

Chemical Bonding

→ The force of attraction which keeps atoms, ions, etc. together is chemical bond.

Octet rule: Ability of atoms & ions to get e⁻ config. of nearest noble gas.

Exception - i) LiCl , BeH_2 , BCl_2

ii) odd e⁻ molecules - NO , NO_2 , ClO_2 , He_2^+

iii) expanded octet - PCl_5 , SF_6 , H_2SO_4 .

Ionic bond: Transfer of e⁻s from metal to non-metal ions.

→ electronegativity diff > 1.7

→ formed two species having high lattice energy.

→ Lattice energy \uparrow = inter ionic attraction \uparrow
- means \rightarrow energy released 1 mole of ionic compound formed from gaseous state

$$LE \propto \frac{q^+ q^-}{r_a + r_c}$$

→ charge on anion is dominating over size for ionic nature.

Ex: Al_2O_3 (covalent) $<$ AlN (ionic)
 $\text{O}^{2-} < \text{N}^{3-}$ size order

Properties: \rightarrow high m.p, b.p & non directional bonds.

\rightarrow Show isomorphism

Isomorphism - i) config. of cation must be same.

ii) hybridisation of anion must be same

Ex: NaClO_4 , MgSO_4

Hydration energy - Ion-dipole attractions formed when ionic compound dissolved in water this is called Vanderwaal's force.

Solubility \propto hydration energy $\propto \frac{1}{LE}$

Ex: $\text{I}^+ < \text{II}^+$ (more soluble)

Polarisation - Ability of small cation to attract an e⁻ cloud towards itself is called polarisation.

Polarisation \uparrow Covalent nature \uparrow solubility \downarrow

$PP \propto \frac{1}{\text{size of cation}} \propto \text{size of anion}$

→ Ionic mobility ↑ from Li^+ to Cs^+ to, electrical conductivity ↑

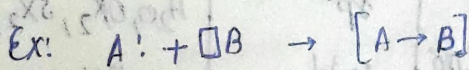
Solubility order: i) $\text{LiClO}_4 > \text{NaClO}_4 > \text{KClO}_4 > \text{RbClO}_4 > \text{CsClO}_4$ (X-Br)
 ii) $\text{LiOH} < \text{NaOH} < \text{KOH} < \text{RbOH} < \text{CsOH}$ (I-Br)

Covalent Bond: The bond formed b/w 2 atoms of ions due to sharing of e⁻.

Covalency - no. of covalent bonds b/w 2 atoms.

Fajan rules - i) small size of anion & large p.f. cation ionic nature
 ii) large charge on cation & anion leads to more covalent nature.
 Ex: NaCl , CsCl
 Ex: NaCl , AlCl_3

Coordinate Covalent bond: It is a special type of covalent bond formed b/w an atom containing 1 or more l.p of e⁻ and an atom deficient to get octet.

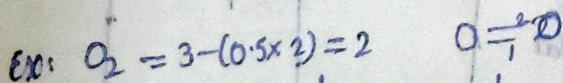


Bond parameters

- I) Bond angle - i) Hybridisation of central atom $\text{B.A} \propto \frac{1}{\text{size of C.M.A}}$
 ii) l.p of e⁻ on central atom $\propto \frac{1}{\text{B.A}}$
 iii) e⁻ of central atom
 iv) e⁻ of terminal atom $\propto \frac{1}{\text{B.A}}$

(H_2O has more B.A than H_2O due to presence of valant 3d orbitals)

II) Bond order - No. of bonds b/w 2 atoms
 $\text{B.O} = 3 - (0.5 \times n)$ $n = \text{diff. b/w e}^- \text{ present from } 14 \text{ e}^-$



III) Bond length - $\propto \frac{1}{\text{stability}} \propto \frac{1}{\text{bond order}}$

IV) Bond enthalpy - amount of energy required to break all atoms in gaseous state.

$\text{B.O} \propto \text{bond strength} \propto \text{B.E}$

Formal charge: $\text{F.E} = (\text{total no. of v.e.}) - (\text{l.p of e}^-) - \frac{1}{2} (\text{no. of bonded e}^-)$



Hybridisation: Mixing of atomic orbitals of same atom.

Forms same size & equal energy.

$$\text{Hybridisation} = \frac{V + m - C}{2}$$

V = no. of valence e^s
 m = no. of monovalent atoms
 C = charge on it.

Formulae	Shape	B.A	hybridisation	example
AB_2	Linear	180°	sp	$BeCl_2, CH_2$
AB_3	Trigonal planar	120°	sp^2	BX_3, CH_3, SO_3, AlX_3
AB_2E	Trigonal Angular	$<120^\circ$	sp^2	SO_2
AB_4	Tetrahedral	$109^\circ 28'$	sp^3	CH_4, XeO_4, NH_4^+
AB_3E	Pyramidal	$<109^\circ 28'$	sp^3	$NH_3, H_3O^+, XeO_3, CH_3^+$
AB_2E_2	Angular	$<109^\circ 28'$	sp^3	H_2O, OF_2, SX_2, TeO_2
AB_5	Trigonal bipyramidal	$120^\circ, 90^\circ, 180^\circ$	sp^3d	PCl_5
AB_4E	See saw (distorted T.H)	$B.A \neq 120^\circ$	sp^3d	SX_4, SeX_4, TeX_4
AB_3E_2	T-shape		sp^3d	ClF_3, BrF_3, IF_3
AB_2E_3	Linear	90°	sp^3d	XeF_2, I_3^+
AB_6	Octahedral	$180^\circ, 120^\circ$	sp^3d^2	SF_6
AB_4E_2	square pyramidal	90°	sp^3d^2	XeF_4
AB_7	Pentagonal bipyramidal	72°	sp^3d^3	IF_7
AB_5E	square pyramidal		sp^3d^2	ClF_5, BrF_5, IO_5

→ \therefore s character in sp - 50%.

sp^2 - 33.33%.

sp^3 - 25%.

Acidic nature & s character.

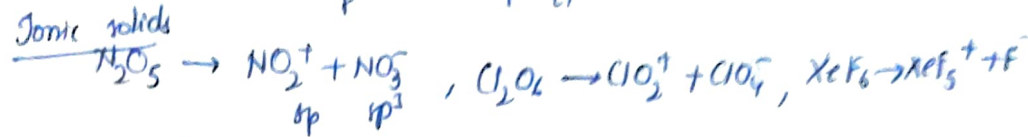
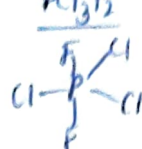
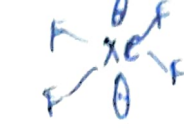
d-orbital used is d_{xy} $\leftarrow sp^3d$ - 20%.

d-orbital used is d_{xy}, d_{yz} $\leftarrow sp^3d^2$ - 16%.

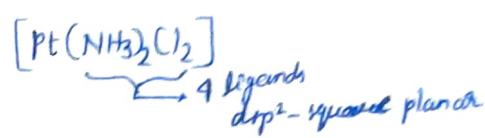
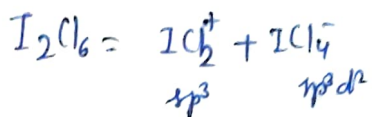
→ Drago's rule - used to explain B.A of hydrides of VA, VIA (8th below 3rd period). Bonding takes place through pure p-orbitals.

→ PCl_5 exists as solid in $[PCl_4]^+ [PCl_6]^-$ sp^3 $sp^3 d^2$ PBr_5 as $[PBr_4]^+ Br^-$

→ if lone pairs occupy axial positions it is the most stable structure.



$[XeO_6]^{4-}$ perxenate ion, $[H_4XeO_6]$ perxenic acid, $[H_2XeO_4]$ - xenic acid



Dipole moment:

$\mu = Q \times d$

μ unit = debye (D), $1D = 3.33564 \times 10^{-30} (C \cdot m) = 10^{-18} (esu \cdot cm)$

→ vector quantity $\xrightarrow{\text{low EN}} \xrightarrow{\text{high EN}}$, $\mu_{res} = \sqrt{\mu_1^2 + \mu_2^2 + 2\mu_1\mu_2 \cos \theta}$

→ for symmetrical molecules (linear, tri-planar, tetrahedral, sq planar, octa, etc) $\mu = 0$

→ for unsymmetrical molecules like (pyramidal, sq-pyr, angular, distorted octa, etc) $\mu \neq 0$

→ for planar molecules $\mu = 0$, non-planar molecules $\mu \neq 0$

→ $\mu \propto EN \text{ diff} \propto \text{no. of lp of } e^-$

\therefore Ionic character = $\frac{\mu_{obs}}{\mu_{cal}} \times 100\%$

$Q = 1.602 \times 10^{-19} C = 4.8 \times 10^{-10} \text{ e.s.u.}$

Formal charge = $\frac{\text{no. of valence } e^- - \text{no. of unshared } e^- - \text{no. of bonds around atom}}{2}$

Valence Bond Theory (VBT)

→ σ bond due axial, π bond due to side wise overlapping.
 $\sigma \text{ bond} > \pi \text{ bond}$, π bond more reactive.

→ $\sigma \text{ p-p} > \sigma \text{ sp} > \sigma \text{ s-s} > \pi$

Molecular orbital theory (MOT)

→ extension of VBT, acc. to VBT O_2 is diamagnetic but paramagnetic O_2 is paramagnetic.

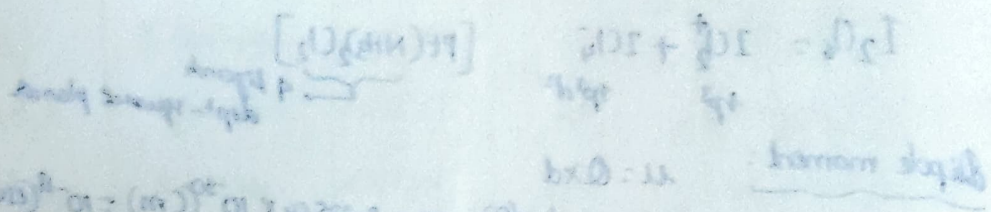
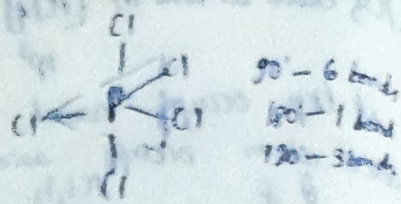
→ no. of atomic orbital = no. of molecular orbitals formed

Energy $\propto \frac{1}{\text{stability}}$

Bonding M.O (B.M.O)
 ↓
 lower energy
 ↓
 higher stability

Anti bonding (A.B.M.O)
 ↓
 higher energy
 ↓
 lower stability

$\text{A} \cdot \text{O} + \text{A} \cdot \text{O} \rightarrow \text{M-O}_2$



For symmetrical molecules (linear, tetrahedral, trigonal bipyramidal, octahedral, etc.)
 Dipole moment = 0
 For unsymmetrical molecules (bent, trigonal pyramidal, etc.)
 Dipole moment $\neq 0$

Valence Band Width (VBI)

Valence bond theory (VBT) is a model of chemical bonding that describes the overlap of atomic orbitals to form molecular orbitals. It is based on the following principles:

- Atomic orbitals (AOs) combine to form molecular orbitals (MOs).
- The number of MOs formed is equal to the number of AOs that combine.
- MOs are formed by the constructive or destructive interference of AOs.
- Constructive interference results in bonding MOs, which are lower in energy than the AOs.
- Destructive interference results in antibonding MOs, which are higher in energy than the AOs.
- The energy difference between bonding and antibonding MOs is the bond energy.
- The bond order is the number of bonding MOs minus the number of antibonding MOs, divided by two.

VBT is a simple model that can be used to explain many aspects of chemical bonding, such as bond strength, bond length, and bond order. However, it is not a complete theory and cannot explain all aspects of chemical bonding, such as the magnetic properties of molecules.

1. $\frac{1}{2}$ of the total population
 2. $\frac{1}{4}$ of the total population
 3. $\frac{1}{8}$ of the total population
 4. $\frac{1}{16}$ of the total population
 5. $\frac{1}{32}$ of the total population
 6. $\frac{1}{64}$ of the total population
 7. $\frac{1}{128}$ of the total population
 8. $\frac{1}{256}$ of the total population
 9. $\frac{1}{512}$ of the total population
 10. $\frac{1}{1024}$ of the total population
 11. $\frac{1}{2048}$ of the total population
 12. $\frac{1}{4096}$ of the total population
 13. $\frac{1}{8192}$ of the total population
 14. $\frac{1}{16384}$ of the total population
 15. $\frac{1}{32768}$ of the total population
 16. $\frac{1}{65536}$ of the total population
 17. $\frac{1}{131072}$ of the total population
 18. $\frac{1}{262144}$ of the total population
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