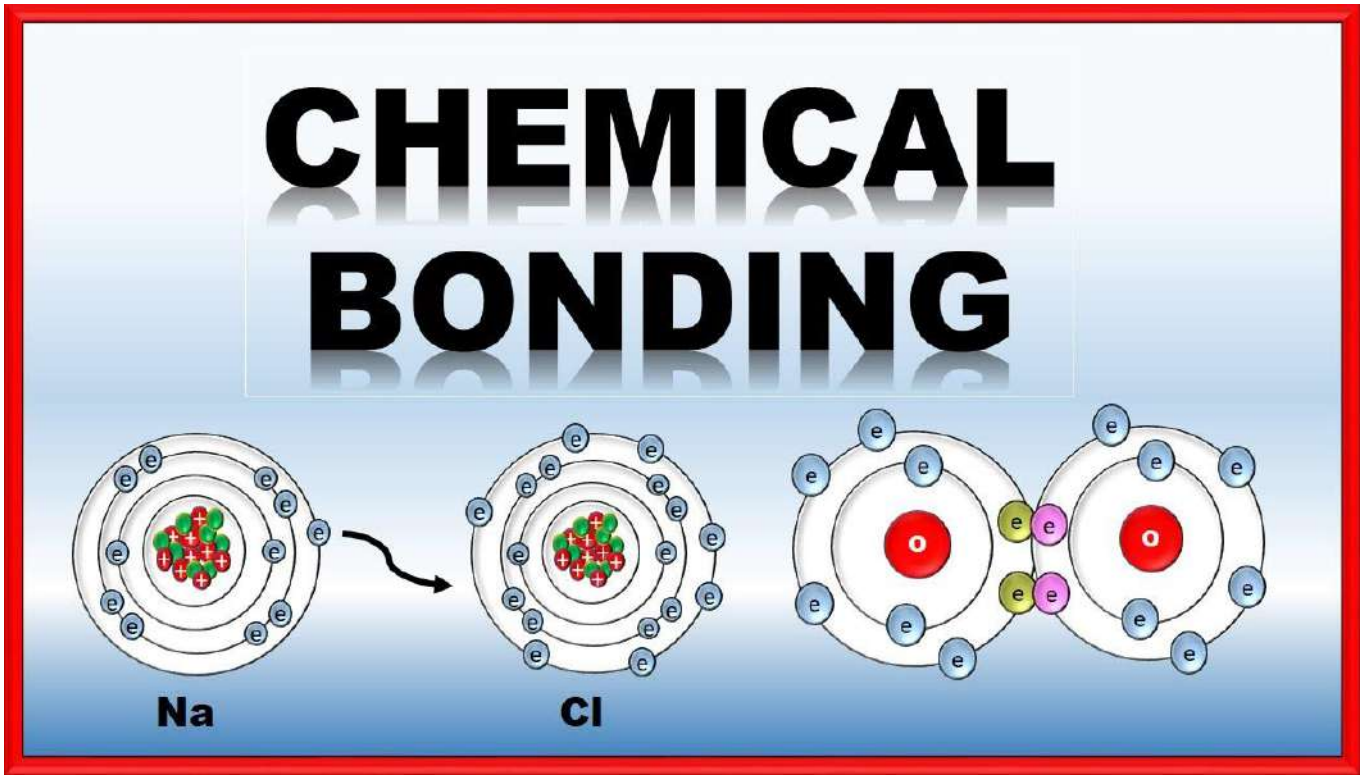
R.C.Patel College Of Engineering & Polytechnic, Shirpur

Department of Applied Science & Humanities

Course Title- Basic Science (Chemistry) **Course Code -** 311305

Department Name – Applied Science **Semester-** First

Unit	Title	COs	Learning hours	R Level	U Level	A Level	Total Marks
1	Chemical Bonding	CO4	06	02	03	04	09



Chemical Bonding

Philosophy of atom by Aacharya Kanad -

- Maharshi Kanada - Aacharya Kanad - Indian scientist - Praposed atomic theory - 600 BCE
- Aacharya Kanad - Belived in matter made up of Ind-Structible (Indivisible) particles It's called 'Parmanu'

For e.g. If we take grain of wheat & cut it then what happend --? It is divisible in two Parts. again cut two Parts is also divisible

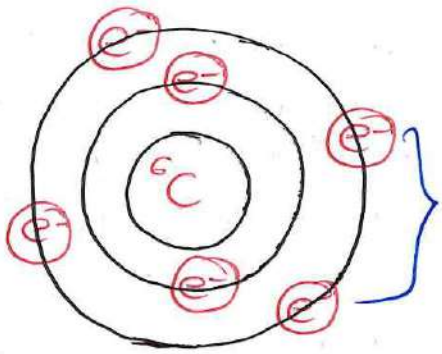
- Hence matter or any substance made up by atom is called permanu.

Electronic theory of valency :-

- the electrons present in outermost shell of atom is called 'Valency of electrons'.

For e.g. Carbon (C) -

- Electronic configuration - ${}^{6}C - 1s^2 2s^2 2p^2$



e-s present at outermost shell is - 4

- therefore of carbon is 4.

- Electronic theory praposed by Kossel & Lewis (1916) & these electronic theory of valency is applied by Langmuir (1919)
- From these theory the Langmuir is condude that-

① Element has tendency to occupy inert electronic configuration (ns^2np^6) of the nearest inert gas because of It's considered as most stable electronic configuration.

② If Last orbit is removed then the rest of atom is called kernel (Core) of atom.

③ the atom contain 8 e-s (Octate) or 2 e-s (duplet) these called stable electronic configuration

④ But those electrons are capable to chemical

combination which have less than 8es in it's outer most shell. because elements aquired tendency to get stable electronic configuration.
⑤ atoms complete there octate by smallest change. For e.g. atoms having less than 4-electrons then it's lost or lend their electrons while atom having more than 4-valency electrons then it will be gain or borrow electrons to complete stable electronic configuration.

Stable Configuration is attained by -
① Transfer of electrons
② Shairing of electrons
③ Donation of electrons
- therefore these types of shairing, Transfer or Donation of electrons are connected by each other & Formation of bonds.

Types of chemical Bond :-
- Electrostatic force of attraction between atoms, ions called chemical Bond.
[or]
• chemical Bonding is Attraction, transfer or shairing of electrons between atom that enable to Formation of chemical compound.

• Types of chemical Bonds -
Ⅰ Ionic Bond (or) Electrovalent Bond.
Ⅱ Covalent Bond
Ⅲ Co-ordinate Bond
Ⅳ Metalic Bond
Ⅴ Hydrogen Bond

Ionic Bond / Electrovalent Bond / kernel Bond -
- An Ionic Bond is a type of chemical Bond formed by the transfer of electrons from one atom to another.
• one atom loses electrons & becomes a positive ion (cation)
• Another atom gains electrons and becomes a negative ion (anion).
• The electrostatic force of attraction betwee -n two opposite ions forms the ionic Bond.

• Ionic Bond is kernel bond because during formation of cation outermost orbit is destroyed and remaining part is called core or kernel.

• the number of electrons that atoms of elements gain or Loss to complete It's Last orbit (octate) is called electrovalency.

• Ionic bond was introduced by Kossel.

For e.g.

$^{19}K - 2,8,8,1$
$^{17}Cl - 2,8,7$

$\longrightarrow K^{\cdot} + :\ddot{Cl}:^{-} \longrightarrow [K^+][Cl^-] \equiv$

K^+ Cl^-
(2,8,8) (2,8,8)

Types of electrovalency or Ionic valency -

• Ionic valency is of two types-

① Positive electrovalency (Ionic valency)

② Negative electrovalency

• Positive electrovalency (Ionic valency)

- the valency obtained by Loss of valency electrons from the metalic atom of an element to complete It's Last orbit (octate) is known as Positive electrovalency.

For e.g. Na^+, K^+, Ca^{2+}

• Negative electrovalency -

- the valency obtained by gain of electrons by the Non-metalic atom of element, to complete their Last orbit.

For e.g. Cl^-, F^-, I^-

Formation of Ionic or electrovalent compound :-

- Formation of Ionic bond depends upon 3-major factor-

① Ionization potential :

• the energy used to removed e⁻s from an atom

• Value of Ionization Potential ↓ Lower → Ability of formation of cations ↑ Greater

② Electron affinity :

• How much energy released when atom gains e⁻s

Electron affinity ↑ Increase → Formation of anion ↑ Increase

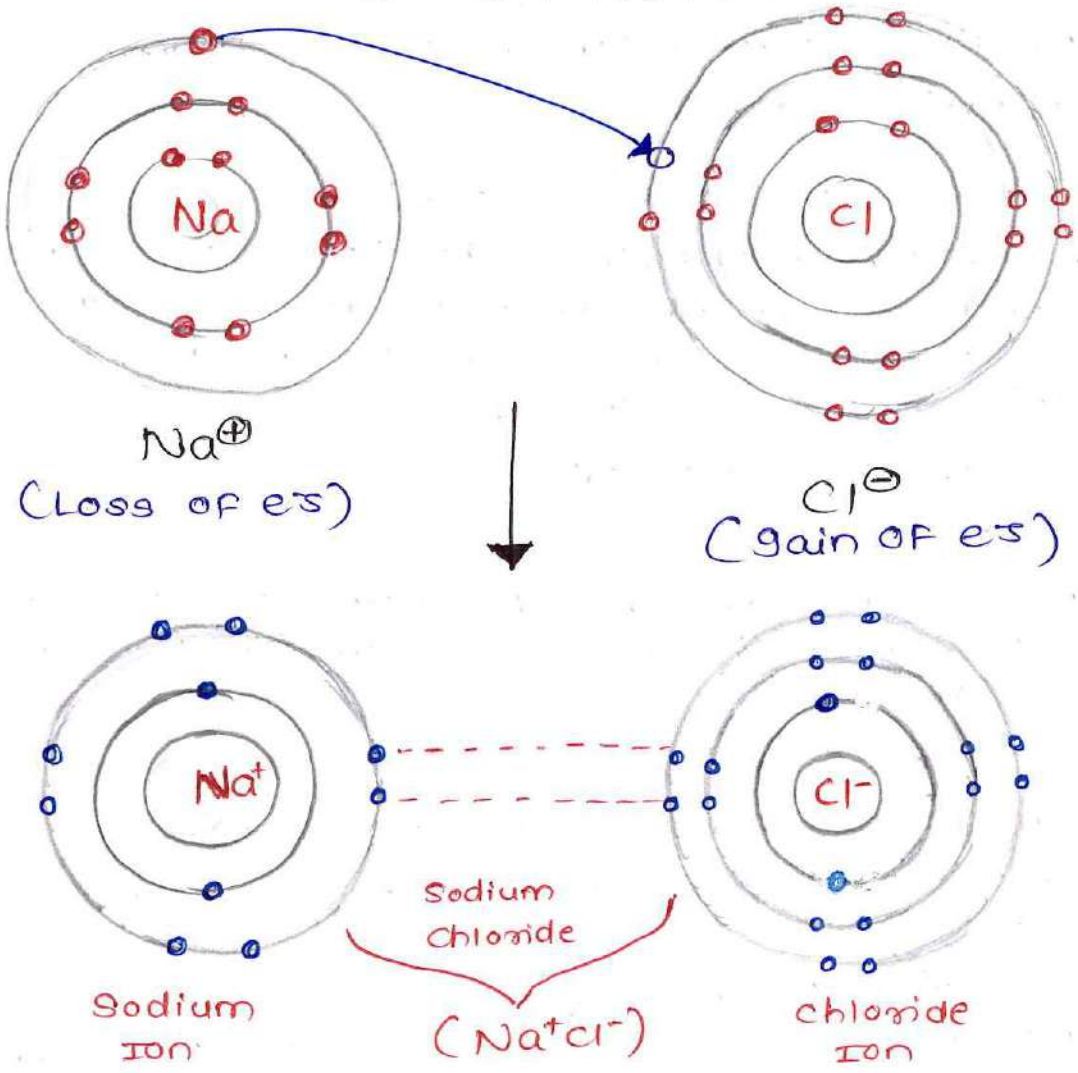
Electron affinity ∝ Formation of Anion.

Formation of sodium chloride (NaCl) -

- molecule of sodium chloride (NaCl) consist of one atom of sodium and one atom of chlorine. it is formed by electrovalent linkage.

$Na^{11} \longrightarrow (2,8,1)$ & $Cl^{17} \longrightarrow (2,8,7)$

- In the formation of sodium chloride sodium atom loss it's one valence electrons & acquirs +ve charged & attain stable configuration of nearst inert gas element Neon (2,8).
- the lossed electrons sodium atom is gained by Chlorine atom it acquirs -ve charge & attains stabel configuration of nearest inert gas element Argon (2,8,8).



$Na^{\times} + \dot{\underset{\cdot\cdot}{\overset{\cdot\cdot}{\underset{\cdot\cdot}{\overset{\cdot\cdot}{Cl}}}}}: \longrightarrow Na^{+} + [:\underset{\cdot\cdot}{\overset{\cdot\cdot}{\underset{\cdot\cdot}{\overset{\cdot\cdot}{Cl}}}}:] \longrightarrow Na^{+}Cl^{-}$

(2,8) (2,8,8)

Electrovalent Bonding / Ionic Bonding

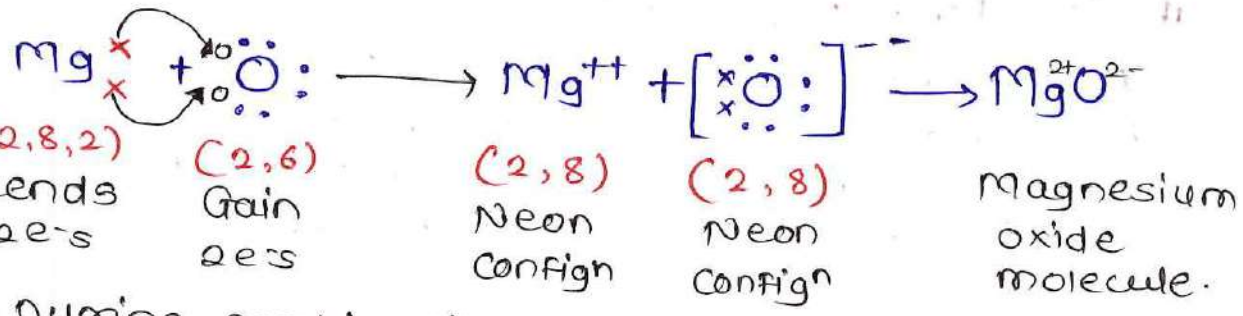
Formation of MgO - (Magnesium oxide) -

- In a molecule of magnesium oxide one atom of Mg combines with one atom of oxygen.

for e.g.

^{12}Mg - (2,8,2) - $1s^2 2s^2 2p^6 3s^2$

^{8}O - (2,6) - $1s^2 2s^2 2p^4$



- During combination of two atoms, 2e-s are transfered from Mg atom to oxygen atom, Hence Loss of 2e-s of Mg atom & Mg acquire +2 charge on itself and occurs stable configuration of nearest inert gas element neon and Loss of 2e-s from Mg atom are gain by oxygen atom & acquired -2 charge and attains stabel configuration nearst to inert gas element. therefore such types of atoms take places by Loss & gain of electrons is called 'electrovalent Linkage'

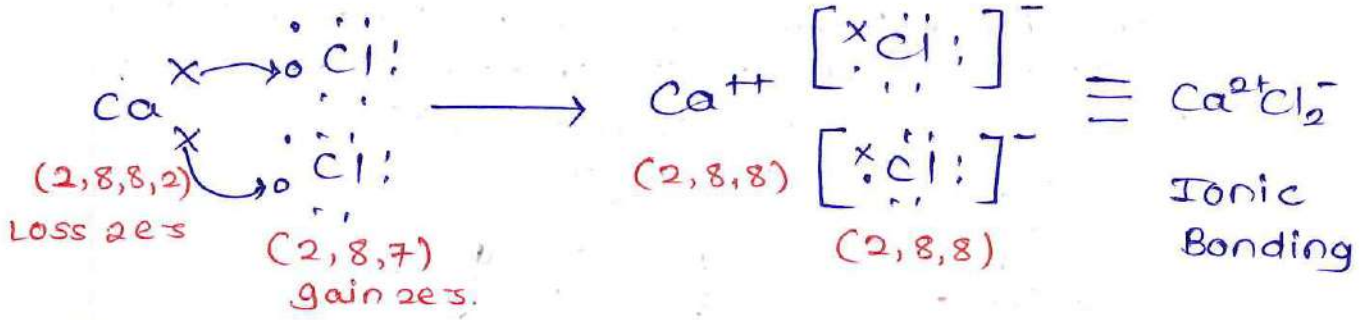
- the compound form these bond is called 'electro-valent compound" or "Ionic compound".

Formation of calcium chloride ($CaCl_2$) -

- It is formed by electrovalent Bond Linkage.
- In which one atoms of Ca is combine with other two elements of Cl.

^{20}Ca = (2,8,8,2) = $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

^{17}Cl = (2,8,7) = $1s^2 2s^2 2p^6 3s^2 3p^5$



- In formation of $CaCl_2$, Calcium atom Losses 2e-s & Cl-atoms gains 2e-s Ca- aquires +2 charge (Ca^{2+}) & thes Losses electrons transfer towards the Cl^- atom

and each Cl-atom gains 1-e's and occurs -ve charge acquired stabel configuration of Argon.
- these equal and opposite charged ion combines themselves by electrostatic force of attraction and formation of $CaCl_2$.

Covalent Bond :-

A covalent bond is the bond formed by the mutual shairing of electrons between similar or disimilar atoms of an element to complete their Last shell is know as covalent Bond.

(or)

- A covalent Bond is bond formed by the mutual shairing of electrons between two Non-metal atoms.

- one bonding pair of e's form single covalent Bond.

e.g. $H_2, F_2 \longrightarrow H-H, F-F$

Single Bonding

- Two or three pairs of electrons from double or triple bond respectively.

For e.g. $O_2 \longrightarrow O=O$ double bonding

$N_2 \longrightarrow N \vdots\vdots N \longrightarrow N \equiv N$ Triple Bonding

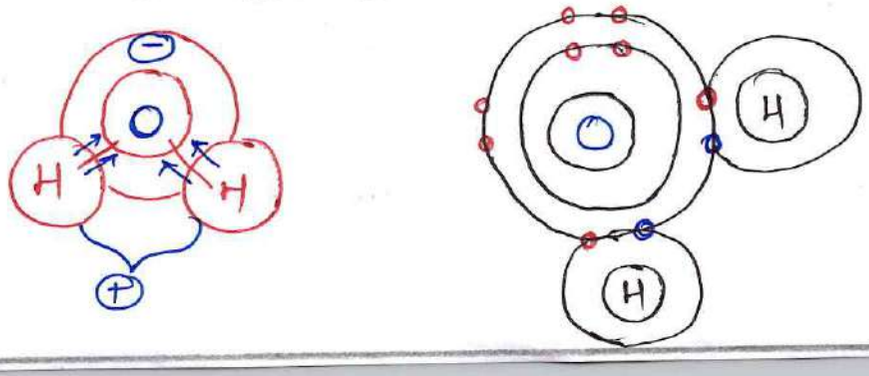
- The bond between all polyatomic ions & diatomic ions are called covalent Bond.

Types of Covalent Bond :-

(1) Polar Covalent Bond
(2) Non-polar covalent Bond.

(1) Polar Covalent Bonds :

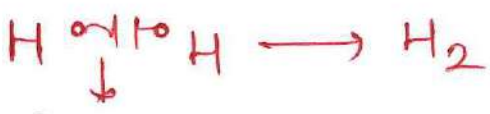
The bond forms due to the partially shairing of electrons i.e. unequally shairing of electrons.
for e.g. H_2O (water molecule)



water is polar molecule because oxygen is more electro negative than H-atom & e⁻s pulled closer to itself (oxygen).

② Non-polar covalent Bond :-

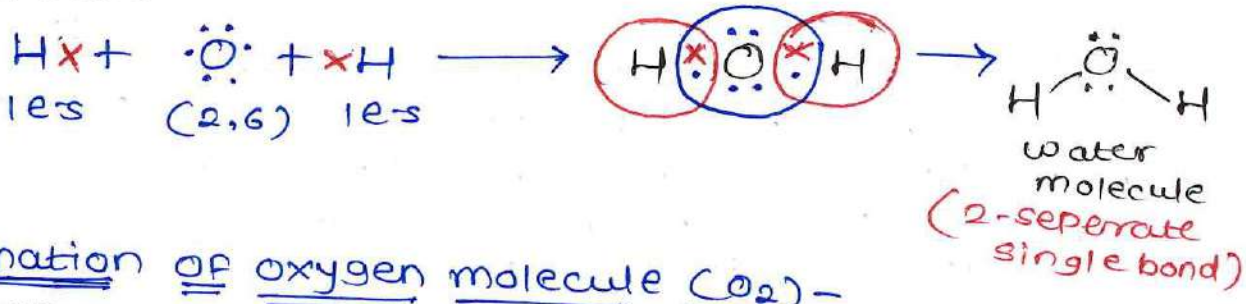
When electrons are shared equally.
fore.g. H_2 or Cl_2



Formation of water molecule (H_2O) -

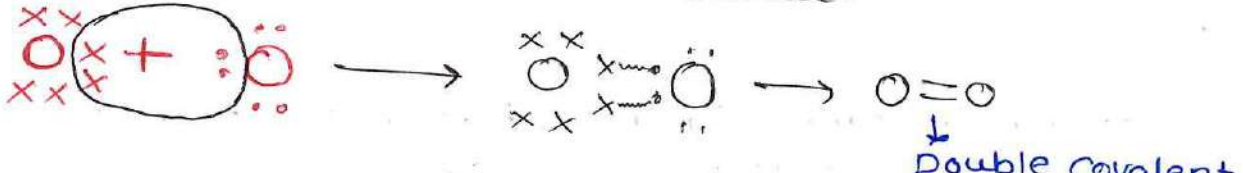
- water molecule is formed by combining 2- atoms of H-atom and 1-atom of oxygen
- During these combination H-atom complete their duplet (dublet) by contributing one e⁻s with oxygen atom & oxygen atom completes It's octate by shairing 2 e⁻s with two H-atom.

therefore,



Formation of oxygen molecule (O_2) -

- oxygen molecule (O_2) contain 2-atoms of oxygen, Hence it is diatomic
- each O-atom containing 6 e⁻s in Last shell & they need 2-e⁻s to complete It's octate.

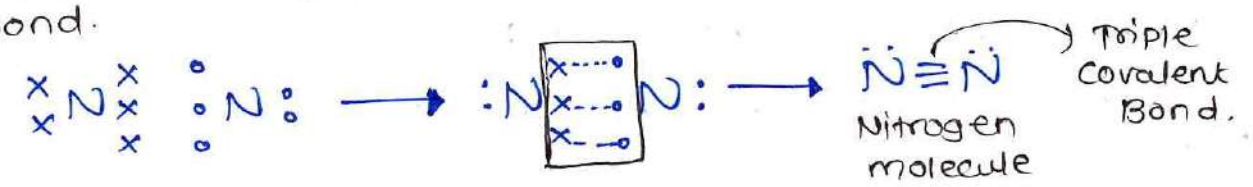


- In the formation of oxygen molecules, each oxygen atom shares two electrons with other oxygen atom to complete the octet.
- Hence there are two shared pairs which constitute double covalent bond between two oxygen atoms

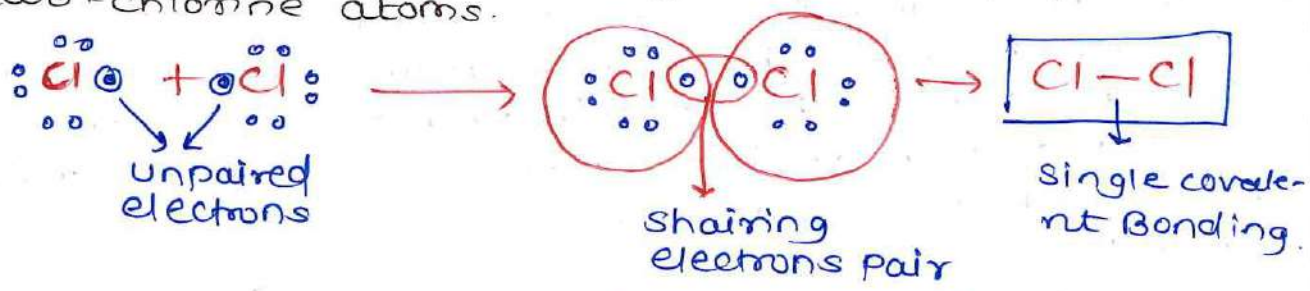
Formation of Nitrogen molecule (N_2) -

- Nitrogen molecule is formed by combining two atoms of N- Hence is called diatomic
- Each Nitrogen atom (2,5) is need of 3electrons to complete It's octate.
- Each Nitrogen atom contributes 3electrons for shairing

- Nitrogen molecule is formed by shairing 3-pairs of electrons between 2-Nitrogen atoms
- these shairing pairs electrons constitute triple covalent Bond.



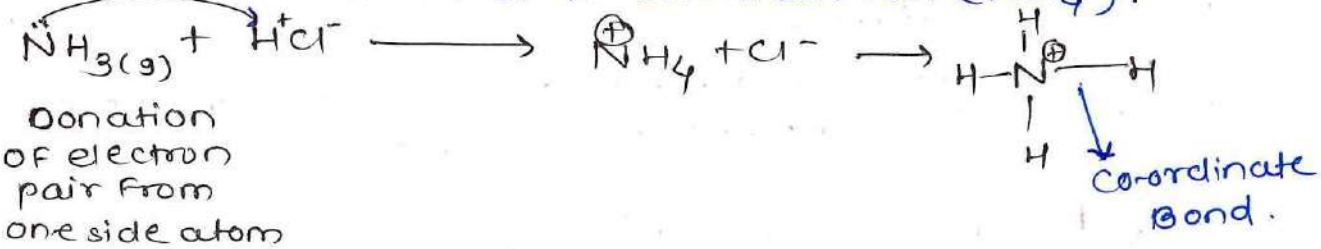
Formation of chlorine molecule (Cl_2)-
- In the formation of Cl-molecule one atom of chlorine combines with other atom of chlorine.
- Each Cl-atom contain (2,8,7) — 7 valence electrons therefore need of 1 e's to complete there octate. Here each Cl-atom containing / contribute 1-electron with other Cl-atom to form 'single covalent Bond' between two-chlorine atoms.



Co-ordinate Bond :- (Dative Bond)
- Co-ordinate Bond is type of covalent Bond in which both electrons are shared by only one atom.

(or) A bond formed by shairing of an electron pair donated by one atom only is called a coordinate Bond.

For e.g. Formation of Ammonium ion (NH_4^+) :-



- Nitrogen in Ammonia (NH_3) has a lone pair of electrons
- Hydrogen ion (H^+) has no electrons
- Nitrogen donates both electrons to Hydrogen & form Coordinate Bond

Metalic Bond :-
- metalic bond is the force of attraction between positively charged metal ions & free-moving electrons in metal (sea model)

o In metals, outer electrons are loosely held & become free to move. these free electrons move throughout the metal structure & hold the metal ions together.

-We sea see models - 3 have been proposed as follows-

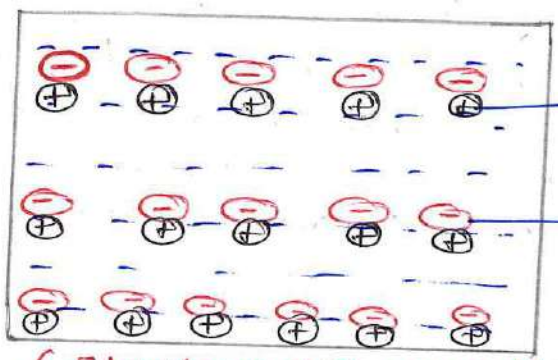
(1) The free electron model
(2) The valence bond model
(3) The band-model - molecular orbital.

(1) The free electron model -

- "the free electron model states that metals contain free-moving electrons responsible for their electrical & thermal conductivity"
- metal atoms lose their outermost electrons easily.
- these electrons become free electrons or delocalized electrons
- positive metal ions remain fixed in position.
- Free electrons move randomly between the ions like "sea of electrons"

* Free electrons Helps metal conduct electricity & Heat
* The movement of electrons also give metals - Lustre (shine), malleability, Ductility.

For e.g. copper metal -
-copper atoms release some electrons move freely through the metal



(Electron sea model)

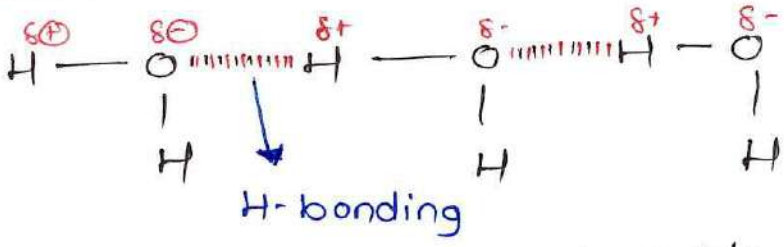
Metalic properties :-

(1) High electric conductivity -
(2) High thermal conductivity
(3) Metalic Lusture
(4) High tensile strength
(5) softness, malleability & ductility

Hydrogen Bond :-

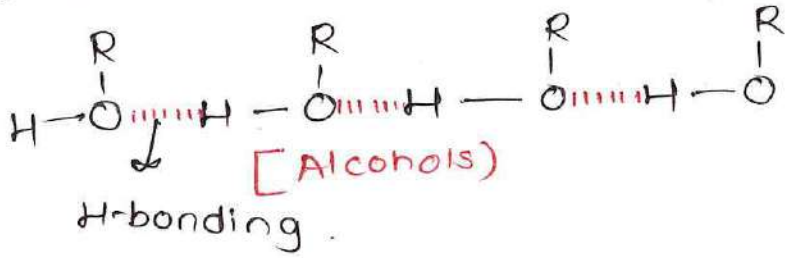
-Hydrogen Bond is a weak chemical bond formed between a Hydrogen atom and highly electronegative atom like oxygen (O), Nitrogen (N) or Fluroine (F)
(or)
- Electrostatic force of attraction between strongly electronegative element such as F, O & N and Hydrogen atom slightly electropositive with respective atom is called Hydrogen bond.

For e.g. In water (H_2O) Hydrogen of one water molecule is attracted to oxygen of another water molecule.



• If water does not carry H-bonding then it consider as - gas & No life would haven been possible on this globe.

e.g. Alcohols, carboxyalic acids, amines also form associated molecule for the same reason.



Types of H-bonding :-

Hydrogen bonds are 2-types -

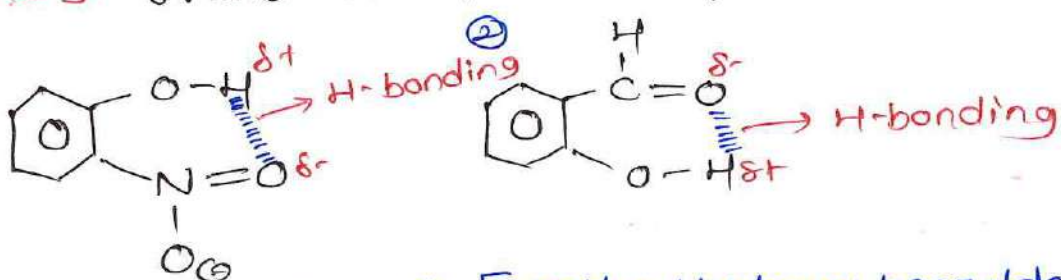
(1) Intramolecular H-bonding
(2) Intermolecular H-bonding.

(1) Intramolecular H-bonding - (In same molecule)

- In this bond Hydrogen atom & electronegative element both are present within the molecule or same molecule is called Intramolecular H-bonding.

For e.g. ortho-Nitrophenol & ortho-Hydroxy benzaldehyde

(1)

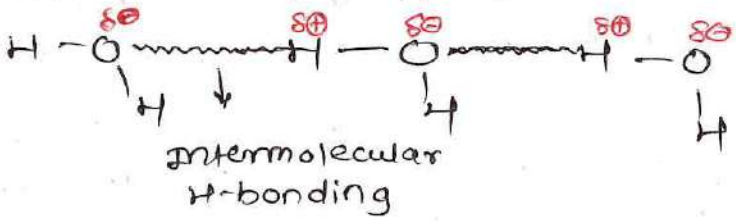


[ortho-Nitro phenol] [ortho-Hydroxy benzaldehyde]

(2) Intermolecular H-bonding - (In different molecule)

- In intermolecular H-bonding H-atom and other electro-negative atoms are present in different molecules of the same substances.

For e.g. water, HF, Ammonia, alcohol & Acids.



Effect of H-bonding on properties -

① Boiling point - Having Intermolecular H-bonding show higher Melting point and B.P.

(ex) Fore.g. B.P. of ethanol is - 78.5°C while dimethyl ether is 23°C.

② solubility in water - due to H-bonding water show Higher solubility than other that are not making H-bonding.

Fore.g. - Lower alcohols are highly soluble in water but alkanes are insoluble, because alkanes Cannot make H-bonding.

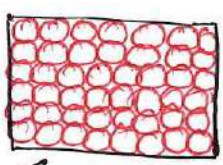
③ Physical State of matter - Due to H-bonding water molecule found in Liquid state.

significance of H-bonding -

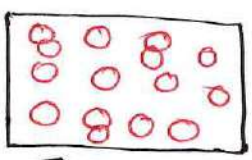
- water exist in Liquid state because of H-bonding in it.
- two coils of DNA-molecule are Held together by H-bonding at specific places.
- Tertiary structure of protein is Largely affected by H-bonding.
- H-bonding plays imp. role in making wood fibers more rigid & thus makes it an article of great utility.
- The stickiness of glue or Honey is due to H-bonding.

Molecular Arragement in solid, Liquid & Gases :-

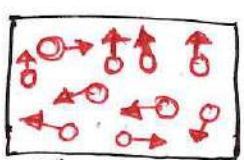
o the molecular arragement in solid, Liquid & gases If different with regards to packing atoms / molecules, shape, volume etc.



[solid] (A)



[Liquid] (B)



[Gas] (C)

(A) In solid, the atoms are closely packed & Held in Place due strong chemical forces. It has definite shape & volume

(B) In a Liquid, the atoms are held together by weak chemical forces, & can have movement around themselves it has definite volume but acquire shape of container

(C) In gas the atoms are not held together, the atoms can move around freely. It has no-definite shape

Solid	Liquid	Gas
• Atoms are closed Packed	Atoms have moderate	Atoms have Large space.
• molecules ~~does not~~ have definite shape	molecules have no shape, but acquire shape of container	molecules does not have definite shape.
• strong chemical process forcess	weak chemical forees	No chemical forces
• molecules remaining same volume & shape	molecules remains in same volume in container	molecules expand to till container & also get compressed under pressure.

Structure of solid :-

The structure of solids reffers to ~~arrag~~ arrangement of particles (atoms, ions or molecules) in a solid substance. solid are mainly classified into 2-types based on particle Arragement :

1. Crystaline Solids
2. Amorphous Solids

1. Crystaline solids – (Ionic Bonding)

- the crystaline form of Ionic compounds. An ionic crystal consist of ions bound together by electrostatic attraction
- crystaline solids, particle are arraged in regular & repeating pattern.

• Characterstics –

1. Definite shape & volume
2. sharp Melting point
3. ordered arragement of particles
4. Anisotropic Nature (Prop. vary diff. direction)

for e.g. Sodium Chloride, Diamond, Quartz.

2. Amorphous solids – (Covalent Bonding)

In Amorphous solids, particles are arranged randomly without a fixed pattern

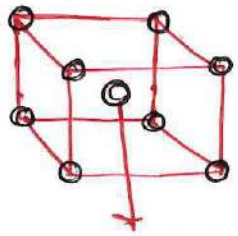
• Characterstics –

1. No sharp Melting Point
2. irregular ~~arrag~~ arrangement
3. Isotropic nature (same properties in all direction)

For e.g. Polonium

- Co-ordination number of SC = 6

(2) Body-centered cubic (BCC)-



Atoms at centre

- Atoms in BCC = Atoms at corner + Atoms at centre.

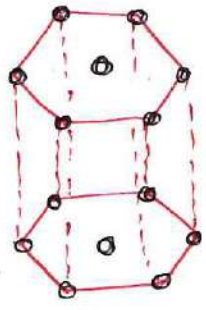
$$= \left(\frac{1}{8} \times 8\right) + 1$$

$$= 2$$

∴ Co-ordination Number of BCC = 8

For e.g. Fe, Cr, W (tagstun) etc.

(3) Hexagonal closed Packed :- (HCP)



(HCP)

- A Hexagonal closed packed (HCP) structure is type of crystal arrangement in which atoms are packed very closely together for maximum space utilization.
- Number of Atom in HCP unit cell

∴ Total Number of atoms = 12-corner atoms $\times \frac{1}{6}$ + 2 Faced-centered Atoms $\times \frac{1}{2}$ + 3-atoms completely inside

$$= 12 \times \frac{1}{6} \times 2 \times \frac{1}{2} + 3$$

$$= 2 + 1 + 3$$

∴ Total Number of atoms HCP = 6

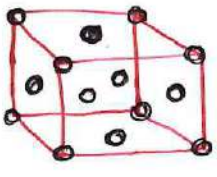
for e.g. Mg, Zn, Cd, Berilyum, Co, graphite etc.

- Co-ordination number of HCP = 12

- An atom is directly surrounded by how many nearest atom is called Co-ordination number.

For e.g.

(4) Face centred cubic (FCC) ⇒



- Face centered cubic (Fcc) unit cell is a cubic crystal structure in which atoms at all 8 corners of the cube and centre of each of 6-faces

For e.g. Glass, rubber, plastics, rubber, gels etc.

Properties of metalic solids -

- Metallic solids are solids in which metal atoms are held together by metalic bonds formed due to the attraction between positive metal ions & free electrons.

• Characteristics of metalic solids -

(1) Good conductors of electricity - Free electrons move easily & carry electric current
(2) Good conductors of heat - Heat transfers quickly through free electrons.
(3) Malleable - Metals can be beaten into thin sheets.
(4) Ductile - Metal can be drawn into the wires
(5) Lustrous (shiny) - Free electrons reflect light
(6) High M.P & B.P.

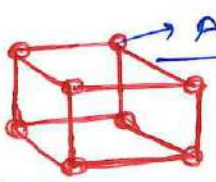
For e.g. Iron (Fe), copper (Cu), Alluminium (Al), Silver (Ag), Gold (Au).

Types of Ionic Crystals -

- The basic simplest arrangement of spheres, which can represented / reproduce the entire crystal structure of the molecule, is called unit cell.

(or)

Unit cell is the smallest, repeating unit of crystal lattice which, when repeated in all directions, form the complete crystal structure



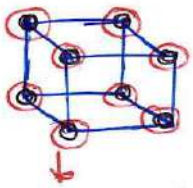
(Simple unit cell)

• Number of atoms in unit cell -
Each corner atom is shared by 8 unit cell
contribution $= \frac{1}{8}$

Types of unit cell :-

(1) Simple cubic (SC)
(2) Body-centered cubic (BCC)
(3) Face-centered cubic (FCC)
(4) Hexagonal closed cubic (HCP)

• Simple cubic - (primitive cubic)



Atoms in simple cubic $= \frac{1}{8} \times 8$

= Each corner atom contribution × atom per unit cell

[Atoms in simple cubic = 1]

Total Number of atoms in FCC = Face side Atom + corner atom

$= \left(\frac{1}{2} \times 6\right) + \frac{1}{8} \times 8$

$= 3 + 1$

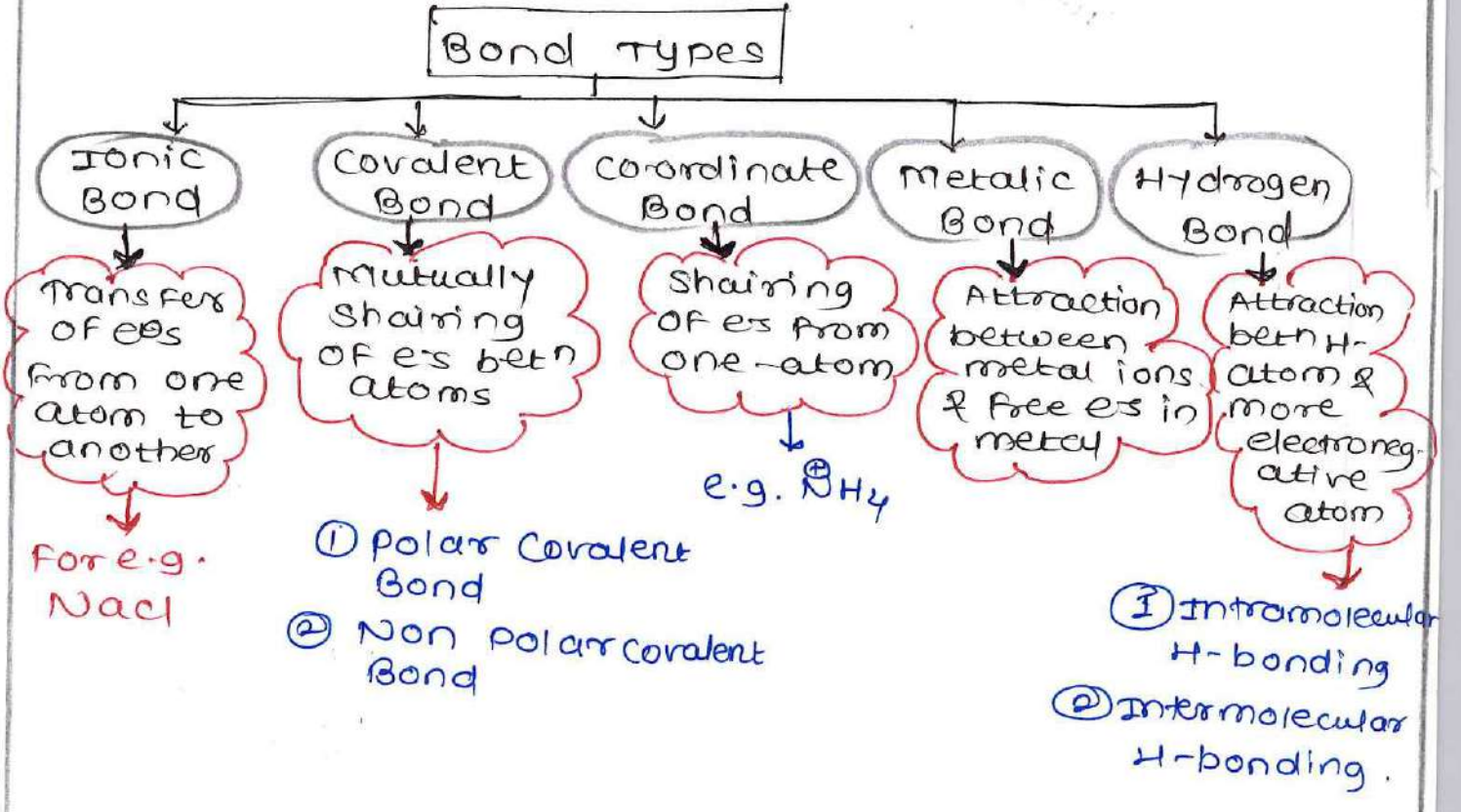
Total Number of atoms in FCC = 4

- Co-ordination Number of FCC = 12

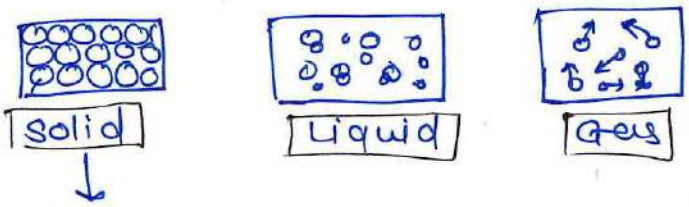
For e.g. Mg, Cd, Zn, Silver (Ag), Gold (Au), Copper (Cu), Alluminium (Al) etc.

- Summary :-

- Philosophy of atom by - Aachanya Kandd / Maharshi Kanad - 600 BCE
- Electronic theory of valency -
- Valency - electrons present in outermost shell of atom.
- Types of Bonds -
- Chemical Bond - Electrostatic force of Attraction between atoms.



- Molecular Arrangement → Solid, Liquid, gas.



↓

(1) Crystaline
(2) Amorphous

Types of Ionic crystals / Unit cell

	Atoms	Coordination No.
(I) Simple cubic (SC)	SC - 1	6
(II) Body centered Cubic (BCC)	BCC - 2	8
(III) Face-centered Cubic (FCC)	FCC - 4	12
(IV) Hexagonal closed Cubic (HCP)	HCP - 6	12

Subject Incharge - Ms. S.N. Patil / Mrs M.R. Patil

20/05/26 20/5/26

Head of Department -

20/5/2026

[Assignment Question]

• Unit -1 Chemical Bonding •

Q.1) Define the term valency with their example.

Q.2) Explain electronic theory of valency with their suitable example.

Q.3) Define chemical Bond ? and give it's types.

Q.4) Define - ① Ionic Bond ③ Co-ordinate Bond
② Covalent Bond ④ Metalic Bond
⑤ Hydrogen Bond.

Q.5) Explain Ionic Bond with suitable example.

Q.6) Describe formation of NaCl molecule with diagram & their type of Bonding.

Q.7) Explain types of covalent Bond.

Q.8) Define covalent Bond ? write their types.

Q.9) Explain Intramolecular and Intermolecular Hydrogen bonding with their suitable example.

Q.10) Write significance of Hydrogen Bonding ?

Q.11) Distinguish between Solid, Liquid & gas.

Q.12) Write the types of Ionic crystal.

Q.13) Calculate number of atoms in BCC, FCC, HCP, SC Unit cell ?

Q.14) Differentiate between crystaline solid and amorphous solid ?

Q.15) Explain the formation of N_2 molecule with their bond types?

20/05/26

MRPatil
20/05/26

⟵ Best of Luck ⟶

20/5/26