Chapter- 01

The smallest unit of an element is called atom.

Fundamental particles are:

1) Stables particales: Proton, Neutron and Electron

(2) Unstable particles: Present in atom very short time, Like neutrino, anti-neutrino, positron and meson etc.

(3) Composite particles: Other than stable and unstable Like deuteron and alpha.

Atomic symble: mass number Z ±n, Atomic number = A

	Mass(Kg)	R.mass
proton → p^+ →	1.673×10^{-27} →	1
Neutron → n^0 →	1.675×10^{-27} →	1
Electron → $\bar{e}$ →	9.109×10^{-31} →	0.00055

Isotope: same atomic number but different mass number.

For example: Hydrogen (^1_1H), Deuterium (^2_1H) Tritium (^3_1H)

Isobar: same mass ~~m~~ number but different atomic numbers

Isotone: same neutron number but different proton numbers

Rutherford Atom model: Limitation -

(i) Rutherford atom model was unstable to explain the stability of an atom.

(ii) The model didn't explain how electrons are arranged in orbits around the nucleus.

(iii) Some of the Rutherford's postulates were inaccurate.

(iv) The model didn't follow Maxwell's theory, which states that accelerated charged particles release electromagnetic radiation.

(v) Nucleus: Later discoveries of Protons and neutrons nullified hypthasis of the Rutherford model.

Bohr's atomic model:

(1) The electron revolves different energy level such as K, L, M and N etc.

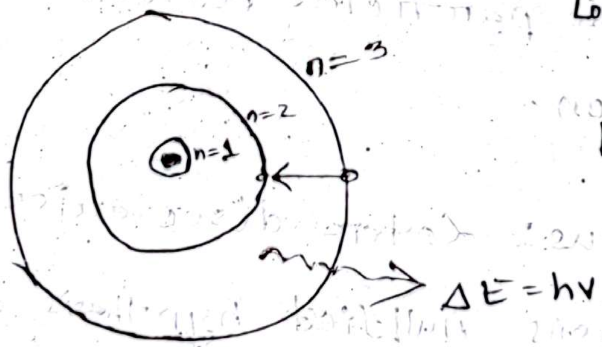
(2) Angular momentum of electron can be expressed -

$$mvr = n \times \frac{h}{2\pi};$$

Where, n = 1, 2, 3, 4 ..... etc
m = mass of the electron
v = velocity of the electron
r = radius of the orbits
h = Plank's constant

(3) It define the when electron absorb and emits energy. The energy absorbed by the electron -

$$\Delta E = E_2 - E_1 = h\nu$$



Lower to higher level = Absorbs energy

higher to lower level = emits energy

Q. Difference between orbit and orbital.

⇒ Difference are given below -

	Orbit	Orbital
Definition	The path that an electron follows around the nucleus is an atom	The region in space around the neucleus where there is a high probability of finding an electron
Shape	Circular or elliptical path	defined specific shapes: s (spherical), p (dumbbell), d, f orbitals
Energy level	Only fixed energy levels are allowed	Contains sublevels within each energy level, each with distinct shapes and energies
Electron position	Assumes a fixed path and precise location	Defines a probability region; exact position cannot be pinpointed
Example	K-shell, L-shell	1s, 2p, 3d orbitals

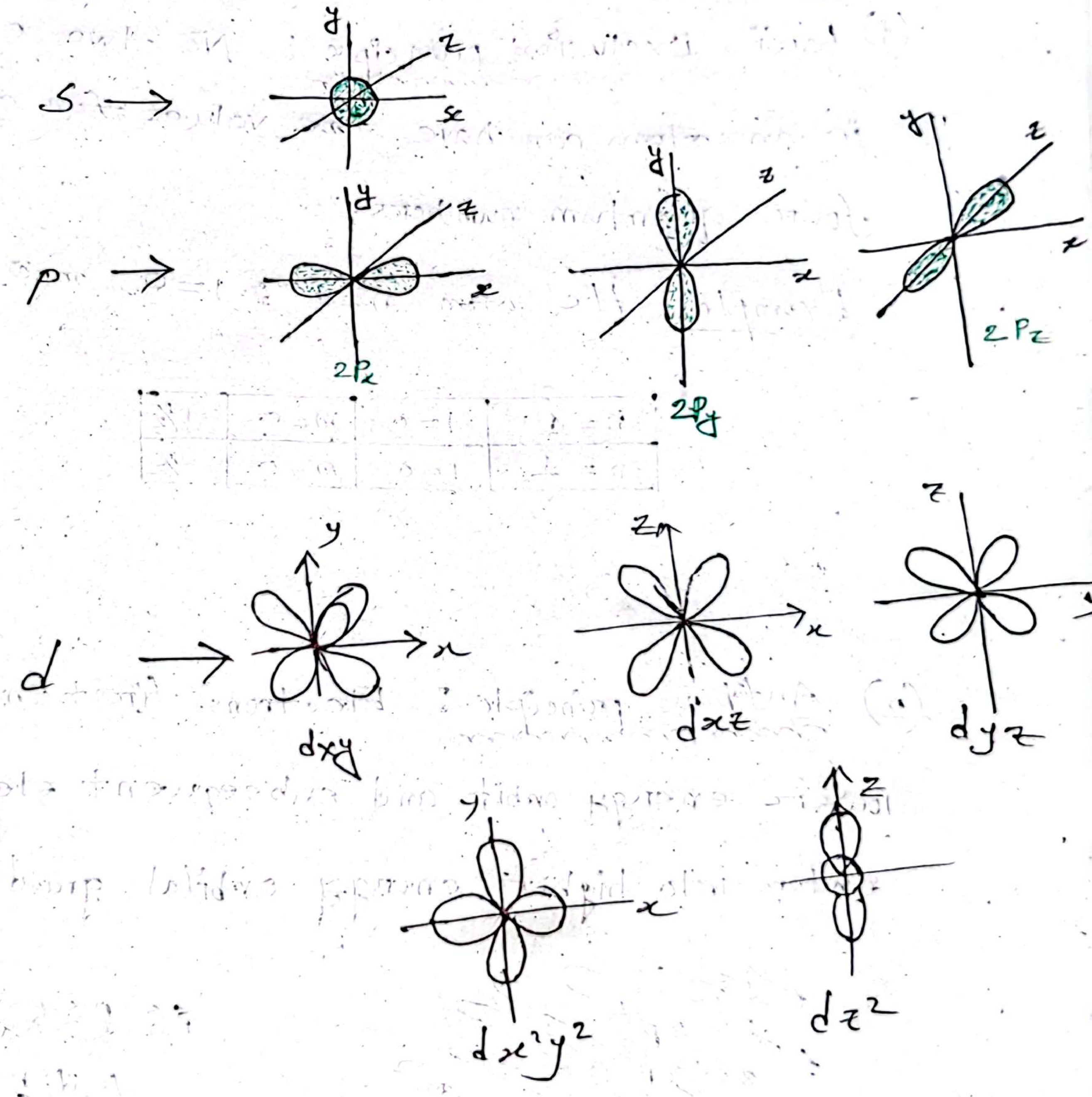
Quantum number ?

= A quantum number is value that describes the position and energy of an electron in an atom.

There are four types of quantum number:

	$n = 1, 2, 3, 4, \dots \infty$	$l = n-1$	$-l, +l$		Max electron
orbit	principle quantum number (n)	Azimuthal q. n. (l)	Magnetic q. n. $m = -l \to +l$	Spin quantum n.	
K	1	0 (s)	0	$+\frac{1}{2}, -\frac{1}{2}$	2
L	2	0 (s) 1 (p)	0 -1, 0, +1	$+\frac{1}{2}, -\frac{1}{2}$	2 + 6 = 8
M	3	0 (s) 1 (p) 2 (d)	0 -1, 0, +1 -2, -1, 0, +1, +2	$+\frac{1}{2}, -\frac{1}{2}$	2 + 6 + 10 = 18
N	4	0 (s) 1 (p) 2 (d) 3 (f)	0 -1, 0, +1 -2, -1, 0, +1, +2 -3, -2, -1, 0, +1, +2, +3	$+\frac{1}{2}, -\frac{1}{2}$	2 + 6 + 10 + 14 = 32

Spatial arrangement of atomic (s, p and d) orbitals:



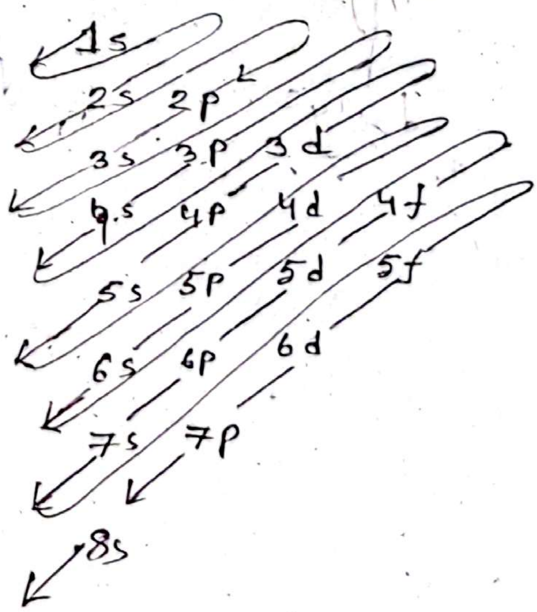
① **Electron configuration** : Distribution of electrons in atom called electron configuration.

(1) **Pauli's Exclusion principle** : No two electron's in an atom can have same values for all the four quantum numbers.

Example: He atom $n=1$; $l=0$; $m=0$; $s=+1/2$; $-1/2$

$n=1$	$l=0$	$m=0$	$s=+1/2$
$n=1$	$l=0$	$m=0$	$s=-1/2$

(2) **Aufbau principle** : Electrons first enter into lower energy orbit and subsequent electrons enter into higher energy orbital gradually.



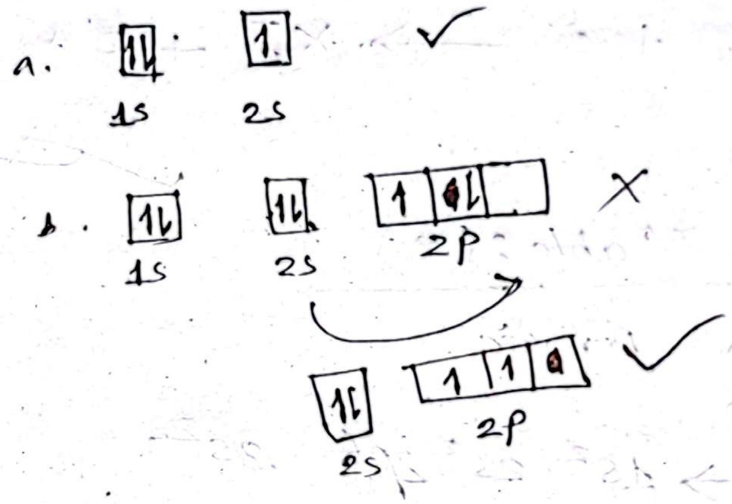
s s p s p s d p s d p s
1 2 2 3 3 4 4 5 5 6

f d p s f d p s
6 7 8

1s 2s 2p 3s 3p 4s 3d

4p 5s 4d 6s 4f 5d

(3) Hund's Rule: Electrons pairing will not take place in orbit of same energy until each orbit is singly occupid



Example configurations:

He (2) $\rightarrow 1s^2$

O (8) $\rightarrow 1s^2\ 2s^2\ 2p^4$

Fe (26) $\rightarrow$ [Ar] $3d^6\ 4s^2$

$\boxed{1-30 \text{ atom}}$

Electron affinity: Electron affinity of an element is the amount of energy released when an electron is added to a gaseous atom to form an anion

$$X_{(g)} + e^- \longrightarrow X^-_{(g)} + EA$$

Periodic Table: (2)

Mendeleev's Periodic

$Mg(12) \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2$; group = 2, Shell = 3 (m)

$S(16) \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$; group = 6+10 = 16, shell - 3^{rd} shell

$Cr(24) \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$;

shell = 4th

group = 6

Periodic properties:

	Left to Right	Top to Bottom
1. Metallic property	Decreases	Increases
2. Atomic size	Decreases	Increases
3. Non-metallic	Increases	Decrease
4. Ionization energy	Increases	Decrease
5. Electron affinity	Increases	Decrease
6. Electronegativity	Increases	Decreases

Ionization Energy: The energy required by one mole of atom to remove one mole of electrons by one electron from each atom is called the ionization energy of that atom.

L → R increase → T → D Decrease

$Na^+_{(10)} \rightarrow 1s^2 2s^2 2p_x^2 2p_y^2 2p_z^2$

$Na_{(11)} \rightarrow 1s^2 2s^2 2p^6 3s^1$

$Na^+ > Na$

$Na^+_{(10)} \rightarrow 1s^2 2s^2 2p_x^2 2p_y^2 2p_z^2$

$Mg^+_{(11)} \rightarrow 1s^2 2s^2 2p^6 3s$

$Na^+ > Mg^+$

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Electron affinity: The energy released by one mole of atoms to add one mole of electrons by one electron to each atom is called the electron affinity.

$Cl > F > Br > I$

Q. Why Cl has high electron affinity than F?

Answer: Cl has more electron and its size is shorter than F

- The ammount of energy released when an ~~atom~~ electron is added to a neutral atom to form an anion.

or • Eletetron affinity is a measure the attraction between the incoming electron and the nucleus.

Electronegativity: Electronegatibvity is a measure of an atom's ability to attract th shared electrons of a covalent bond to itself

Example: $F > Cl > Br > I$

- Electronegativity is the tondency of an atom to attract electrons in a molecule.

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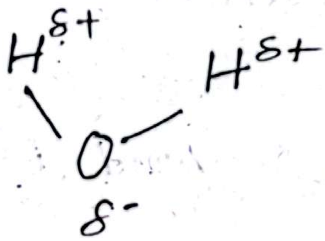
Q. prove that H_2O is a polar compound.

Answer: There are two Hydrogen and one oxygen in water with covalent bond. O is electro negative atom but H is electropositive. Hence partial positive charge generates over H and partial negative charge generates over O. though partial charge generates, H_2O is polar compound.



Chemical Bonding (3)

A chemical bond is defined as a force that acts between two or more atoms to hold them together as a stable molecule.

There are three different types of bonds -

(1) Ionic or Electrovalent bond.

(2) covalent bond.

(3) Coordinate covalent bond.

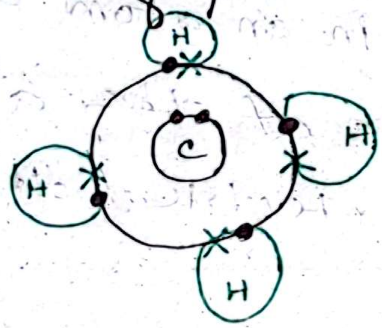
(1) An ionic bond is a chemical bond formed by the transfor of electrons from one atom to another atom, resulting in oppositely charged ions that attract each other

* Electrons are transferred between valence shells of atoms.

* electronegativity difference > 2.

Covalent Bond : A covalent bond involves the sharing of electron pairs between atoms.

These electron pair are known as shared pairs or bonding pairs.



NH_3 - ammonia

H_2O - water

Fig: CH_4 (methane)

- Electronegativity diff. < 2.0
- Low melting and boiling point

Covalent bond

- polar
  - ↳ HCl, H_2O, NH_3 etc
  - electronegativity diff. zero ~~and but~~ less than 2.0
- Non-polar
  - ↳ Cl_2, O_2, H_2 etc
  - electronegativity diff zero

Metallic bond: They are good conductors of heat and electricity

polarization: Polarization is the distortion of the electron cloud in an atom or molecule caused by the influence of ~~the~~ a nearby charged particle or electric field.

Hydrogen bond: A hydrogen bond is a weak intermolecular force formed when a hydrogen atom, covalently bonded to a highly electronegative atom (like O, N or F) interacts with another electronegative atom.

⊛ Difference between ionic and covalent bond?

Ionic Bonding	Covalent Bonding
(i) Transfer of electrons between atoms	(i) ~~Transfer~~ a Sharing of electron pairs between atoms
(ii) Element involved between matals and non-matals.	(ii) Only non-matals.
(iii) Forms positive and negative (anion) ions in formation.	(iii) Forms molecules by sharing electrons.
(iv) Strong bond duo to electrostatic forces between ions	(iv) varies: single bond are weaker, while double and triple are stronger
(v) melting and boiling points high	(v) melting and boiling points lower than ionic compound.
(vi) conducts electricity in molten or aqueous states.	(vi) poor conductor (no free ions), except in some polar moleculars.
(vii) Physical state: at room temperature is solid. Example: NaCl, MgO	(vii) Can be solid, liquid and gas at room temperature. Exmple: H_2O; CH_4

properties of ionic bond –

(I) High melting and Boiling points high.

(II) Hardness and Brittleness : hard because strong attraction between ion

(III) Electrical conductivity.

(IV) solubility (দ্রাব্যতা)

(V) strong electrostatic forces

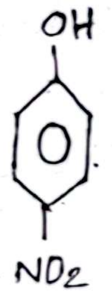
(VI) Formation of crystalline structure.

(VII) Examples – NaCl, MgCl, CaF_2

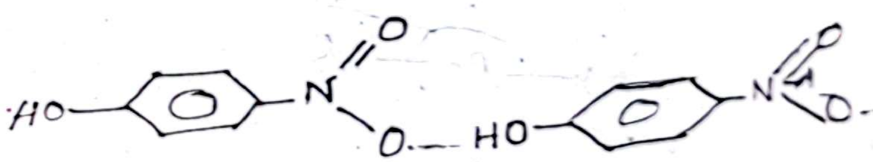
⊕ Difference boiling point of 2-Nitrophenol and 4-Nitrophenol, why?

Soln:

Intermolecular hydrogen bonding is present in p-nitrophenol, molecules association take place due to extensive by hydrogen bonding therefore hydrogen boiling point increase.

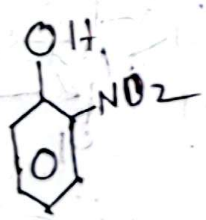


4-Nitro phenal
(279°C)

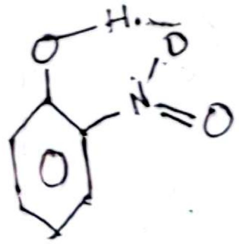


p- Nitrophenal

Intra molecular hydrogen bonding is present in o-nitrophenal, which decrease the boiling point.



2-Nitrophenol
(216°C)



o-nitrophenol

Using VSEPR Theory: Geometry of molecule

① $BeCl_2$

$Be(4) \rightarrow 1s^2\ 2s^2$; It has 2 balance electron

Cl has 7 balance electron :

$\cdot\ddot{\underset{\cdot\cdot}{Cl}}:$

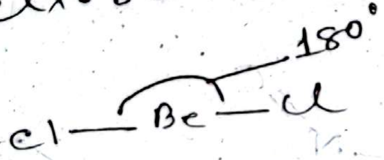
n = 2 ; linear

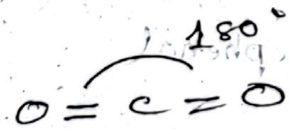
n = 3 ; Trigonal pair

n = 4 ; Tetrahedral

n = 5 ; Trigonal bi pyramm

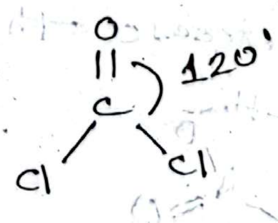
Cl×•Be•×Cl



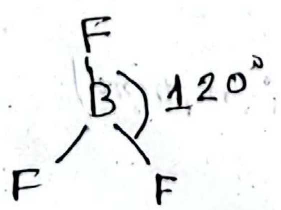
② 

CO_2 : 180°

③ $COCl_2$:

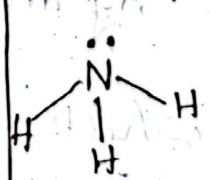


④ BF_3 :

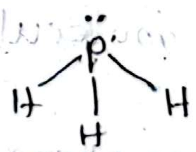


Trigonal Shape planer

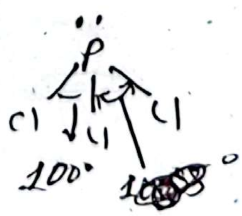
⑥ Trigonal ~~planar~~ Pyramidal :



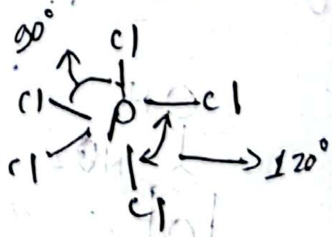
107.3°



AsH_3

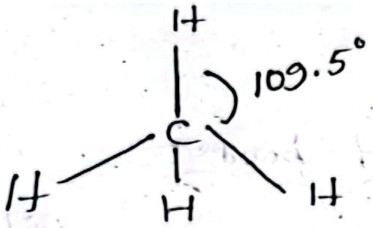


PCl_3 (Trigonal pyramid)



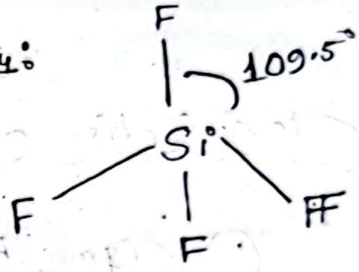
PCl_5 (Trigonal Bipyramid)

(5) CH_4:



$CH_4 = 109.5°$
Shape: Tetrahedral

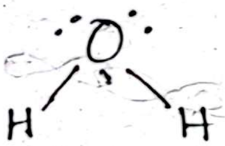
SiF_4:



SiF_4 : 109.5°
shape: Tetraphedral

(7) Bent:

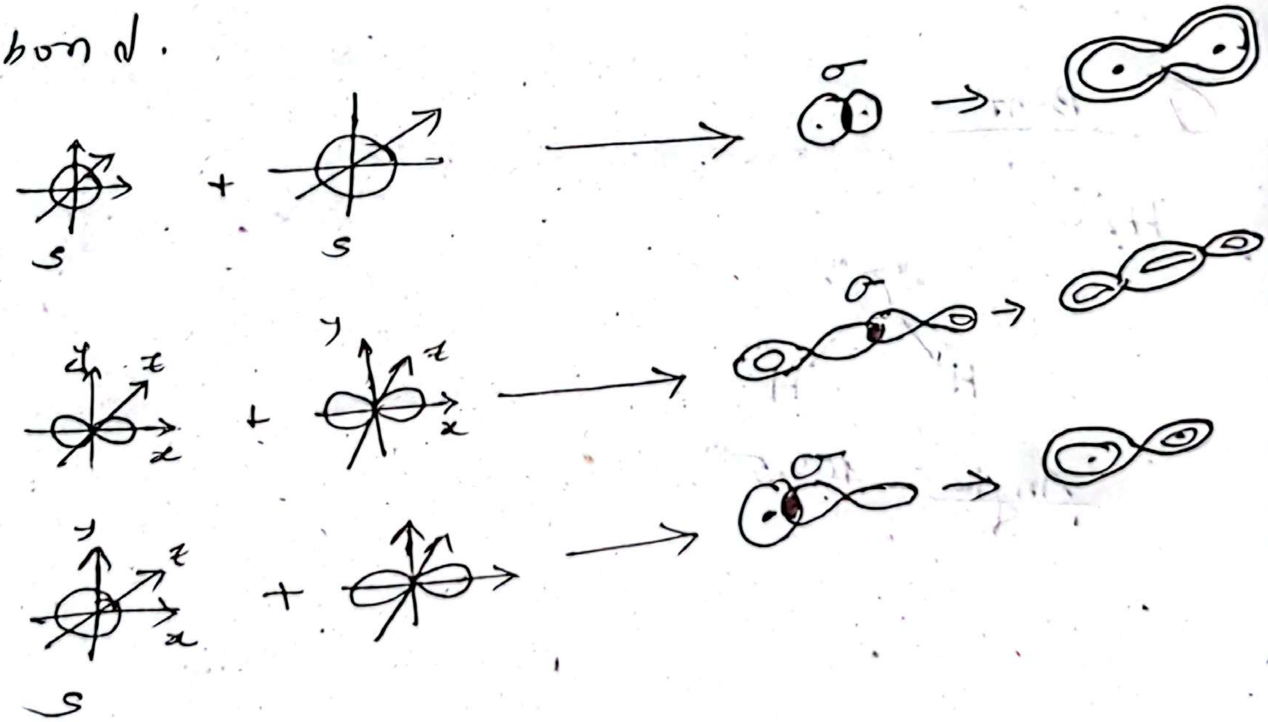
H_2O:



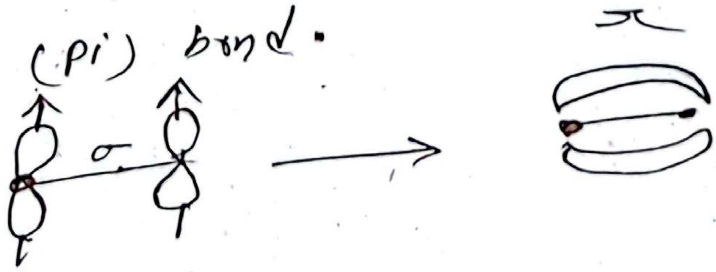
Angle: 104.5°

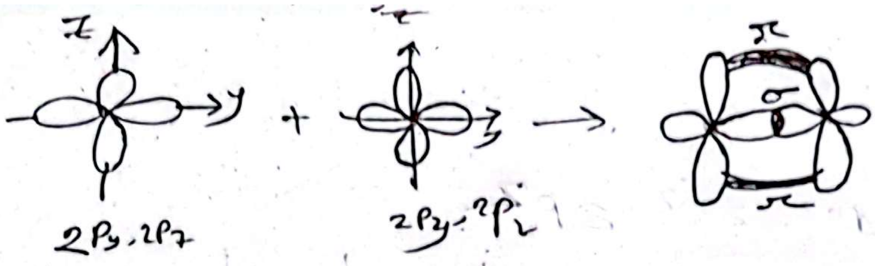
Classification of Co-valent bonds:

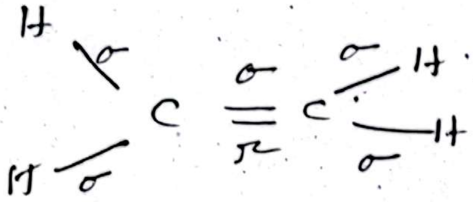
(i) **Sigma bond (σ):** If two orbital (s–s), (s – p) orbital and two p orbital (p–p) facing intersect than we called it sigma bond.



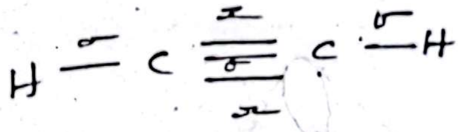
(ii) **Pi - bond (π):** After creating sigma bond between two atoms than two parallal p orbital intersect from side, is called π- (pi) bond.







Eithiline



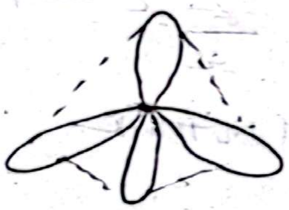
Achitiline

Hybridization :

$C^*(6) \rightarrow 1s^2\ 2s^2\ 2p^2$

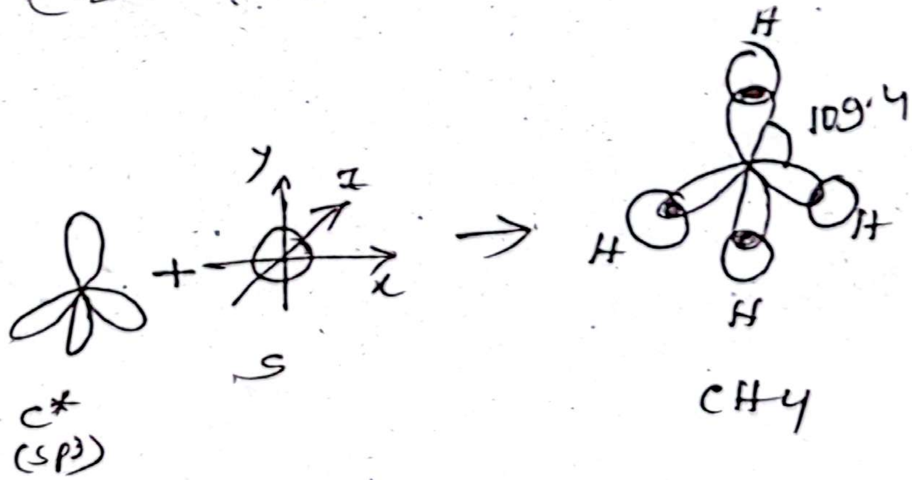
$C^*(6) \rightarrow 1s^2\ 2s^1\ 2p_x^1\ 2p_y^1\ 2p_z^1$

(sp)



sp^3 (চতুস্তলকীয় - tetrahedral

$CH_4 \rightarrow$

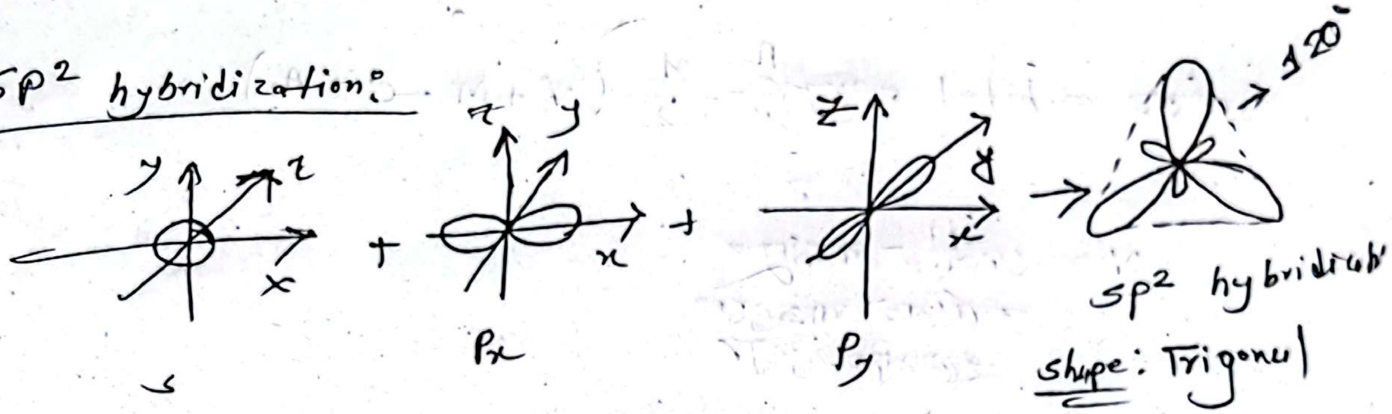


C_2H_4 :

$$\begin{matrix} H & & & & H \\ & \diagdown & & \diagup & \\ & C & \overset{\pi}{=} & C & \\ & \diagup & & \diagdown & \\ H & & & & H \end{matrix}$$

sp^2 — hybridization

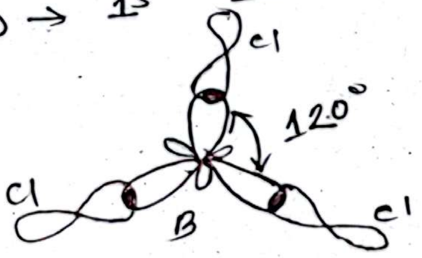
sp^2 hybridization:



shape: Trigonal

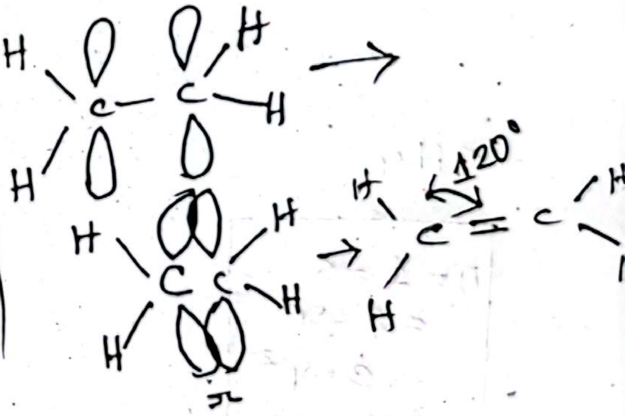
$B(5) \rightarrow 1s^2\ 2s^2 2p^1$

$B^*(5) \rightarrow 1s^2\ 2s^1\ 2p_x^1\ 2p_y^1$



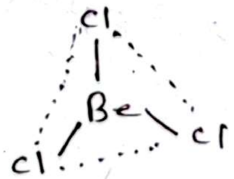
BCl_3

Ethyne: C_2H_4



$BeCl_2 \rightarrow sp \rightarrow Cl - Be - Cl \rightarrow 180° \rightarrow$ lineare

$BCl_3 \rightarrow sp^2 \rightarrow$

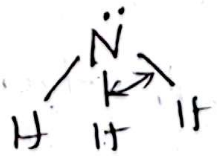


$\rightarrow 120° \rightarrow$ Trigonal planar

$CH_4 \rightarrow sp^3 \rightarrow$

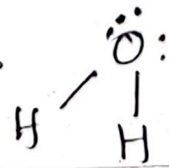
$\rightarrow 109.5° \rightarrow$ Tetrahedral

$\ddot{N}H_3 \rightarrow sp^3 \rightarrow$



$\rightarrow 107° \rightarrow$ Trigonal pyramidal

$H_2O \rightarrow sp^3 \rightarrow$



$\rightarrow 104.5° \rightarrow$ V shape

সংকর orbital সংখ্যা, $n = \frac{1}{2}(V + M - C + A)$

V = কেন্দ্রীয় পরমাণুর সর্বশেষ শক্তিস্তরের ইলেকট্রন সংখ্যা

M = এক যোজী পরমাণু সংখ্যা

C = ক্যাটায়নের চার্জ

A = অ্যানায়নের চার্জ

CH_4:

$$\boxed{\begin{aligned} n &= 1 = s \\ &= 2 = sp \\ &= 3 = sp^2 \\ &= 4 = sp^3 \\ &= 5 = sp^3d \\ &= 6 = sp^3d^2 \end{aligned}}$$

CH_4: $C(6) \rightarrow 1s^2\, 2s^2\, 2p^2$, ∴ $V = 4$

$M = 4$ ∴ Number of H

$$n = \tfrac{1}{2}(4 + 4 - 0 + 0)$$
$$= \tfrac{1}{2}(8)$$
$$= 4$$
$$= sp^3 \text{ hybridization}$$

$PCl_5 : n = \frac{1}{2}(5+5+0-0)$; $V=5$

$M=5$

$C=0$

$A=0$

$NH_4^+ : n = \frac{1}{2}(5+4-1+0)$

$= 4$

$= sp^3$

$CO_3^{2-} := n = \frac{1}{2}(4+0-0+2)$

$= 3$

$= sp^2$

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