CHEMISTRY

AARYAN GURUKUL
HIGHER SECONDARY SCHOOL

STUDY MATERIAL
FOR FOUNDATION COURSE – 2020

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CHEMISTRY MATERIAL

Chemistry – A branch of Science:

Science : ***Science may be defined as the classified knowledge of facts gained through observation, generalization and correlation.***

Chemistry- ***Chemistry is a branch of science which deals with the study of the composition of matter and the chemical changes involved in it.*** In other words chemistry is the science of **matter** and its transformation.

R.M. : A French chemist ***Lavoisier*** is regarded as the father of Modern chemistry.

Branches of Chemistry :

1. Organic Chemistry

It deals with the study of the carbon compounds derived from animal and plant kingdom.

2. Inorganic chemistry

It deals with the study of all the elements and their compounds. It does not include the covalently bonded compounds of carbon.

3. Physical chemistry

It deals with the fundamental principles underlying various chemical phenomena.

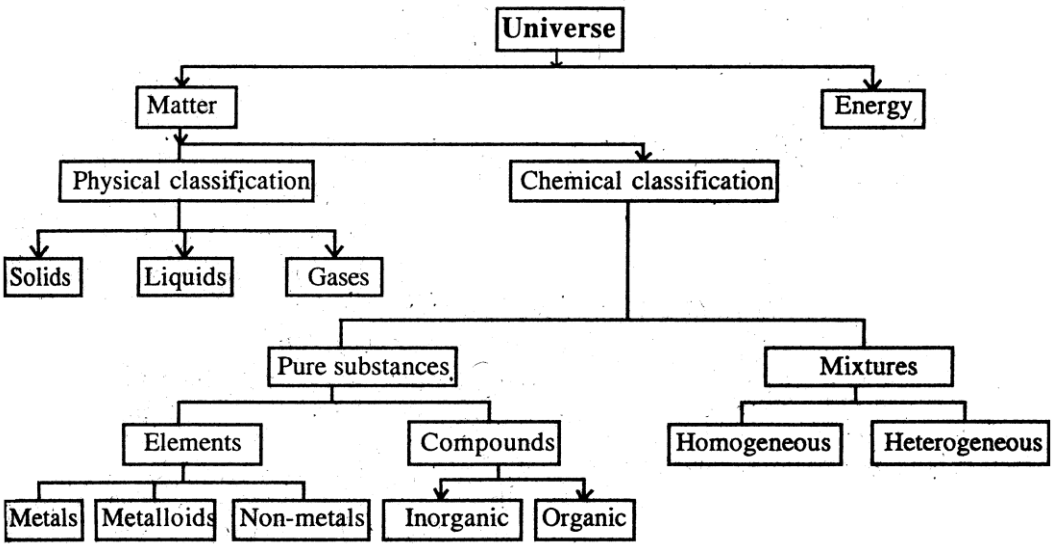
4. Analytical chemistry

It deals with the detection and estimation of elements and compounds.

NATURE OF MATTER :

Matter : Matter is defined as any thing that has mass and occupies space.

Examples : Copper, hydrogen, salt, book, pen, water etc.



Physical classification of matter: **Matter exists in three states :-**

1. Solid State
2. Liquid state
3. Gaseous State

These three states of matter are due to difference in the intermolecular force of attraction which depends upon the temp and pressure.

Solid State : A substance is said to be solid if it possesses definite shape and definite volume which is due to strong intermolecular force of attraction.

Ex : Sugar, gold, iron rod, copper etc.

Liquid State : A substance is said to be liquid if it is possesses definite volume but no shape which may be due to weak intermolecular force of attraction.

Ex : water, milk, oil, alcohol, mercury.

Gaseous State : A substance is said to be gaseous, if it neither possesses a definite shape nor a definite volume, which is due to negligible intermolecular force of attraction.

Ex : N_2, H_2, O_2 etc.

Chemical Classification : The chemical classification of matter is made on the basis of its composition. Matter is classified on the basis of chemical composition into three types.

1. Element, **2.** Compound, **3.** Mixture.

Element : ***An element is defined as the simplest form of matter which can not be broken down into still simple form by any means.***

Or

It is one form of matter which is made up the same kind of atoms.

Ex : Fe, W, O, Na etc.

Types of element : There are three different types of element :

1. Metal**,** **2.** Non-metal, **3.** Metalloid

1. **Metal :** The highly electro (+)ve element which is good conductor of heat and electricity is called metal. It shows malleable, ductile and metallic luxture character.

Ex : Cu, Au, Fe, Na etc.

2. **Non-metal :** The highly electro -ve element which is bad conductor of heat and electricity called non-metal. It does not shows malleable, ductile and luxture character.

Ex : Cl, Br, O etc.

3. **Metalloid :** The element which shows both metallic and non-metalic character is called metalloid.

Ex : Sb, As, Ge etc.

Compound : ***A chemical compound is defined as a substance which is formed by the union of two or more elements in a definite ratio by mass and each element loss their identity inside the compound.***

Ex : H_2O, CO_2, $C_6H_{12}O_6$, C_6H_6 etc.

Types of compounds : The compounds may be classified into two types :

a. **In-organic Compounds :** The compounds which are obtained from non-living sources, such as rocks, soil, minerals etc. are known as Inorganic compounds.

Ex : Nacl, Na_2CO_3-, $CaCO_3$ etc.

b. **Organic Compounds :** The compounds which are obtained from living sources such as plants and animals are called organic compounds.

Ex : $C_6H_{12}O_6$, NH_2CONH_2, C_6H_6 etc.

Mixture : A mixture is defined as a substance composed of two or more elements or compounds in any ratio by mass and each components do not lose their identity.

Ex : Brass (Cu + Zn), Air, Gun powder (C + S + KNO_3)

Types of mixture : Mixtures are of two types :

1. Homogeneous mixture
2. Heterogeneous mixture.

1. Homogeneous Mixture : (Homo = same, geneous = properties)

Mixture that has uniform composition and identical properties through out the phase is called homogeneous mixture : It consist of only one phase.

Ex : i. Different elements (Cu, Zn, H_2, O_2 etc.)

ii. Homogeneous solution (Nacl Solution, sugar solution, glucose solution)

iii. A pure liquid, solid or gases (H_2O, alcohol, NaCl, KCl, Air etc.)

Heterogeneous mixture : Mixture that has different composition and consist of two or more phase is called heterogeneous mixture.

Ex : i. Oil + water

ii. Sugar + sand iii. Water + sand

Phase : Phase is defined as a part of system which has uniform properties and composition.

Particle Nature of Matter :

The Smallest and ultimate particle states matter are atoms and molecules.

Atoms : ***An atom is defined as the smallest particles of an elements, which can take part in chemical reaction and may or may not have independent existence.***

Example :

(i) Atoms of metals like copper, silver, gold, iron, aluminium etc. and atoms of inert gases like helium, neon, argon etc. have independent existence.

(ii) Atoms of non-metals like hydrogen, nitrogen, oxygen etc. do not have independent existence. These atoms always remain in combined form (i.e molecular form)

Molecules : ***A molecule is defined as the smallest particle of an elements or a compound which has independent existence.***

Types of Molecule :

1. Homo-atomic molecule
2. Hetro-atomic molecule

1. Homo-atomic molecule : It is formed by the combination of atoms of the same element.

Ex : H_2, O_2, N_2, O_3, P_4, S_4 etc.

i. Mono atomic molecule : He, Ne, Ar etc.

ii. Diatomic molecule : H_2, O_2, Cl_2, Br_2 etc.

iii. Tri-atomic molecule : O_3

iv. Tetra-atomic molecule – P_4

2. Hetro-atomic molecule : The molecule which is made up of two or more atoms of different kind is called hetro-atomic molecule.

Ex : i. Diatomic molecule – HCl, HBr, HI

ii. Triatomic molecule : H_2S, H_2O, Na_2O etc.

iii. Tetra-atomic molecule – NH_3, PH_3, HNO_2 etc.

iv. Penta-atomic molecule – $CaCO_3$, CH_4, $MgCO_{3-}$, HNO_3 etc.

Properties of Matter :

Generally, matter is characterised by two types of properties, such as (a) chemical properties and (b) physical properties.

(A) CHEMICAL PROPERTIES : The properties of matter in which they undergo change in composition either alone or by reacting with other substances to form new substances having different composition are called chemical properties.

Example : Burning of magnesium in air.

(B) PHYSICALS PROPERTIES : The properties of matter observed without any change in composition are called physical properties.

Example : Hardness, rigidity, melting point, boiling point, density, colour, refractive index, conductivity, mallebility, ductility, elasticity, plasticity etc., are the example of physical properties.

Extensive and intensive Properties :

On the basic of dependence of properties on the quantities of matter, the properties are classified into (i) Extensive properties and (ii) Intensive properties.

(i) Extensive properties: The properties which depends on the quantity of matter are called extensive properties.

Example : Energy, volume, heat capacity etc. are extensive properties.

(ii) Intensive properties : The properties which do not depends on quantity of matter are called intensive properties.

Example : Melting point, boiling points, density, specific heat etc. are intensive properties.

SOME SPECIFIC PROPERTIES OF MATTER :

(i) Malleability : The property of metal to be hammered into sheet is known as malleability.

Example : Copper, silver, gold, aluminum, iron, tin etc. are malleable in nature. Gold is the most malleable metal used in ornaments.

(ii) Ductility : The property of metal to be drawn into wire is known as ductility.

Example: Copper, silver gold, platium etc. are ductile in nature, where platinum is the most ductile metal.

(iii) Plasticity : When a solid substances cannot regain its original shape, size or volume after removal of the stress (beyond a certain limit). the property of matter is called plasticity.

Example : Easily moldable substance like clay and a large number of polymeric mouldable materials like nylon, polyster etc. are plastic matter.

(iv) Elasticity : When a solid substances regains its original shape, size of volume after the removal of deforming force, this property of matter is called elasticity.

Example : Ivory, steel, glass etc. are elastic matter.

Very Short questions :

1. Is diamond and element or a compound ?

Ans:

2. Define molecules.

Ans;

3. Diamond and graphite are .....

Ans:

4. Which of the following is an element ?
   (a) Hydrogen peroxide (b) Ozone
   (c) Sand (d) Wood

Ans:

5. Name two elements which act as metalloids.

Ans:

Fill in the blanks :

(i) The elements can be classified as ..... and .....

(ii) ..... is a metal which exists in the liquid state.

(iii) Among the non-metals .....exists in the liquid state.

(iv) Sulphur is a .....while ..... is a metalloid.

(v) Argon is an inert gas and it can have an .....existence.

(vi) Molecules is an ultimate particle of a .....

(vii) Smallest particle of an element or compound which can exist independently is called .....

Elements	Compounds	Mixtures
Iodine, oxygen, diamond, ironfillings, granulated zinc, copper wire, hydrogen, graphite, liquid oxygen.	Common salt, lime, sand, sugar, saw-dust, acetone, starch, marble, steam, anhydrous copper sulphate.	Gun powder, green vitriol, air, glass powder, brass, coffee, milk, fog, smoke, icecream, sugar solution.

Symbol, Valency, Formula And Chemical Equations:-

Symbol

Definition – It is the shorthand or abbreviated form of representation of the full name of an element with the help of either the first letter of the English name or the two letters of the English name or the name or the two letters of the English name or the names derived from Latin names or named after country's name, scientist's name and planet's name.

Significance:

(i) It stands for the name of an element.

(ii) It represents one atom of an element.

(iii) It represents the number of parts by mass of an element.

(iv) It shows one gram atom of an element.

For example, O represents:

(i) One atom of oxygen

(ii) 16 parts by mass of oxygen.

(iii) One gram atom of oxygen i.e. 16gm

Rule: The first letter of the symbol must be a capital letter and other subsequent letters are small letters of the English alphabets.

A. Elements named after 1st letter of English name.

Element	Symbol	Element	Symbol
Boron	–B	Carbon	–C
Flourine	–F	Hydrogen	–H
Iodine	–I	Oxygen	–O
Phosphorous	–P	Sulphur	–S
Uranium	–U	Vanadium	–V

B. Elements named after the two letters of the name.

Element	Symbol	Element	Symbol
Aluminium	Al	Nickel	Ni
Argon	Ar	Neon	Ne
Arsenic	As	Strontium	Sr
Barium	Ba	Cadmium	Cd
Berylium	Be	Calcium	Ca
Bismuth	Bi	Chlorine	Cl
Bromine	Br	Cobalt	Co
Lithium	Li	Silicon	Si
Magnesium	Mg	Platinum	Pt
Palladium	Pd	Radon	Rn
Zinc	Zn		

C. Symbols derived from latin name:

Element	Symbol	Element	Symbol
Antimony	Sb	Copper	Cu
Gold	Au	Iron	Fe
Lead	Pb	Mercury	Hg
Potassium	K	Silver	Ag
Sodium	Na	Tin	Sn
Tungsten	W		

D. Symbols derived from the name of scientists. Countries and planets.

Country's Name	
Element	Symbol
Americium	Am
Berkelium	Bk
Californium	Cf
Polonium	Po
Scientist's Name	
Curium	Cm
Einsteinium	Es
Fermium	Fm
Mendelevium	Md
Nobelium	No
Planet's Name	
Neptunium	Np
Plutonium	Pu
Uranium	U

RADICAL OR IONS

Definition

A molecule of an Ionic compound like acid, base or salt which is electrically neutral consists of two oppositely charged parts called radicals or ions. On the basis of the charge, these are classified as:

(i) Electropositive ions of cations or basic radicals (Na^+, K^+).

(ii) Electronegative ions or anions or acid radicals (Cl^-, Br^-, O^{2-}).

Classification of Radical (on the basic of structure)

Radical

Simple **Compound** **Complex**

(i) Simple radical: These radicals contain one or more atoms of the same element.

Ex.: Chloride ion (Cl^-), sodium ion (Na^+) etc.

Compound radical: These radicals contain two or more atoms of different elements acting as a single unit.

Ex: Sulphate ion (SO_4^{2-}). Phosphate ion (PO_4^{3-}), Ammonium ion (NH_4^+) etc.

Complex radical:

(i) These radicals contain atoms of different element.

(ii) It is placed inside the co-ordination sphere ([])

(iii) The central metal atom is bonded by dative bonds with ligands surrounding it.

(iv) The atoms or groups present inside the coordination sphere can't be ionised.

e.g $[Fe(CN)_6)]^{2-}$, $[Fe(CN)_6]^{3-}$, $[Cu(NH_3)_4]^{2+}$

Valency:

Valency is defined as the combining capacity of one atom of an element.

Old concept:

The valency of an element is defined as the number of hydrogen atoms or the number of chlorine atoms or double the number of oxygen atoms with which it combines.

Ex:- 1: The valency of bromine in HBr is 1.

Ex:-2: The valency of sodium in NaCl is 1.

Ex:-3: The valency of carbon in CO_2 is 4.

Variable Valency: Some elements of p-block (As, Sb, Sn, Pb etc.) and most of the elements of d-block (Cr, Mn, Fe, Cu, Hg, Au etc) exhibt more than one valency and are said to have variable valencies.

Examples as given below:

Name of compound and its	**Valency of element combining with chlorine**
Stannous chloride ($SnCl_2$)	2
Stannic chloride ($SnCl_4$)	4
Arsenous chloride ($AsCl_3$)	3
Arsenic chloride ($AsCl_3$)	5
Plumbic chloride ($PbCl_2$)	2
Plumbic chloride ($PbCl_4$)	4
Ferrous chloride ($FeCl_2$)	2
Ferric chloride ($FeCl_3$)	3
Aurous chloride (AuCl)	1
Auric chloride ($AuCl_3$)	3
Mercurous chloride ($Hg_2 Cl_2$ or HgCl)	1
Mercuric chloride ($Hgcl_2$)	2
Cuprous chloride (CuCl)	1
Cupric chloride ($CuCl_2$)	2

(b) Modern concept: The valency of an element is defined as number of electrons donated, gained or shared by the valency shell of an atom to achieve the nearest inert gas configuration.

List of Basic radicals and Acid radicals with their valencies.

As the knowledge of valency is quite essential for writing the formula of various compounds, two separate lists of valencies of common basic and acid radicals are given in the following tables.

List of Basic Radicals or Cations.

Name of the Cation	Symbol of Cation
Monovalent Cations	
Hydrogen	H^+
Lithium	Li
Sodium	Na^+
Potassium	K^+
Rubidium	Rb^+
Cuprous	Cu^+
or Copper (I) silver	Ag^+
Silver	Ag
Aurous or Gold (I)	Au^+
Mercurous	Hg^+
Or Mercury (I)	Or (Hg_2^{2+})
Ammonium	NH_4^+
Phosphonium	PH_4^+
Name of the Cation	**Symbol of Cation**
Divalent	
Beryllium	Be^{2+}
Magnesium	Mg^{2+}
Calcium	Ca^{2+}
Strontium	Sr^{2+}
Barium	Ba^{2+}
Radium	Ra^{2+}
Cupric or Copper (II)	Cu^{2+}
Mercuric or Mercury (II)	Hg^{2+}
Ferrous or iron (II)	Fe^{2+}
Chromous or Chromium (II)	Cr^{2+}
Cobaltous or Cobalt (II)	Co^{2+}
Nickel	Ni^{2+}
Manganous or Manganese (II)	Mn^{2+}
Cadmium	Cd^{2+}
Zinc	Zn^{2+}
Plumbous or Lead (II)	Pb^{2+}
Stannous or Tin (II)	Sn^{2+}
Name of the Cation	**Symbol of Cation**
Trivalent	
Ferric or Iron (III)	Fe^{3+}
Manganic or Manganese (III)	Mn^{3+}
Aluminium	Al^{3+}
Auric or Gold (III)	Au^{3+}
Antimonous or Antimony (III)	Sb^{3+}
Arsenous or Arsenic (III)	As^{3+}
Cromium	Cr^{3+}
Cobaltic or Cobalt (III)	Co^{3+}
Boron	B^{3+}
Name of the Cation	**Symbol of Cation**
Tetravalent	
Platinic or Platinum (IV)	P_t^{4+}
Plumbic or Lead (IV)	P_b^{4+}
Stannic or Tin (IV)	S_n^{4+}
Name of the Cation	**Symbol of Cation**
Pentavalent	
Arsenic or Arsenic (V)	AS^{5+}
Antimonic or Antimony (V)	Sb^{5+}

List of Electro-Negative Radicals (Anions)

Following tables include all the electro- negative radicals (Acid radicals or anions).

Monovalent Radicals Having a Unit Negative Charge.

Radical	Symbol	Radical	Symbol
Acetate	CH_3COO^-	Hydroxide	OH^-
Bicarbonate	HCO_3^-	Hypochlorite	ClO^-
Bisulphate	HSO_4^-	Hypobromite	BrO^-
Bisulphite	HSO_3^-	Hypoiodite	IO^-
Bromide	Br^-	Hypophosphate	$H_2PO_2^-$
Chlorate	ClO_3^-	Iodate	IO_3^-
Chloride	Cl^-	Iodide	I^-
Cyanide	CN^-	Meta-aluminate	AlO_2^-
Cyanate	CNO^-	Metaborate	BO_2^-
Fluoride	F^-	Metaphosphate	PO_3^-
Hydride	H^-	Nitrate	NO_3^-
Nitrite	NO_2^-	Permanganate	MnO_4^-
Perchlorate	ClO_4^-	Sulphocyanide	CNS^-
Bisulphide	HS^-	Superoxide	O_2^-
Divalent Radicals having two Units of Negative Charge			
Radical	**Symbol**	**Radical**	**Symbol**
Carbonate	CO_3^{2-}	Stannate	SnO_3^{2-}
Chromate	CrO_4^{2-}	Stannite	SnO_2^{2-}
Dichromate	$Cr_2O_7^{2-}$	Sulphate	SO_4^{2-}
Manganate	MnO_4^{2-}	Sulphite	SO_3^{2-}
Molybdate	MoO_4^{2-}	Sulphide	S^{2-}
Oxalate	$C_2O_4^{2-}$	Tetra or	
Oxide	O^{2-}	Pyroborate	$B_4O_7^{2-}$
Peroxide	O_2^{2-}	Thiosulphate	$S_2O_3^{2-}$
Plumbate	PbO_2^{2-}	Tetra-thionate	$S_4O_6^{2-}$
Pyrite	S_2^{2-}		
Silicate	SiO_3^{2-}	Zincate	ZnO_2^{2-}
Trivalent Radicals having Three Units of Negative Charge			
Radical	**Symbol**	**Radical**	**Symbol**
Aluminate	AlO_3^{3-}	Ferricyanide	$[Fe(CN)_6]^{3-}$
Antimonate	SbO_4^{3-}	Nitride	N^{3-}
Arsenate	AsO_4^{3-}	Phosphate	PO_4^{3-}
Arsenite	AsO_3^{3-}	Phosphite	PO_3^{3-}
Borate	BO_3^{3-}	Phosphide	P^{3-}
Cobaltinitrite	$[Co(NO_2)_6]^{3-}$		
Tetravalent Radicals having Four Units or Negative Charge			
Radical	**Symbol**	**Radical**	**Symbol**
Carbide	C^{4-}	Pyro-phosphate	$P_2O_7^{4-}$
Ferrocynide	$[Fe(CN)_6]^{4-}$		

Empirical Formula

Empirical formula is defined as the simplest formula which gives the simplest whole number ratio between the atoms of different elements present in the molecules of a substance.

Molecular Formula

The actual formula which gives the actual number of atoms of different elements present in the molecule of a substance.

Relationship Between Empirical And Molecular Formula

Molecular formula = $(\text{empirical formula})_n$

Formula mass, i.e, $\frac{\text{Molecular mass}}{\text{Empirical formula mass}} = n$

Ex: Let us consider the formula of glucose. The actual formula is $C_6H_{12}O_6$, but its empirical formula is CH_2O.

CHEMICAL EQUATIONS

Chemical equations are mainly of two types:

(1) Skelton equation (2) Balanced equation.

(1) Skelton equation:- $FeS + O_2 \longrightarrow Fe_2O_3 + SO_2$.

Thus, a skeleton equation is an unbalanced equation which represents the reactants and the products written side by side with the help of symbols and formulae with an arrow head in between.

(2) Balanced equation.:- A chemical equation in which the number of atoms of each element is the same on both the sides is called a balanced equation. $NH_4NO_3 \longrightarrow N_2O + 2H_2O$.

How to Balance A Chemical Equation?

The skeleton equation which is balanced by either of the following methods:

(1) Hit and Trial method
(2) Partial equation method
(3) Oxidation number method and
(4) Ion- electron method.

Problem Balance The Equation By Hit And Trial Method

$C_2H_6 + O_2 \rightarrow CO_2 + H_2O$

Sol.

Converting the oxygen to elementary state.

$C_2H_6 + O \rightarrow CO_2 + H_2O$

Balancing the carbon atoms.

$C_2H_6 + O \rightarrow 2CO_2 + H_2O$

Balancing the hydrogen atoms

$C_2H_6 + O \rightarrow 2CO_2 + 3H_2O$

Balancing the oxygen atoms

$C_2H_6 + 7O \rightarrow 2CO_2 + 3H_2O$

Changing the molecular formula by multiplying whole

$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

Problem Balance the following skeleton equation.

$Sb_2O_3 + SnCl_2 + HCl \rightarrow SnCl_4 + Sb + H_2O$

Sol.

The skeleton equation is:

$Sb_2O_3 + SnCl_2 + HCl \rightarrow SnCl_4 + Sb + H_2O$

Balancing arsenic and oxygen atoms by multiplying as by 2 and H_2O by 3.

$Sb_2O_3 + SnCl_2 + HCl \rightarrow SnCl_4 + 2Sb + 3H_2O$

Multiply HCl by 6 to balance H atoms.

$Sb_2O_3 + SnCl_2 + 6HCl \rightarrow SnCl_4 + 2Sb + 3H_2O$

To balance chlorine atoms, multiply $SnCl_2$ and $SnCl_4$ both by 3.

$Sb_2O_3 + 3Sncl_2 + 6HCl \rightarrow 3SnCl_4 + 2Sb + 3H_2O$.

MOLE CONCEPT

The word "mole" is derived from the Latin "moles", meaning heap, mass or pile.

1 mole of every substance will contain 6.023×10^{23} number of individual particles.

Significance Of The Mole Concept In Chemical Calculations

1. Mole-Number Relationship

A mole is a number equal to Avogadro number (N = 6.023×10^{23}) of species (particles, – electrons, photons, atoms, ions or molecules) present in a substance.

2. Mole-Mass Relationship

A mole represents the quantity of the substance containing N (Avogardro number) particles.

1 mole = 1 molar mass, or one gram molecular mass

= 1 gram formula mass

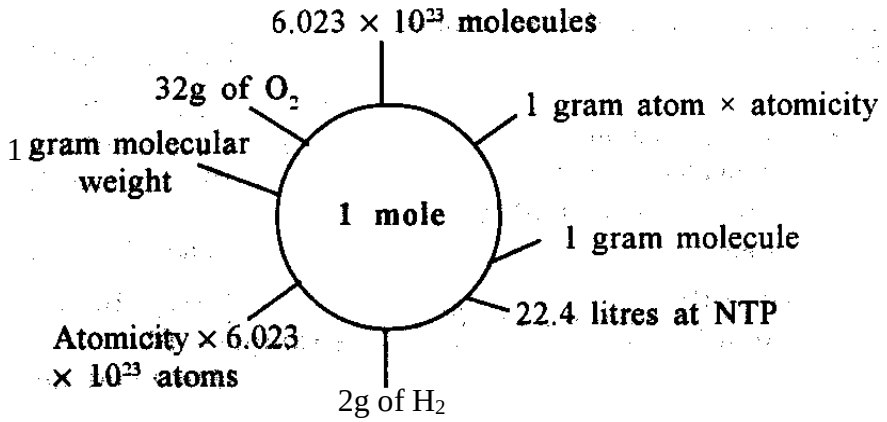
= 1 gram molecule (= 6.023×10^{23} molecules)

= 1 gram atomic mass.

= 1 gram atom = 6.023×10^{23} atoms

3. Mole-Volume Relationship

1 mole of a gaseous substance = 22.4 litres of the gas at N.T.P. = 22400 ml of the gas at N.T.P. (for gases only).



Problem solve for space :-

Molecular Mass

Definition:

The molecular mass of a substance (element or compound) is the relative average mass of one molecule of the substance as compared to the mass of an atom of carbon (^{12}C) taken as 12. Alternatively, the molecular mass of a substance is a number which express how many times the mass of one molecule of it is heavier than one twelveth the mass of an atom of ^{12}C.

Molecular Mass Is An Additive Property

Substance	Formula	Molecular mass (a.m.u.)
Nitrogen	N_2	$2 \times 14 = 28$
Oxygen	O_2	$2 \times 16 = 32$
Chlorine	Cl_2	$2 \times 35.5 = 71$
Ammonium Chloride	NH_4Cl	$14+1 \times 4 + 35.5 = 53.5$
Potassium Chloride	KCl	$39 + 35.5 = 74.5$
Sodium sulphate	Na_2SO_4	$(2 \times 23) + (1 \times 32\_ + 4 \times 16) = 142$
Magnesium Nitrate	$Mg(NO_3)_2$	$24+(2 \times 14) + (6 \times 16) = 148$

Gram Molecular Mass Or Gram Mole

Substance	Formula	Molar Mass	Gram Molecular Mass	Number of Particles Mass
Hydrogen	H_2	2	2g	6.023×10^{23}
Oxygen	O_2	32	32g	6.023×10^{23}
Nitrogen	N_2	28	28g	6.023×10^{23}
Sulphur dioxide	SO_2	64	64g	6.023×10^{23}
Sodium carbonate	Na_2CO_3	106	106g	6.023×10^{23}
Carbonation ion	CO_3^{2-}	60	60g	6.023×10^{23}
Nitrate ion	NO_3^-	62	62g	6.023×10^{23}

Equivalent Mass

"The equivalent mass of a substance is a number of parts of that substance which can directly or indirectly combine or displace 1.008 parts by mass of hydrogen 8 parts by mass of oxygen and 35.5 parts by mass of chlorine"

Equivalent mass of an element

$$\Rightarrow \quad = \frac{\text{Atomic mass}}{\text{valency}}$$

Equivalent Mass Of Acids, Bases And Salts, Ions

(1) $\Rightarrow$ Equivalent mass of an ionic compound

$$= \frac{\text{Ionic Mass}}{\text{Total valency of its cations or anions}}$$

Ex: Equivalent mass of SO_4^{2-}

$$= \frac{\text{Ionicmass of } SO_4}{\text{Magnitude of ion}}$$

$$= \frac{32+64}{2} = \frac{96}{2} = 48$$

Equivalent Mass of Acids

(2) Equivalent mass of an acid

$$= \frac{\text{Molecular mass of an acid}}{\text{Basicity of acid}}$$

Examples:

1. $\therefore$ Equivalent mass of HCl

$$= \frac{\text{Molecular mass of HCl}}{\text{Basicity of HCl}} = \frac{36.5}{1} = 36.5$$

2. $\therefore$ Equivalent mass of H_2SO_4

$$= \frac{\text{Molecular mass of } H_2SO_4}{\text{Basicity of } H_2SO_4}$$

$$= \frac{98}{2} = 49$$

3. Similarly, CH_3COOH ionizes to give one H^+ ion,

$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$, thus, the basicity of CH_3COOH = 1

$\therefore$ Equivalent mass of CH_3COOH

$$= \frac{\text{Molecular mass of } CH_3COOH}{\text{Basicity of } CH_3COOH}$$

$$= \frac{60}{1} = 60$$

(3) Equivalent Mass of Salt:

Equivalent mass of a salt

$$= \frac{\text{Molecular mass of the salt}}{\text{Total valency of cations or metalatoms}}$$

Examples:

1. Equivalent mass of NaCl

$$= \frac{\text{Molecular mass of NaCl}}{\text{Valency of one } Na^+ \text{ ion}}$$

$$= \frac{58.5}{1} = 58.5$$

2. Equivalent mass of Na_2CO_3

$$= \frac{\text{Molecular mass of } Na_2CO_3}{\text{Total valency of two } Na^+ \text{ ions}}$$

$$= \frac{106}{2} = 53$$

RELATIVE ATOMIC MASS:

"The relative atomic mass (or atomic mass) of an element is the number of times of an atom of that element is heavier than the mass of an atom of carbon- 12 isotope."

$$\text{Relative atomic mass} \Rightarrow = \frac{\text{Mass of one atom of an element}}{1/12\text{th of the mass of one atom of C}-12}$$

Expressed in a.m.u or unified mass.

GRAM ATOMIC MASS:

"The atomic mass of an element expressed in gram is called its gram atomic mass. It is also called one gram atom.

For Example:

(i) Atomic mass of carbon = 12 amu ⇒ Gram atomic mass of carbon = 12g

(ii) Atomic mass of nitrogen = 14amu ⇒ Gram atomic mass of nitrogen = 14g

(iii) Atomic mass of hydrogen = 1.008 amu ⇒ Gram atomic mass of hydrogen = 1.008 g.

Average atomic mass :

"The concept of average atomic mass comes into the picture due to the presence of different isotopes in the element. The isotopes are the atoms of the same element but have different atomic masses."

For example, chlorine is a mixture of two isotopes having atomic mass 35u and 37u in the 3:1 by mass (I.e. Cl^{35} 75% and Cl^{37} 25% by mass observed from mass spectrometer). Thus,

$$\text{Average atomic mass of chlorine} = \frac{35 \times 75 + 37 \times 25}{100} = 35.5\,\text{amu}$$

DeterminatIon of AtomIc Mass :

$\therefore$ Atomic mass = $\frac{\text{Equivalent mass}}{\text{Valency}}$

So atomic mass

= Equivalent mass × valency

Problem solve for space :-

Gaseous State

CHARACTERISTICS OF GASES:

Gases have the following characteristic properties due to very negligible intermolecular force of attraction and high kinetic energy:

(i) **Shape and volume:** Gases have **neither definite shape nor definite volume.**

(ii) **Density:** Gases have **low densities.**

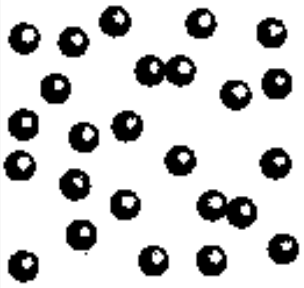
(iii) **High expansibility:** Gases have **high expansibility.**

(iv) **High Compressibility:** Due to presence of large vacuum space gases **show high compressibility.**

(v) **Rapid diffusion:** Gases **show rapid diffusion i.e.** intermix with each other rapidly to form homogeneous mixture.

(vi) **Pressure: Gases exert** Pressure on the wall of the container,

(vii) **Liquefaction:** Gases undergo liquefaction below their critical temperation under high pressure.



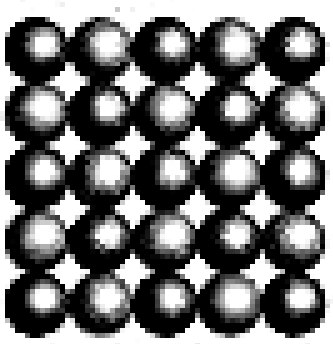
Gaseous state

SOLID STATE

CHARACTERISTICS OF SOLIDS

Solids have the following characteristic properties:

1. **Hardness and Rigidity:** Solids are in general hard and rigid.
2. **Definite shape and volume:** Solids have definite shape and definite volume.
3. **Compressibility:** Due to close packing of constituent particles, solids are almost incompressible.
4. **High density:** Solids have high density due to close packing.
5. **Slow diffusion:** Due to strong force of attraction, solids show extremely slow diffusion.
6. **Crystalline state:** Due to orderly arrangement of particles, most of the solids possess crystalline structure.
7. **Melting point:** The temperature at which a solid changes into liquid is called its melting point. Every solid has its own characteristic melting point.

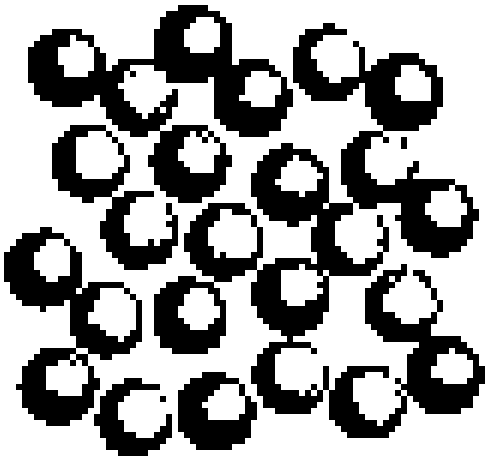


SOLID STATE

LIQUID STATE AND SOLUTION

Liquids have the following characteristic properties:

1. **Volume and shape :** Liquids have definite shape due to less intermolecular force of attraction.
2. **Slow diffusion:** Liquids have slow diffusion as compared to gases.
3. **Density:** Liquids have low density as compared to solids.
4. **Fluidity:** Liquids have property to flow but the fluidity of liquid is less than gases due to greater intermolecular attraction.
5. **Evaporation:** Liquids spontaneously change into vapour state at its surface when taken in an open vessel.
6. **Semi-crystalline state:** Due to weak intermolecular force of attraction liquids remain in semi crystalline state with less orderly arrangement as compared to solids.



LIQUID STATE

Structure of Atom

It was found that atom s made up of three fundamental particles, viz., Electrons, Protons and Neutrons.

Electron (Discovered by J. J. Thomson)

An electron is defined as sub-atomic particle having a unit negative charge and a mass equal to $\frac{1}{1835}$ th the mass of the hydrogen atom.

About the Electron

(a) Discovered in Cathode Ray experiment

(b) Charge = 1.602×10^{-19} Coulomb (determined by Mulliken in his oil drop experiment)

(c) Mass of electron = 9.11×10^{-31} kg (Calculated by J.J. Thomson)

(d) Specific charge of electron (e/m ratio) = 1.76×10^{8} coulombs/ gm. (It decreases with increase in velocity because the increase in velocity increases the mass of electron)

(e) Density of Electron = 2.17×10^{17} gm/cc

(f) Radius of Electron = 10^{-15}cm

(g) Mass of one mole of electron (N electrons) = 0.55 mgm (nearly)

(h) Charge on one mole of electrons = 96500 coulombs = one Faraday (nearly)

PROTON (Discovered By GOLDSTEIN)

A proton is defined as a sub atomic particle having a unit positive charge and mass equal to that of hydrogen atom.

About The proton

(a) Discovered in Anode ray experiment (E. Goldstein discovered anode rays.)

(b) Charge on proton = + 1.602×10^{-19} coulombs

(c) Mass of Proton = 1.672×10^{-27} kg.

(d) Specific charge of proton = 9.58×10^{4} coulombs/gm. (Sp. Charge of anode rays is maximum when gas enclosed in discharge tube is hydrogen. I changes with the gas present in the tube).

(e) Mass of 1 mole of protons = 1.007 gm (nearly)

(f) Charge on 1 mole of protons= 96500 coulombs (nearly)

NEUTRONS Discovered by Chadwick

About the Neutron

(a) Neutron was discovered by Chadwick

(b) Mass of neutron = 1.675×10^{-27} kg

(c) Specific charge of neutron = 0

(d) Density of neutron = 1.5×10^{14} g/cc

(e) Mass of 1 mole of neutrons = 1.008 gm nearly

(Isolated neutron is unstable and disintegrates into electron, proton and neutron.)

Worked out Examples

Example 1.

An element consists of 9 protons and 10 neutrons. Calculate its mass number and atomic number.

Solution. No. of protons in the atom = 9; No. of neutrons in the atom = 10

Atomic number of atom is equal to the number of electrons or protons in it.

Thus, its atomic number = 9

Also, mass number = p +n = 9 + 10 = 19

Example 2.

The mass number and atomic number of calcium are 40 and 20 respectively. Determine the number of electrons, protons contained in Ca^{+2} ion.

Solution. We know that Ca^{+2} ion is formed when the calcium atom loses two electrons.

$$Ca - 2e \rightarrow Ca^{2+}$$

Atomic number of calcium = No. of protons = No. of electrons.

Atomic number of calcium = 20 (given)

In Ca^{2+} ion, two electrons have been lost.

Thus, No. of proton in Ca^{2+} = **20.**

No. of electrons in Ca^{2+} = 20 – 2 = **18**

No. of neutrons = Mass number – No. of protons = 40 – 20 = **20.**

FOLLOW UP PROBLEMS

1. Determine the number of protons and neutrons in an element with mass number 23 and atomic number 11 and nucleus of an element with mass number 7 and atomic number 4.

2. Find the number of electrons in K^+ ions and Cl^- ion (Z For K = 19, Cl = 17).

3. How many neutrons and electrons are present in $^{19}_{9}F$ and $^{16}_{8}O$ atoms.

4. How many protons and neutrons are there in the following nuclei:

   (i) $^{38}_{38}Sr$ (ii) $^{12}_{6}C$

   (iii) $^{56}_{26}$

   (iv) $^{25}_{12}Mg$ (v) $^{17}_{8}O$

5. Write the complete symbols for the nuclei having:
   (i) atomic number 56 and mass number 138
   (ii) atomic number 26 and mass number 55
   (iii) atomic number 4 and mass number 9 .

Distribution of Electrons In Various Orbits

Element	At.No. (Z)	Mass No. A	No. of electrons or protons	Neutrons (A – Z)	Electrons in different orbits		
					K (1)	L(2)	M(3)
Hydrogen	1	1	1	0	1		
Helium	2	4	2	2	2		
Lithium	3	7	3	4	2	1	
Berylium	4	9	4	5	2	2	
Boron	5	11	5	6	2	3	
Carbon	6	12	6	6	2	4	
Nitrogen	7	14	7	7	2	5	
Oxygen	8	16	8	8	2	6	
Fluorine	9	19	9	10	2	7	
Neon	10	20	10	10	2	8	
Sodium	11	23	11	12	2	8	1
Magnesium	12	24	12	12	2	8	2
Aluminium	13	27	13	14	2	8	3
Silicon	14	28	14	14	2	8	4
Phosphorus	15	31	15	16	2	8	5
Sulphur	16	32	16	16	2	8	6
Chlorine	17	35	17	18	2	8	7
Argon	18	40	18	22	2	8	8

ORGANIC COMPOUNDS

Organic Compounds. These are obtained from animals or plants directly or indirectly. A living body is called an organism and hence the name of these compounds. The chemistry of organic compounds is called organic chemistry. All these compounds involve covalent bonds.

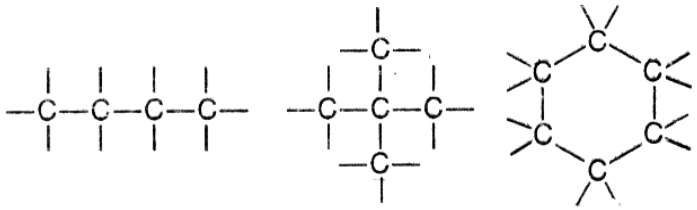
History of Organic Compounds

In 1828, a German chemist named Wohler performed a noble experiment in the laboratory. He heated Ammonium cyanate (NH_4 CNO) which is purely an inorganic compound and found that it was converted into a compound, urea (NH_2CONH_2) which is an organic compound.

$$\underset{\text{Amm.cyanate}}{NH_4CNO} \xrightarrow{\text{Heat}} \underset{\text{Urea}}{NH_2CONH_2}$$

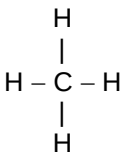
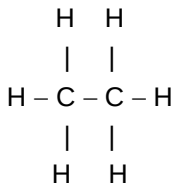
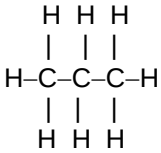
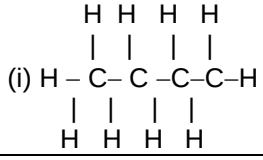
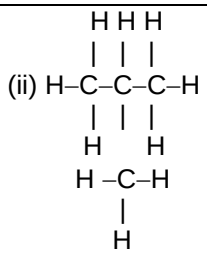
Organic Chemistry – A Separate Branch

The self linking property of atoms to form long chains is called ctenation.



1. Hydrocarbons. (a) **Saturated Hydrocarbons or Alkanes or Paraffins.** in alkanes, carbon atoms are linked by single covalent bonds (C –C) and these are the parent compounds.

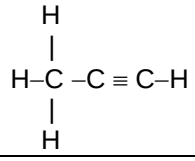
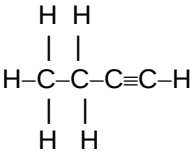
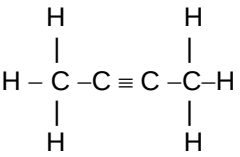
A L K A N E S. [C_nH_{2n+2}] n = 1, 2, 3 …….

Value of n	Molecular formula	Structural formula			Name	
		Expanded	Condensed	Common	IUPAC	
1.	CnH_{2n+2} / CH_4		CH_4	Methane	Methane	
2.	C_2H_6		$CH_3 – CH_3$	Ethane	Ethane	
3.	C_3H_8		$CH_3 – CH_2 –CH_3$	Propane	Propane	
4.	C_4H_{10}		$CH_3 – CH_2 –CH_2–CH_3$	n-Butane	Butane	
			$CH_3 – CH(CH_3) – CH_3$	Isobutane	2-methylpropane	

A L K A N E S. C_nH_{2n}[n = 2 ,3 ……..]

Value of n	Molecular formula	Structural formula	Common	Name IUPAC
2	C_2H_4	$CH_2 = CH_2$	Ethylene	Ethene
3	C_3H_6	$CH_3 – CH = CH_2$	Propylene	Propene
4	C_4H_8	$CH_3 – CH_2 – CH = CH_2$	α- Butylene	But-1-ene
		$CH_3 –CH = CH – CH_3$	β- Butylene	But-2-ene
		$CH_3 – C(=CH_2) – CH_3$	Iso-Butylene	2-Methylpropene

Alkynes. $[C_nH_{2n-2}]$ **n = 2, 3, 4 ……..**

Value of n	Molecular formula	Structural formula			Name
		Expanded	Condensed	Common	IUPAC
2	C_2H_2	H–C ≡ C –H	HC ≡ HC	Acetylene	Ethyne
3	C_3H_4		$CH_3 - C \equiv CH$	Methyl acetylene or Allylene	Propyne
4	C_4H_6	(i) 	$CH_3 - CH_2 - C \equiv CH$	Ethyl acetylene or α- Crotonylene	But-1-yne
		(ii) 	$CH_3 - C \equiv C - CH_3$	Dimethyl acetylene or β-Crotonylene	But-2-yne

Types of Carbon Atoms in Alkanes

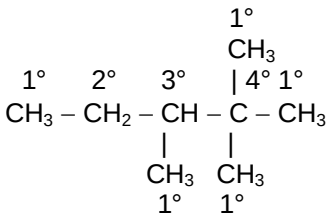
There can be four types of carbon atoms in an alkane.

(i) The carbon atom to which other carbon atoms are attached only on one side, to form a chain is called a primary carbon atom (1°- Carbon).

(ii) The carbon atom to which other carbon atoms are linked on two sides is called a secondary carbon atom (2° -carbon).

(iii) A tertiary carbon carries other carbon atoms on three sides of it. It is designated as 3°-carbon.

(iv) A quarternary carbon carries other carbon atoms on all the four sides of it. It is designated as 4°-carbon.



Problem solve for space :-