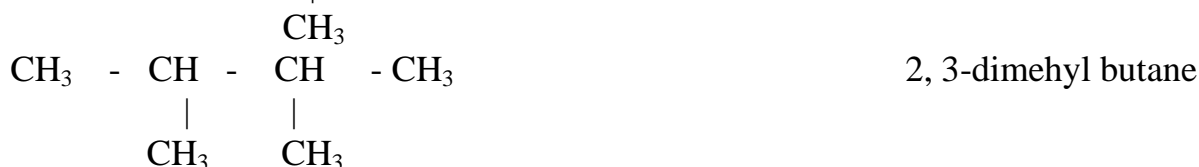
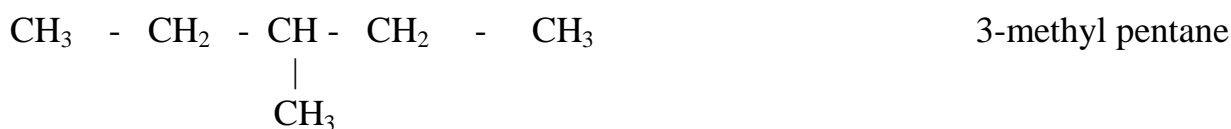
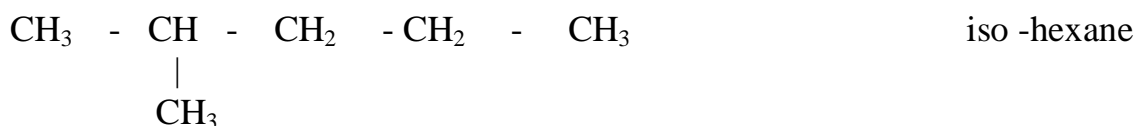
n- pentane



3. Isomers of hexane (C_6H_{14}) it has 5 isomers



n- hexane



3. Isomers of heptane (C₇H₁₆) it has 9 isomers.

- | | |
|---------------------------|------------------------------|
| i) n - heptane | ii) 2-methyl hexane |
| iii) 3-methyl hexane | iv) 2,2-dimethyl pentane |
| v) 3,3-dimethyl pentane | vi) 2,3-dimethyl pentane |
| vii) 2,4-dimethyl pentane | viii) 2,2,3-trimethyl butane |
| ix) 3-ethyl pentane | |

11.4 Nomenclature

1. Common name system-(Trivial name system): First four members of alkanes are named by their source i.e. methane, ethane, Propane and butane.

Remaining members are named by Greek work indicated number of carbon atoms presents in their molecules.

i.e.	pentane	(5 carbon atoms)	octane	(8 carbon atoms)
	hexane	(6 carbon atoms)	nonane	(9 carbon atoms)
	heptane	(7 carbon atoms)	decane	(10 carbon atoms)

2. IUPAC system (international union of pre and applied chemistry)

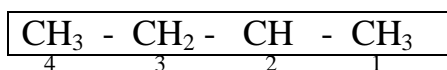
Rule for IUPAC system.

- Longest carbon chain selection:** Select the longest continuous chain of carbon atoms and considered as parent alkane.
- The carbon atoms which are not included in the parent chain are named as substitute or branched chain or side chain.
- If more than one sets of longest chain are present, select longest chain which have maximum side chain.
- Lowest numbering or locant rule:** Numbering as 1, 2, 3,.....,etc. is started from nearest to point of branching and branched carbon atoms is indicated by lowest possible number. The number that indicates the position of side chain is called locant.

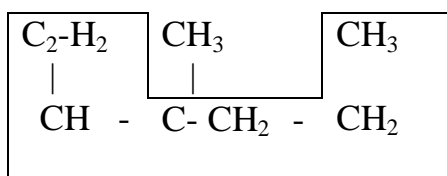
- v) If two different alkyl groups are equidistance from both the side, then numbering is started from that side, the group which comes first in alphabetical order.
- vi) If same side chain or alkyl groups occurs more than once the prefixes di, tri, tetra, penta, etc. are used.
- vii) If two or more different side chain are present in the molecule, they are named in the alphabetical order along with their number.
- viii) **Lowest sum rule:** If more than two side chains are present in the molecule apply lowest sum rule (sum of lacant must be lowest).
- ix) If side chain is complex or branched, it is also numbered by selecting its longest chain. The carbon atom attached to parent chain is numbered one and such group is kept in bracket to avoid confusion.
- x) The final IAPAC name is written by first indicating the position of side chain, then wirting the name of side chain followed by name of parent alkne, The each numbers are separated by cummas and number and alphas are separated by bypen(-). The name of last alkyl group and that of parent chain is written as one word.

The final IUPAC name is,

Number which shows _ Name of the _ Parent
 The position of alkyl group alkyl group hydrocarbon



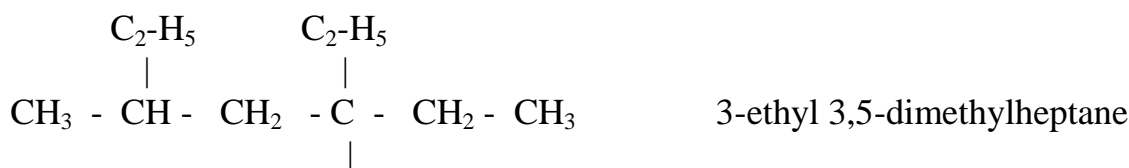
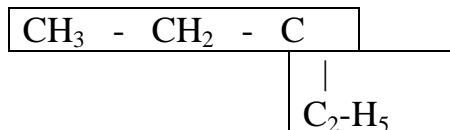
2-methylbutane

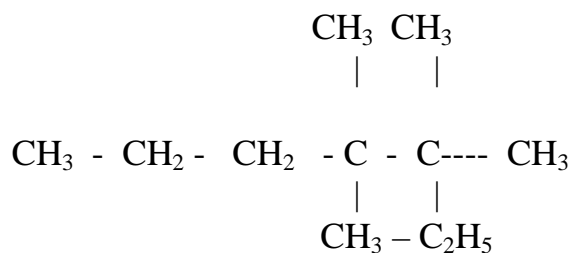
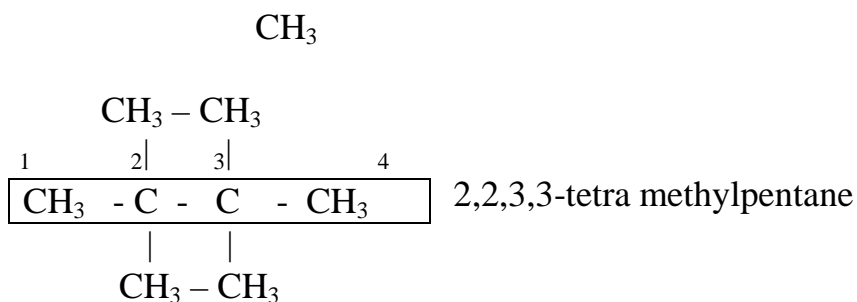


3,4,4-tri methylheptane

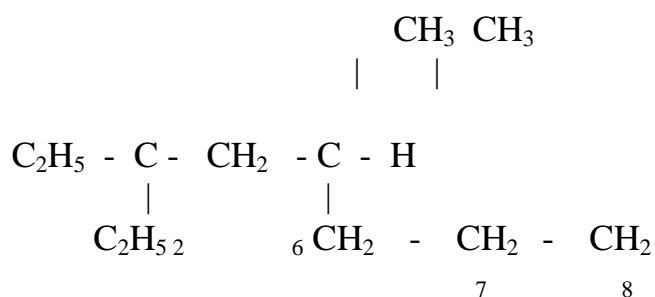


5 4 3 | - CH₂ - CH₃ 3 ethyl 3-methylpentance

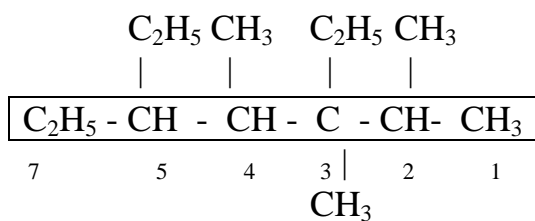
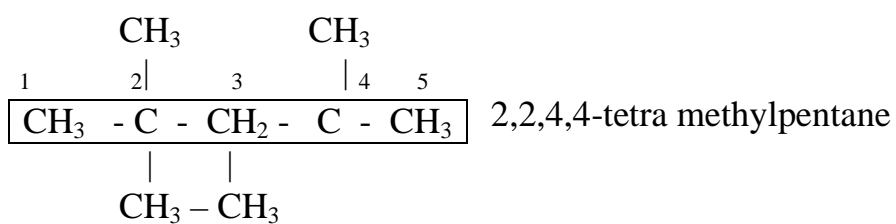




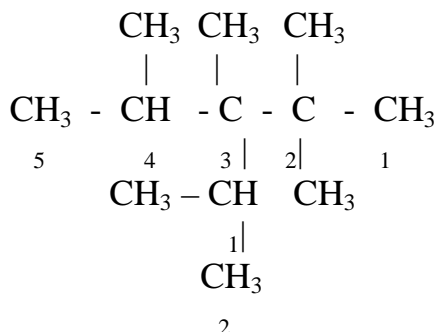
3,3,4,4-tetra methylheptane



3-ethyl 3, 5-dimethyloctane



3, 5 diethyl 2, 3, 4 methylheptane



2,2,3,4- tetramethyl 3-(1-methyl ethyl) pentane

11.5 Physical properties of alkanes

1. First four members of alkanes i.e. methane, ethane, propane and butane are gaseous C_5 to C_{20} are liquids and higher members are solids.
2. Liquid alkanes are lighter than water.
3. Alkanes are nonpolar and insoluble in water and soluble in organic solvent i.e. ether, Benzene, CCl_4 etc.
4. Boiling point of alkanes increases as molecular weight increases branched alkanes have lower boiling point than corresponding normal isomeric alkanes.

11.6 Chemical properties of alkanes

Alkanes undergoes substitution reactions in which hydrogen atoms from alkanes are successively replaced by another groups or atoms.

Easy of substitution of hydrogen atom is $3^{\circ}H > 2^{\circ}H > 1^{\circ}H$.

Types of carbon atoms:

1. Primary carbon atoms (1°): The carbon atom which is attached to another only one Carbon atom or solitary carbon atom.
2. Secondary carbon atoms (2°): The carbon atom which is attached to another two carbon atoms.
3. Tertiary carbon atoms (3°): The carbon atom which attached to another three carbon atoms.
4. Quaternary carbon atoms (4°): The carbon atom which is attached to another four carbon atoms.

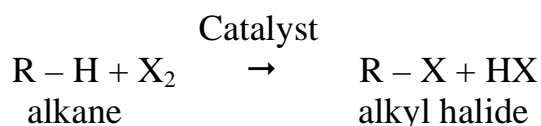
Types of Hydrogen atoms :

1. Primary hydrogen atoms (1°): The hydrogen atoms which are present on primary carbon atoms.
2. Secondary hydrogen atoms (2°): The hydrogen atoms which are present on secondary carbon atoms.

3. Tertiary hydrogen atoms (3^0): The hydrogen atoms which are present on tertiary carbon atoms.

1. Halogenation:

When alkanes are halogenated in the presence of catalyst gives alkyl halides.

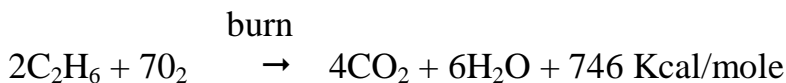
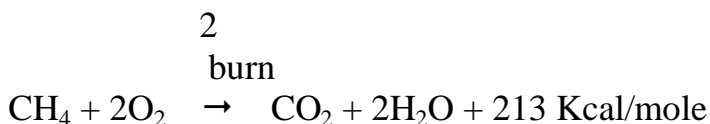
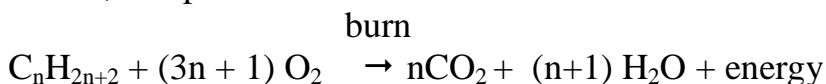


These are substitution reaction in which hydrogen atoms from alkanes are replaced by halogen atoms.

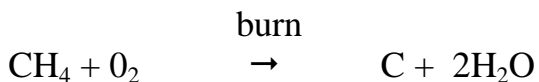
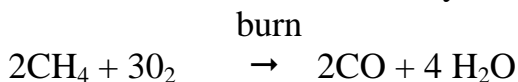
Reactivity halogen is $\text{F}_2 > \text{Cl}_2 > \text{Br}_2 > \text{I}_2$

In substitution reaction ease of replacement of hydrogen is,
 $3^0 > 2^0 > 1^0 \text{H}$.

Monohalogenation of alkane is seldom (rare) used, because several isomeric monosubstituted halides are formed because alkane have different type of hydrogen atoms. Their separation is difficult. Thus, halogenation method is not used unless the alkane contains equivalent hydrogen atoms, good yield are obtained in alkane such as methane, ethane, neo pentane etc.

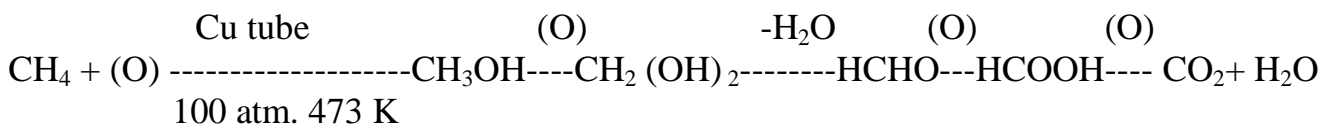


b) Incomplete combustion: When alkanes are burnt in limited supply of oxygen carbon monoxide or carbon black may be formed.



c) Catalytic oxidation (industrial method) : Loweralkanes undergoes oxidation in the presence of copper catalyst at comparatively low temperature and high pressure to form alcohols, aldehydes, ketones, acids, CO₂ and H₂O. In these reactions hydrogen atom changes to OH group successively and the final product is CO₂ and H₂O.

When methane and oxygen mixed in the ratio 9:1 at 473K gives methyl alcohol, formaldehyde, formic acid, CO₂ and H₂O.



11.7 Uses of alkanes

1. Methane in the form of natural gas is used as industrial fuel and illuminants.
2. The mixture of lower alkanes mainly propane, n-butane and iso butane are used as Cooking gas under the name L.P.G.
3. Methane is used for making carbon black, which is used as a black pigment in ink, Polishes, tyres, paints, etc
4. Methane is used to prepare methyl chloride, which is used to prepare industrial Important compound like methyl alcohol, formaldehyde, formic acid, etc.
5. Methane is a source of hydrogen used in preparation of NH₃.
6. Liquid alkanes ranging from C₁₇ to C₂₀ are used as lubricants (oil for machines), Ointments, etc
7. Solid alkanes ranging from C₂₁ to C₄₂ are used to prepare candles, cosmetics, etc.
8. Propane is used as cooling agent in petroleum industry.
9. Mixture of liquid alkane known as petrol (iso-octane) is used fuel for engines.
10. Benzene is the mixture of hexane and heptane used for drycleaning.

Chapter No. 12

Alkenes

12.1 Introduction

Alkenes are aliphatic unsaturated hydrocarbon containing C = C bond. These are represented by general formula C_nH_{2n} .

Alkenes also known as olefins because lower members of alkenes forms oily compounds with Cl_2 Br_2 .

First four members of alkenes series are.

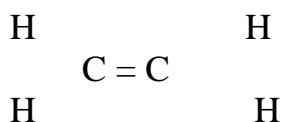
$CH_2 = CH_2$	ethane
$CH_3 - CH = CH_2$	propene
$CH_3 - CH_2 - CH = CH_2$	but - 1 - ene
$CH_3 - CH = CH - CH_3$	but - 2 - ene

12.2 Structure o ethene

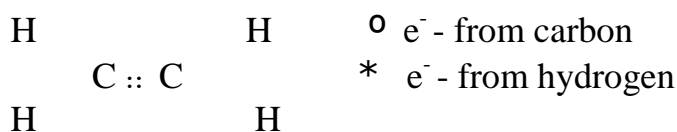
Ethene molecules is formed by two carbon atoms and four hydrogen atoms.

1. In the ethene central atom is carbon, atomic number six and arrangement of electrons in shell is 2,4. Carbon contains four unpaired electrons in outermost orbit hence it is tetra valent. Carbon requires another four electrons to complete its octet.
2. During formation of ethene carbon atom shares two electrons with another carbon atom to form C = C double bond and remaining four electrons shares with electrons of four hydrogen atoms to form four C - H covalent bonds.

Electron dash structure of ethene: It is planer molecule with H-C-H bond angle is 120° . Thus in ethene C = C bond length is 1.34 \AA and C - H bond length is 1.08 \AA



Electron dot structure of ethane:



12.3 Isomerism in alkenes

Alkenes shows both types of isomerism i.e. structural isomerism and stereo isomerism.

1. Structural isomerism:

Compounds have same molecular formula but different structural formula are known as structural isomers and phenomenon is known as structural isomerism.

a) Chain or nuclear or skeletal isomerism: It is shown by the compounds which differ in the arrangement of carbon atoms.

e.g. $\text{CH}_3 - \text{CH}_2 = \text{CH} - \text{CH}_2$ α - butylenes



b) Position isomerism: It is shown by the compounds which have different position of C = C bonds in same carbon chain.

e.g. $\text{CH}_3 - \text{CH}_2 - \text{CH} = \text{CH}_2$ but - 1 - ene
 $\text{CH}_3 - \text{CH} = \text{CH} - \text{CH}_3$ but - 2 - ene

2. Geometrical isomerism:

The isomer having same molecular formula and structural formula but different in spatial arrangement of the groups or atoms across the double bond.

It is shown by the alkenes of the type $\text{RCH}=\text{CHR}$, $\text{RR}'\text{C}=\text{CRR}'$, $\text{R}'\text{R}''\text{C}=\text{CR}''\text{R}'''$
 e.g. 2 - butane shows cis trans isomerism.

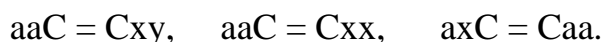
When similar groups or atoms are at the same side of the double bond is known as cis isomer.

When similar groups of atoms are at the opposite side of the double bond is known as trans isomer.

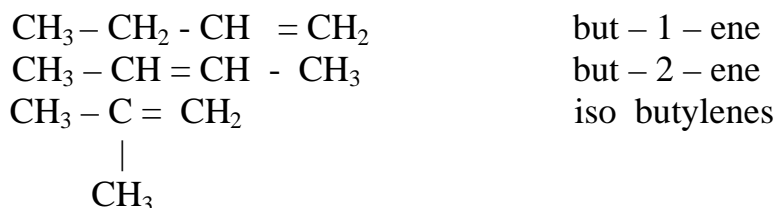


Trans form is stable than cis form, this is because the bulky groups are on the opposite side of the double bond. The steric repulsion of the alkyl groups present at same side makes cis isomer less stable.

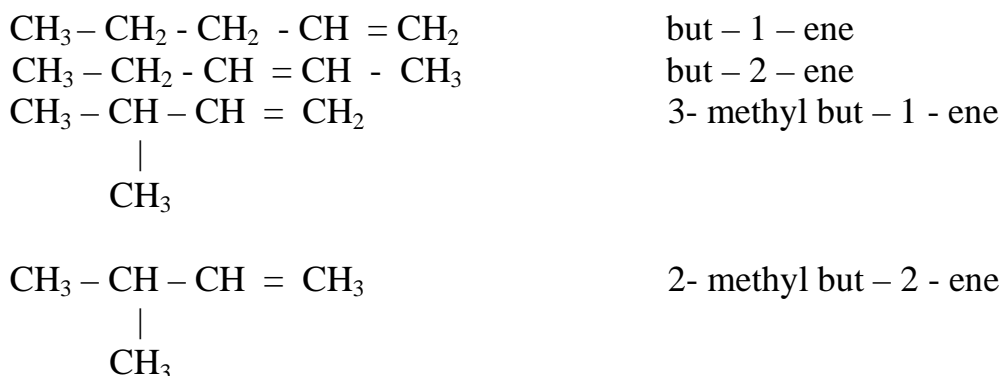
Remember that geometrical isomer is possible when each of the doubly bonded carbon atoms have two different groups of atoms. Thus compound of the following type does not show geometrical isomerism.



e.g. i) Isomers of C_4H_8 . It has three isomers.

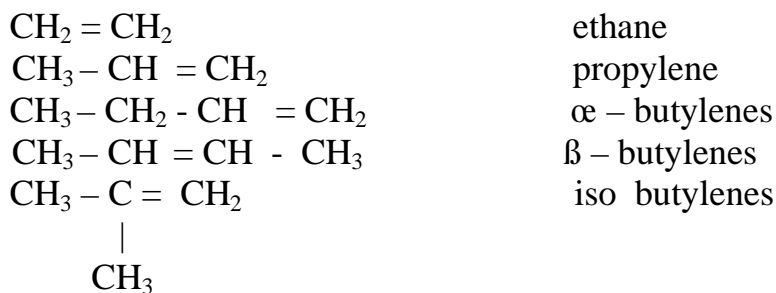
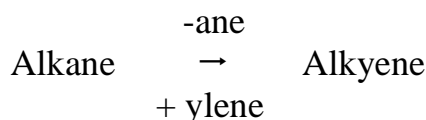


iii) Isomers of C_5H_{10} . It has four isomers.

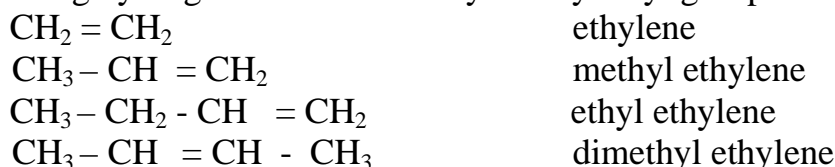


12.4 Nomenclature of alkenes

1. Common names: According to common name system alkenes are named as alkylene. In these suffix 'ane' of the corresponding alkenes is replaced by 'ylene'.



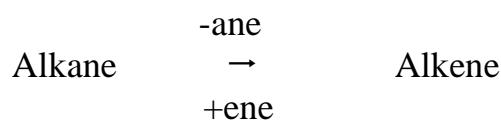
2. Derived names: Higher alkenes are considered as derivatives of ethylene obtained by replacing hydrogen atoms from ethylene by alkyl groups.



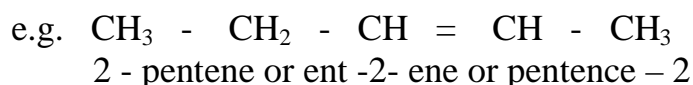
3. IUPAS names:

i) **Longest carbon chain selection:** Select the longest continuous chain of carbon atoms containing $\text{C} = \text{C}$ bond and considered as parent alkanes.

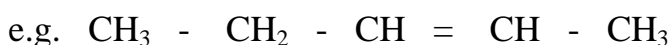
- ii) The carbon atoms which are not included in the parent chain are named as substituent or branched chain or side chain.
- iii) If more than one set of longest chain are present, select longest chain which has maximum side chain.
- iv) **Lowest numbering or locant rule:** Numbering as 1,2,3,..... etc. is started from nearest to double bonded carbon atom and one of the double bonded carbon atom indicated by lowest possible number. Next preference will be given to side chain. The number that indicates the position of double bond and side chain are called locants.
- v) If two different alkyl groups are equidistant from the C=C bond, then numbering is started from that side, the group which comes first in alphabetical order.
- vii) If two or more different side chains are present in the molecule, they are named in the alphabetical order along with their number.
- viii) **Lowest sum rule:** If more than two alkyl groups are present at either side of double bonded carbon atoms. The sum of their numbers must be lowest.
- ix) Suffix 'ane' of the corresponding alkane is replaced by 'ene'



- x) The position of double bond may be indicated by any of the three ways,

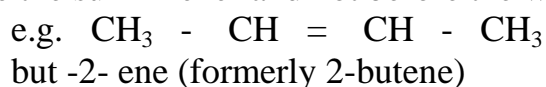


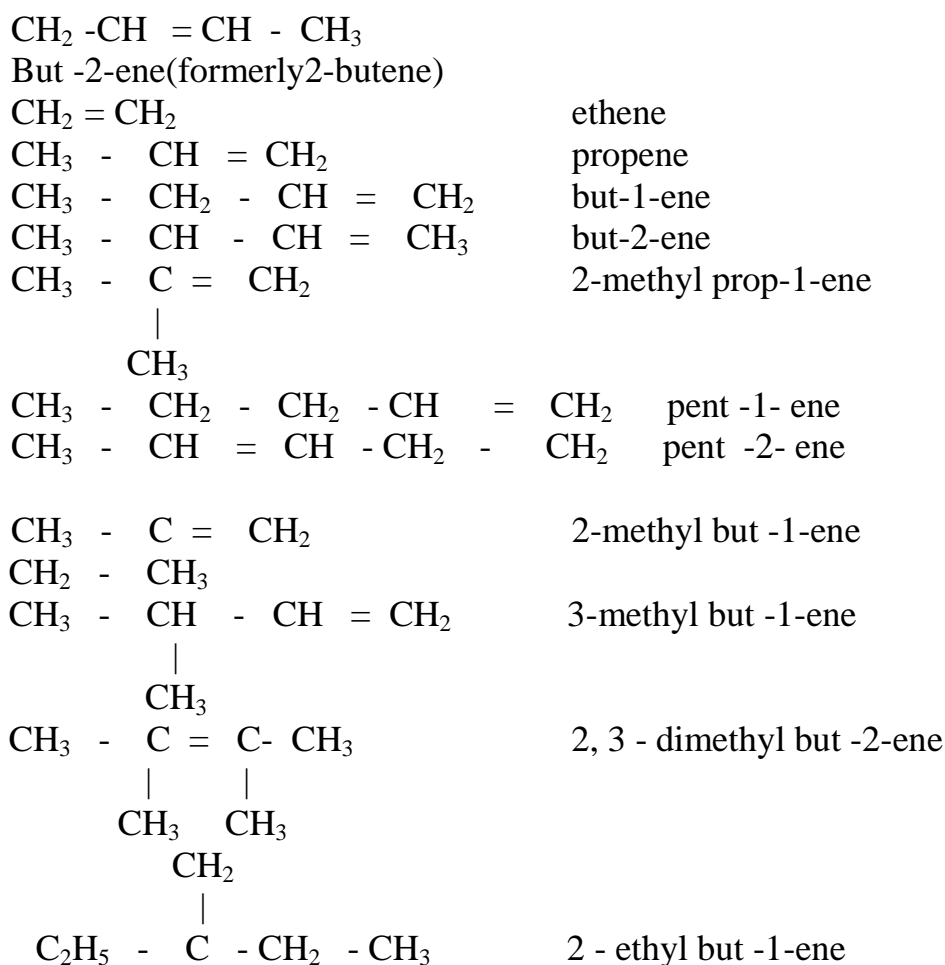
Generally the first two methods are used. However according to the latest IUPAC rules (1993 recommendation), while naming the organic compounds, the locants (numerical or letters) are placed immediately before the part of the name to which they relate. That means that in case of alkenes the locant of double bond is placed immediately before the suffix 'ene' and not before the word root.



2 - pentene or pent-2-ene or pent-2-ene

Generally the first two methods are used. However according to the latest IUPAC rules (1993 recommendation), while naming the organic compounds, the locants (numerical or letters) are placed immediately before the part of the name to which they relate. That means that in case of alkenes the locant of double bond is placed immediately before the suffix 'ene' and not before the word root.

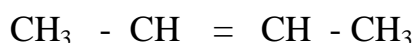
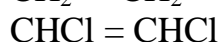
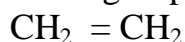




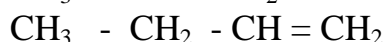
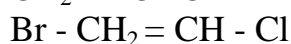
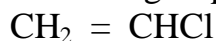
12.5 Classification of alkenes

These are classified as,

- 1. Symmetrical alkenes:** In these alkenes both double bond forming carbon atoms carries same groups of atoms.



- 2. Unsymmetrical alkenes:** In these alkenes both double bond forming carbon carries different groups or atoms.



14.7 Physical properties

- Ethene, propene and butene are gaseous, C_5 to C_{17} are liquid and higher members are solids.
- Alkenes are insoluble in water and soluble in organic solvent i.e. ethers, alcohols

benzene etc.

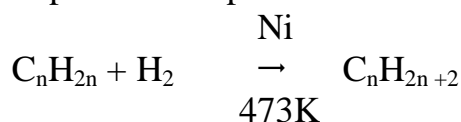
3. Boiling point and melting point increases as molecular weight increases.
4. Branched alkenes have lower boiling point and melting point than corresponding normal isomeric alkenes.

12.6 Chemical properties

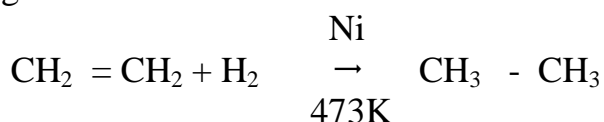
Alkenes are found formed by carbon and hydrogen and contains C=C bond. Double bond in alkene is formed by one sigma bond and one π - bond. The π bonded electrons are held loosely hence π bond is weaker than σ - bond.

Hence alkene undergoes addition reaction because of availability of π - bonded electrons. In addition reaction of alkenes, saturated compounds are formed.

1. Catalytic hydrogenation: Alkenes are reduced by passing H_2 gas in the presence of nickel or platinum or palladium or raney nickel as catalyst at 473K 573K gives alkenes.



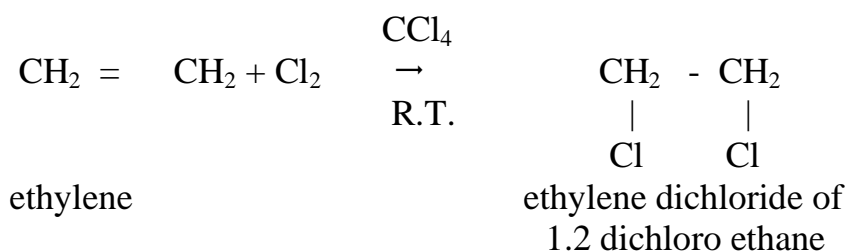
e.g. i) When ethane is reduced by passing H_2 gas in the pressure of nickel at 200° to 300° gives ethane.



2. Reaction with halogens or halogenations (X_2 - Cl_2 , Br_2 only): Alkenes are reacted with halogens in the presence of CCl_4 at room temperature gives dihalo compounds.

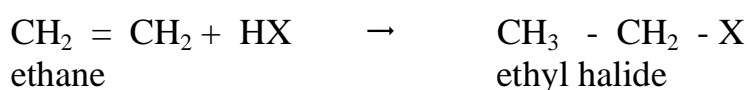
Reactivity of halogens $F_2 > Cl_2 > Br_2 > I_2$

e.g. i) Ethylene is reacted with chlorine in the presence of CCl_4 at room temperature gives ethylene dichloride (1.2 dichloro ethane)



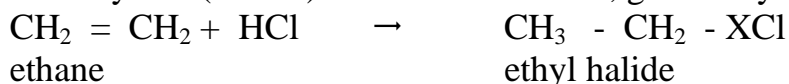
3. Hydrohalogenation or addition of HX (HCl, HBr, HI) :

a) When haloacids (HCl, HBr, HI) are reacted with ethane, gives ethyl halide.

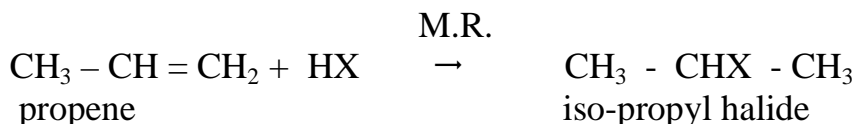


The order of reactivity of HX is $\text{HI} > \text{HBr} > \text{HCl} > \text{HF}$

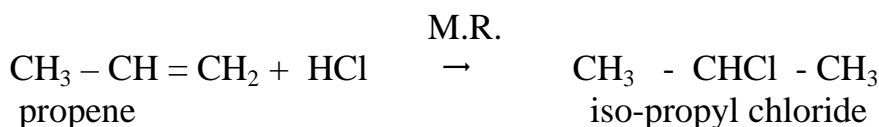
e.g. When ethylene (ethane) is reacted with HCl, gives ethyl chloride.



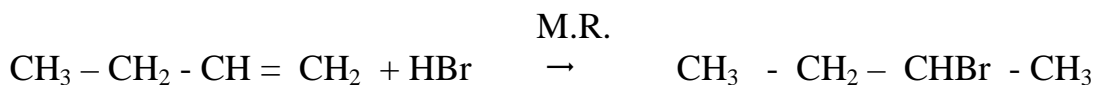
b) When haloacids are reacted with propene (propylene), gives isopropyl halide. Addition takes place by M.R. (Markownikoffs rule) It is state that "When unsymmetrical unsaturated compounds are reacted with unsymmetrical reagent, then negative part of the adding agent (addendum) goes to that carbon atom, having less number of hydrogen atoms."



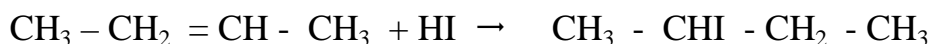
e.g. When propene is reacted with HCl, gives iso - propyl chloride.



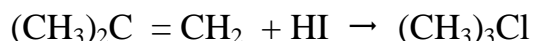
c) When 1 - butane is reacted with HI, gives sec-butyl iodide.



d) When 2 - butane is reacted with HI, gives sec-butyl iodide.



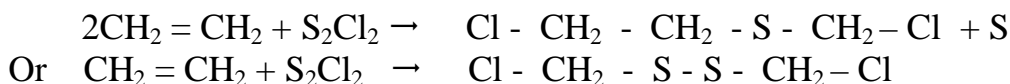
e) When iso - butylene is reacted with HI, gives t- butyl iodide.



12.7 Use alkene

1. Ethene and propene are used in manufacture of polyethene and polypropene, which are used for making plastic bag, electrical cable etc.
2. Ethylene is used as anaesthetic agent in surgery.
3. Ethene is used for making oxy ethylene flame, which is used for cutting and welding metals.
4. Ethene is used for ripening of green fruits i.e. banana, apple etc.
5. Ethylene is used as starting material for the preparation of various organic compounds such as alcohol, alkyl halides, dioxan, etc.
6. Ethylene is used in the preparation of ethylene glycol, which is used as antifreeze reagent in automobiles.

7. Ethylene is used to prepared Mustered gas. Which is used in first world war..



8. Butenes are used to prepare high octane fuels for cars and aeroplanes.

Chapter No. 13

Alkynes

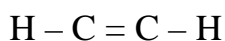
13.1 Introduction

Alkynes are aliphatic unsaturated hydrocarbon containing carbon-carbon triple bond (C≡C). Alkynes are represented by general formula $\text{C}_n\text{H}_{2n-2}$

15.2 Molecular formula of acetylene is C_2H_2

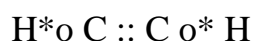
1. In acetylene central atom is carbon is carbon atomic number six and arrangement of electrons in shell is 2,4 containing four unpaired electrons in outmost orbit. Each carbon atom requires another four electrons to complete their octet.
2. Carbon shares three unpaired electrons with another carbon atom to form C = C bond. Remaining electron of each carbon atom shares with electron of hydrogen atom to form C – H single covalent bond.

Electron dash structure of acetylene:



It is planer molecule hence H – C – H bond angle is 180° . The C = C bond length is 120 \AA and C = H bond length is 1.10 \AA .

Electron dot structure of acetylene



13.2 Nomenclature

1. Common names: According to common name system only one compound is known by their common name i.e. acetylene.

$\text{CH} = \text{CH}$	acetylene
$\text{CH} = \text{C} - \text{CH}_3$	allylene
$\text{CH}_3 - \text{C} = \text{C} - \text{CH}_3$	crotonylene
$\text{C}_2\text{H}_5 - \text{C} = \text{CH}$	crotonylene

2. Derived system: According to derived system alkynes are named as derivatives of acetylene.

$\text{CH} = \text{C} - \text{CH}_3$	methyl acetylene
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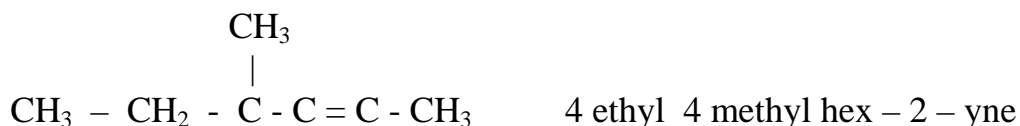
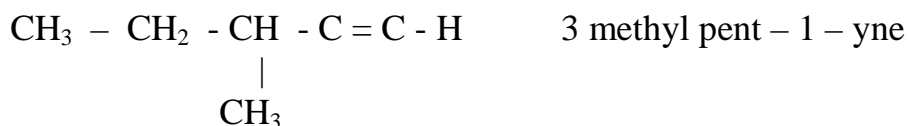
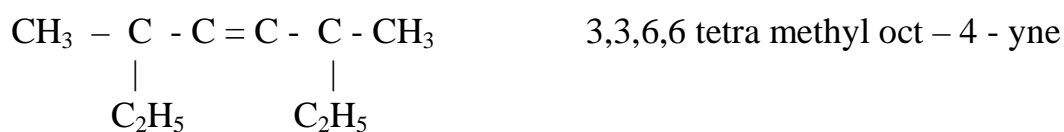
$\text{CH}_3 - \text{C} = \text{C} - \text{CH}_3$	dimethyl acetylene
$\text{C}_2\text{H}_5 - \text{C} = \text{CH}$	ethyl acetylene
$\text{C}_2\text{H}_5 - \text{C} = \text{C} - \text{CH}_3$	ethyl methyl acetylene
$\text{C}_2\text{H}_5 - \text{C} = \text{C} - \text{C}_2\text{H}_5$	diethyl acetylene
$(\text{CH}_3)_2\text{CH} - \text{C} = \text{C} - \text{C}_2\text{H}_5$	ethyl isopropyl acetylene
$\text{CH}_3 - \text{C} = \text{C} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3$	methyl n-propyl acetylene

3. IUPAS names:

- Longest chain selection:** Select longest chain of carbon atom containing $\text{C} = \text{C}$ bond considered as parent alkane.
- Numbering as 1,2,3,....., etc. is started from nearest to triple bonded carbon atoms and it is indicated by lowest possible number. Next preference will given to side chain.
- Other rules for naming alkynes are same are those of alkenes.
- Suffix 'ane' of the corresponding alkane is replaced by 'yne'

Alkane $\xrightarrow[\text{+yne}]{\text{-ane}}$ Alkyne

$\text{CH} = \text{CH}$	ethyne
$\text{CH}_3 - \text{C} = \text{CH}$	prop - 1 - yne
$\text{C}_2\text{H}_5 - \text{C} = \text{CH}$	but - 1 - yne
$\text{CH}_3 - \text{C} = \text{C} - \text{CH}_3$	but - 2 - yne
$\text{CH}_3 - \text{C} = \text{C} - \text{C}_2\text{H}_5$	pent - 2 - yne
$\text{C}_2\text{H}_5 - \text{C} = \text{C} - \text{C}_2\text{H}_5$	hex - 3 - yne
$\text{CH}_3 - \text{C} = \text{C} - \text{CH}_2 - \text{CH}_3 - \text{CH}_3$	hex - 2 - yne





13.3 Physical properties of alkynes

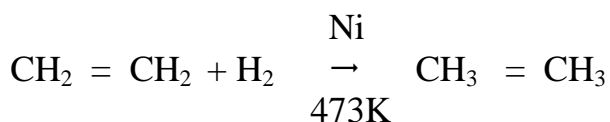
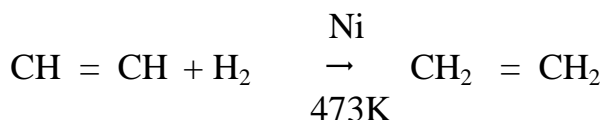
1. First three members of alkynes are gaseous, C₅ to C₁₇ are liquids and higher members are solids.
2. These are colourless and odourless compounds except acetylene has garlic smell.
3. These are insoluble in water and soluble in organic solvent.
i.e. alcohols, benzene, ether, carbon tetra chloride etc.
Their solubility decreases as molecules weight increases.
4. Boiling point and melting point of alkynes are gradually increases as molecular weight increases.
5. Branched alkynes have lower boiling point and melting point than corresponding normal alkynes.

13.4 Chemical properties of acetylene and propyne

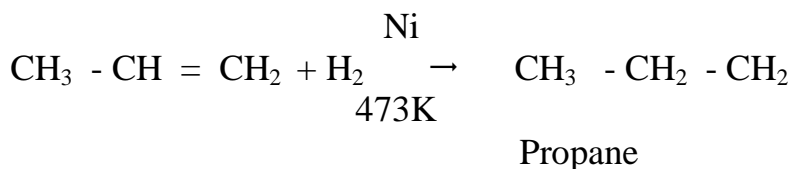
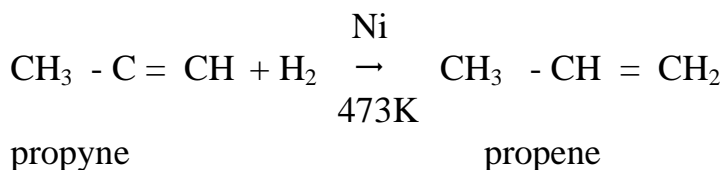
Alkynes undergoes addition reactions. However in alkynes the addition reaction occurs in two steps, because C = C is formed by two π bonds and one σ bond.

1. Catalytic hydrogenation:

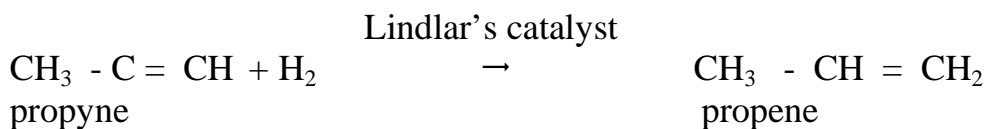
e.g. i) When acetylene is reduced by passing hydrogen gas in the presence on nickel or platinum or palladium catalyst at 473K to 573K first gives ethane and then ethane.



ii)



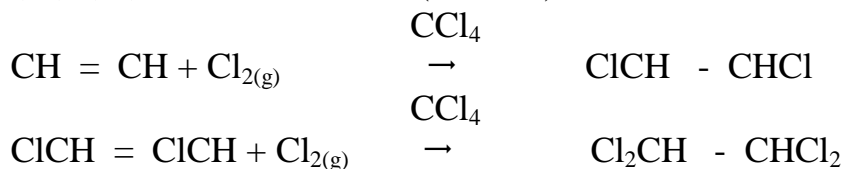
Note : The reduction can be stopped at first stage by using Pd – BaSO₄ and quinoline catalyst (Lindlar's catalyst)



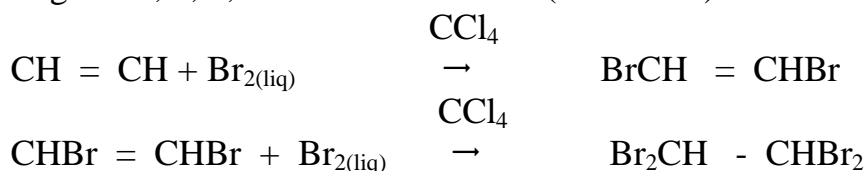
2. Reaction with halogens or halogenation ($\text{X}_2 - \text{Cl}_2, \text{Br}_2, \text{I}_2$)

a) Reaction with acetylene:

e.g. i) When acetylene is reacted with chlorine gas in the presence of carbon tetrachloride first gives 1,2 dichloro ethane (trans). Which is then reacted with chlorine gas gives 1, 1, 2, 2, tetrachloro ethane (westron).

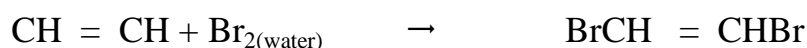


ii) When acetylene is reacted with bromine liquid (red colour) in the presence of carbon tetrachloride first gives 1, 2 dibromo ethane (trans). Which is then reacted with bromine liquid gives 1, 1, 2, 2 tetrabromo ethane (colourless).

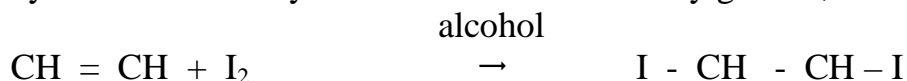


In this reaction red colour or bromine get discharged indicates that the presence of $\text{C} = \text{C}$ bond (unsaturation).

iii) When acetylene is reacted with bromine in water only gives 1, 2 diiodo ethene.

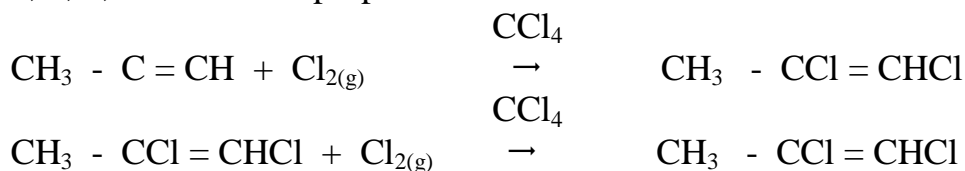


iv) Acetylene reacts slowly with iodine in alcohol only gives 1,2 diiodo ethane.



b) Reaction with propyne:

e.g. When propyne is reacted with chlorine gas in the presence of carbon tetrachloride first gives 1, 2 dichloro propene. Which is then reacted with chlorine gas gives 1, 1, 2, 2 tetrachloro propane.



3. Hydrohalogenation OR reaction with HX ($\text{HCl}, \text{HBr}, \text{HI}$):

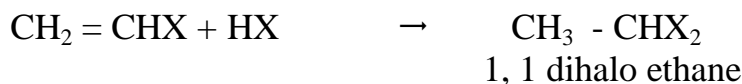
a) Reaction with acetylene: When acetylene is reacted with HX first gives viny halide.

Which is then reacted with HX gives dihalo ethane.

Reactivity of HX is $\text{HI} > \text{HBr} > \text{HCl} < \text{HF}$



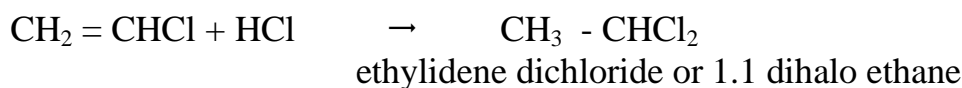
M.R.



e.g. i) When acetylene is reacted with HCl first gives vinyl chloride. Which is then reacted with HCl gives ethylidene dichloride.



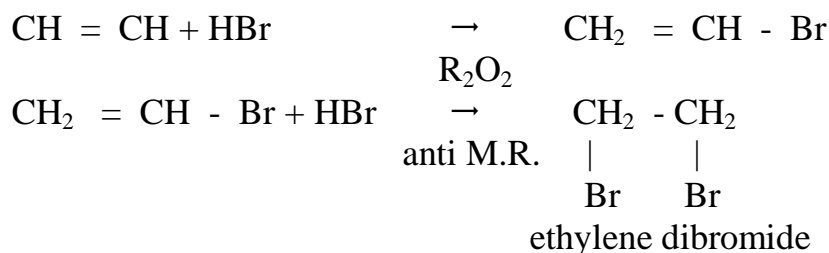
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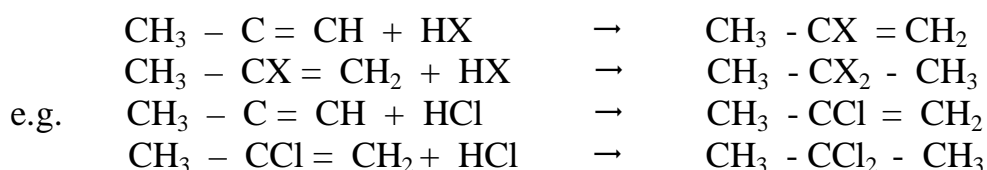
When acetylene is reacted with HCl in the presence of mercuric chloride (HgCl_2) catalyst only one molecule of HCl is added to give vinyl chloride.



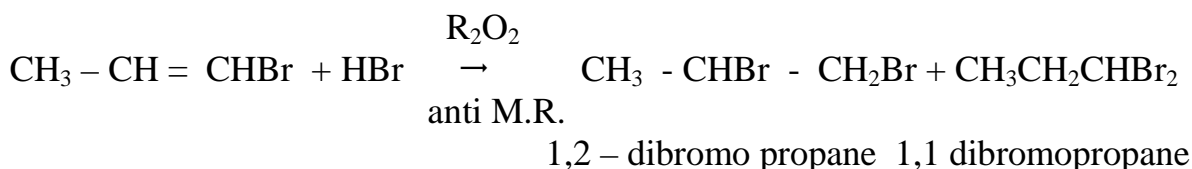
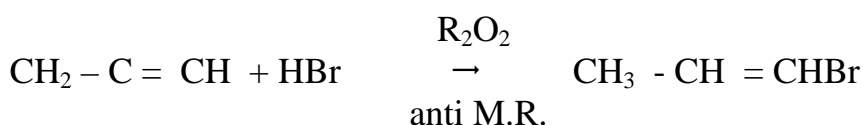
However, when acetylene is reacted with only HBr in the presence of R_2O_2 first gives vinyl bromide, which is then reacted with another molecules of HBr gives 1, 2 dibromo ethane or ethylene dibromide. This addition takes place by anti Markownikoff's rule.



b) Reaction with propyne: When propyne is reacted with HX first gives 2 – halo propene. Which is then reacted with HX gives 2, 2 – dihalo propane.

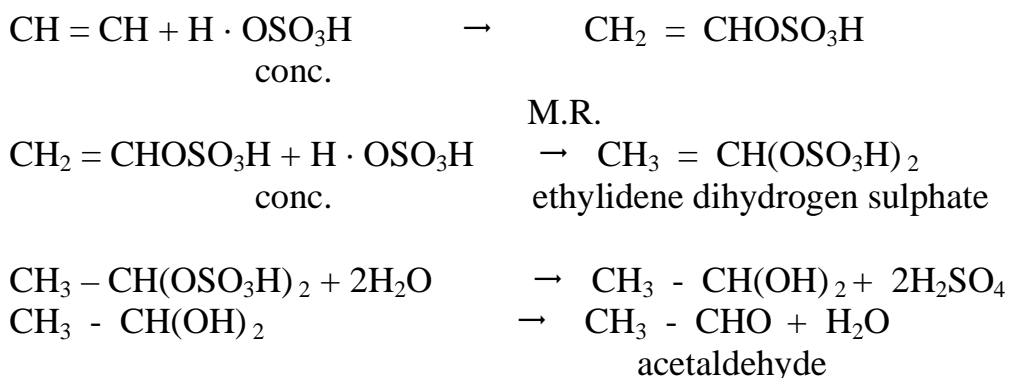


When propyne is reacted with HBr in the presence of peroxide gives 1 – bromopropene. Which is then treated with another molecule of HBr in the presence of peroxide gives 1, 2 dibromo propane and 1,1 dibromopropane.

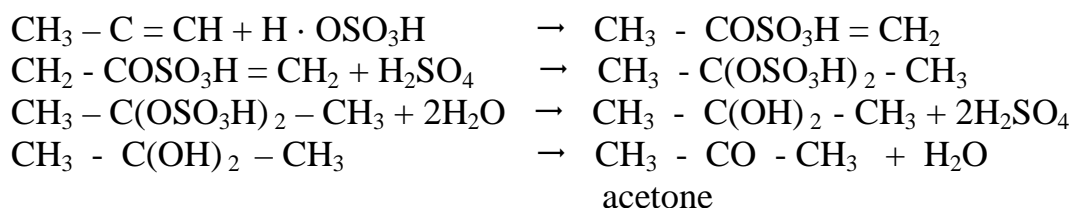


4. Addition of concentrated H₂SO₄

a) Reaction with acetylene: When acetylene is reacted with concentrated H₂SO₄ give vinyl hydrogen sulphate. Which is then reacts with another molecule of H₂SO₄ gives ethylidene dihydrogen sulphate. Ethylidene dihydrogen sulphate on hydrolysis gives 1,1 – dihydroxy ethane, which loses water molecule gives acetaldehyde.

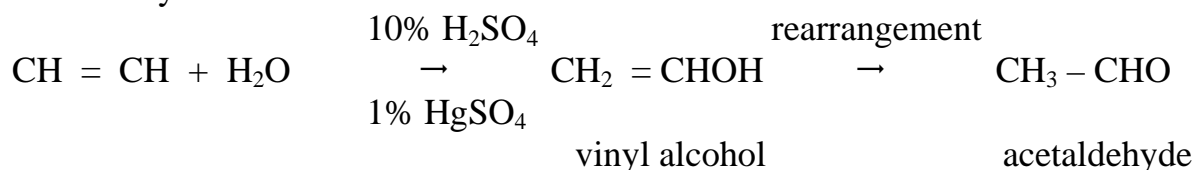


b) Reaction with propyne : When propyne is reacted with concentrated H₂SO₄ gives propene hydrogen sulphate. Which is then reacts with another molecules of H₂SO₄ gives iso-propylidene dihydrogen sulphate. Iso-propylidene dihydrogen sulphate on hydrolysis gives 2, 2 dihydroxy propene, which loses water molecule gives acetone.

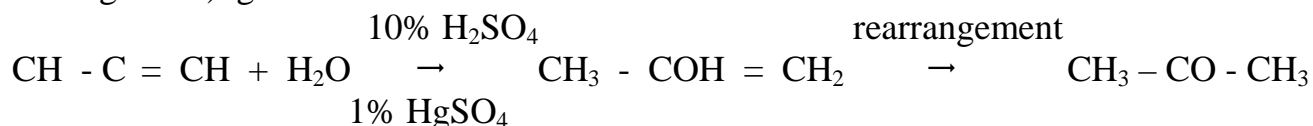


5. Addition of water (hydration)

a) Reaction with acetylene: When acetylene is passed into hot water containing 10% H_2SO_4 and 1% HgSO_4 gives vinyl alcohol. Which isomerise (rearrangement) gives acetaldehyde.



b) Reaction with propyne: When propyne is passed into hot water containing 10% H_2SO_4 and 1% HgSO_4 gives 2-hydroxyl propene (enolic). Which tautomerise (rearrangement) gives acetone.



13.5 Use of acetylene

1. It is used to prepare plastic i.e. polyacetylene.
2. It is used for making oxyacetylene flame which is used for cutting and welding metals.
3. It is used for ripening of green fruits i.e. apple, mango, etc.
4. It is used for preparation of solvent like acetylene tetrachloride (Westron). Which is non inflammable good solvent for oils, fats, resin, etc.
5. It is used for to prepare various organic compound such as acetaldehyde.
6. It is used as illuminant.
7. It is used to prepare Westrosol.
8. It is used to prepare lamp black, which is used to making paints.
9. It is used to prepare anaesthetic agent under the name narcylene

Chapter No. – 14

Aromatic Compounds

14.1 Introduction

Aromatic compound is the name first applied for those organic compounds which are obtained from natural source and have strong specific odour.

Benzene is the simplest and first aromatic compound, first isolated by Faraday in 1825 by fractional distillation of coaltar. Thus aromatic chemistry is the chemistry of benzene and its derivatives.

Benzene nucleus is formed by joining six carbon atoms in ring containing alternate double bond and each carbon atom is attached to one hydrogen atom.

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		Cl	NO ₂	SO ₃ H	CHO	COOH
benzene	naphthalene	chloro benzene	nitro benzene	benzene sulphonic acid	benzaldehyde	benzoic acid

Kekule structural of benzene:

1. Molecular formula of benzene is C₆H₆
2. In 1865 Kekule proposed the hexagonal structure of benzene in which each corner of Hexagon contains carbon atoms and each carbon atoms are attached to one hydrogen at atom.

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3. Then he put three alternate double bonds in order to satisfy the tetra valency of carbon atoms.

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He observe that bond length of every C-C in benzene is 1.39 \AA is intermediate between C-C single bond length 1.54 \AA and C=C bond length 1.33 \AA . Which means that it is lower than C-C single bond and higher than C=C bond.

Hence he concluded that double bonds in structure (i) were not fixed position. But they changing rapidly between another two carbon atoms. Hence he draw another structure of benzene.

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4. In structure (i) and (ii) double bonds changing rapidly between another two carbon atoms. Hence structure (i) and (ii) are named as **resonating or canonical structures** Of benzene (the structure will have same arrangement of atoms but differ electronic arrangement). Infact the benzene molecule exist as a mixture of these two structures which exit in a dynamic equilibrium with each other.

5. So according to resonance theory benzene is believed to be resonance hybrid of Structure I and II.

Hence he draw another structure of benzene, just putting circle in hexagon and named as resonance hybrid structure of benzene.

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16.2 Characteristics of aromatic compounds

1. These are cyclic compounds.
2. Thy have strong specific odour.
3. They burned with sooty flame because these contains high percentage of carbon and low percentage of hydrogen.
4. They prefer substitution reaction in which hydrogen atoms from benzene nucleus are replaced by another groups or atoms.
5. They resist (oppose) addition reaction. Hence they behave as saturated compounds.
6. These are stable towards normal oxidizing and reducing agents.

14.2 Difference between aliphatic compounds and aromatic compounds

1. Aliphatic compounds are open chain compounds.
Aromatic compounds are closed chain compounds.
2. Aliphatic compounds does not burn with sooty flame.
Aromatic compounds are burned with sooty flame.
3. Some aliphatic compounds are odourless.
All aromatic compounds have strong odour.
4. Aliphatic saturated compounds undergoes substitution reaction, but aliphatic unsaturated compounds undergoes substitution as well as addition reaction.

aromatic compounds undergoes substitution as well as addition reaction, but they prefer substitution reaction.

5. Aliphatic hydroxy compounds are alcohols (neutral).
Aromatic hydroxyl compounds are alcohols or phenols (acidic).
6. Aliphatic halogenated compounds are more reactive.
Aromatic halogenated compounds are less reactive.
7. Aliphatic amines are more basic.
Aromatic amines are less basic.
8. Aliphatic amines reacts with nitrous acid gives alcohols, ethers.
Aromatic amines reacts with N_2O + HCL gives benzene diazonium chloride.
9. Aliphatic compounds does not give Friedel Craft reaction.
Aromatic compounds give Friedel Craft reaction.
10. Aliphatic compounds are less stable and can be attacked by acids, alkalies, oxidizing agents etc.
Aromatic compounds are highly stable do not attacked easily by acids, alkalies, oxidizing agents, etc.
11. Aliphatic saturated compounds are less easily reduced, but aliphatic unsaturated compounds are easily reduced. Aromatic compounds are easily reduced.

14.3 Electron dash structure of benzene

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Electron dot structure of benzene

Reaction page no.390 (Chemistry XI) Nikita Puplication Latur

14.4 Physical properties of aromatic compounds

1. They posses strong odour.
2. They burn with sooty flame.
3. These are insoluble in water and soluble in organic solvent i.e. ethers, alcohols, CCl_4 etc
4. Solubility of aromatic compounds decreases as molecular weight increases.
5. Boiling point and milting point increases as molecular weight increases.
Benzene has M.P. 278.4K and B.P. 353K

Various position in substituted benzene:

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14.5 Chemical properties of benzene

Benzene oppose addition reaction and prefer substitution reactions.

I) Addition reactions:

Benzene is quite stable. But it undergo some addition reaction under drastic condition (high temperature and pressure).

1. **Addition of chlorine :** When benzene is reacted with chlorine in the presence of diffused sun light or ultra violet light gives benzene hexachloride (BHC) or gammahexane (lindane or 666). Which is used as insecticide.

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2. **Addition hydrogen:** When benzene is reduced by passing H_2 gas in the presence of nickel at 473 K gives cyclo hexane.

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3. **Ozonolysis:** When benzene is reacted with ozone in the presence of CCl_4 gives Benzene triozone followed by hydrolysis in the presence of zinc dust gives glyoxal.

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II) Substitution reactions

Benzene prefer substitution reaction in which hydrogen atoms from benzene nucleus are replaced by another groups or atoms.

1. **Halogenation:** The reaction in which hydrogen atoms from benzene nucleus are replaced by halogen atoms.

- a) **Chlorination:**

- i) When benzene is reacted with chlorine in dark in the presence of Lewis acid i.e. $FeCl_3$ or $FeBr_3$ or AlX_3 or red P and I_2 at 320 K in dark gives chlorobenzene. The function of Lewis acid is to carry the halogen to aromatic ring. Therefore they are known as halogen carrier.

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- ii) If catalytic chlorination is continuous at slightly high temperature gives mixture of ortho dichloro benzene and paradichloro benzene.

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