FREE NOTES · NCERT + JEE/NEET LEVEL

Chemical Bonding & Molecular Structure

Octet rule, Lewis structures, formal charge, ionic bond aur lattice enthalpy, bond parameters, resonance, polarity aur dipole moment, Fajans' rule, VSEPR shapes, valence bond theory, hybridisation, molecular orbital theory aur hydrogen bonding.

01 Octet rule & Lewis structures
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01 Octet rule & Lewis structures

Atoms judte hain taaki bahari shell me 8 electrons ho jaayein (Kossel-Lewis). Covalent bond me electron pairs share hote; ionic bond me electrons transfer.

$$\text{Formal charge} = V - L - \tfrac{1}{2}B$$

V = valence electrons, L = non-bonding (lone pair) electrons, B = bonding electrons. Sabse achhi Lewis structure me formal charges sabse kam. O_3: beech wala O +1, single bond wala O -1.

OCTET RULE KAHAN FAIL

- Adhoora octet: $BeCl_2$ (4), BCl_3 (6), LiCl.
- Odd electrons: NO, NO_2.
- Expanded octet (period 3+): PCl_5 (10), SF_6 (12), H_2SO_4.
- Noble gas compounds (XeF_2, XeF_4); shape ya energy explain nahi karta.

02 Ionic bond & lattice enthalpy

Aasani se banta jab: metal ki ionisation enthalpy kam, non-metal ki electron gain enthalpy zyada negative, aur **lattice enthalpy** zyada (gaseous ions se 1 mol solid banne pe nikli energy). Zyada charge aur chhote ions ⇒ zyada lattice enthalpy. Born-Haber cycle se calculate karte.

03 Bond parameters & resonance

- **Bond length:** C–C 154 pm > C=C 134 pm > C≡C 120 pm.
- **Bond order** ↑ ⇒ bond enthalpy ↑, bond length ↓.
- **Bond angle**: central atom ke aas paas orbitals ke beech ka angle (H_2O 104.5°).
- **Resonance:** jab ek Lewis structure se molecule samjha na sake, asli structure kai structures ka hybrid hoti (O_3, CO_3^{2-}, benzene). CO_3^{2-} me saare C–O bonds barabar (bond order 1.33). Hybrid kisi bhi ek structure se zyada stable.

04 Polarity, dipole moment & Fajans' rule

$$\mu = q \times d$$

Unit: debye (1 D = 3.336 × 10^{-30} C m). Vector hai: + se − ki taraf (chemistry wala arrow + se −).

- Symmetrical molecules ka μ = 0: CO_2, BF_3, CH_4, CCl_4, BeF_2.
- H_2O (1.85 D) bent hai isliye μ ≠ 0. NH_3 (1.47 D) > NF_3 (0.23 D): NH_3 me lone pair ka moment bond moments me judta; NF_3 me ulta.
- cis-isomer aksar polar, trans non-polar; p-dichlorobenzene μ = 0.

FAJANS' RULE (IONIC BOND ME COVALENT CHARACTER)

Zyada covalent jab: **chhota cation, bada anion, zyada charge**, cation ka pseudo-noble-gas (18 e^-) configuration. LiCl NaCl se zyada covalent; $AlCl_3$ covalent.

05 VSEPR theory & shapes

Central atom ke electron pairs ek doosre ko door dhakelte aur jitna ho sake door rehte. Repulsion: **lp–lp > lp–bp > bp–bp**.

bp + lp	Shape	Example, angle
2 + 0	Linear	$BeCl_2$, CO_2 180°
3 + 0	Trigonal planar	BF_3 120°
2 + 1	Bent	SO_2 ~119°
4 + 0	Tetrahedral	CH_4 109.5°
3 + 1	Trigonal pyramidal	NH_3 107°
2 + 2	Bent	H_2O 104.5°
5 + 0	Trigonal bipyramidal	PCl_5 120°, 90°
4 + 1	See-saw	SF_4
3 + 2	T-shaped	ClF_3
2 + 3	Linear	XeF_2, I_3^-
6 + 0	Octahedral	SF_6 90°
5 + 1	Square pyramidal	BrF_5
4 + 2	Square planar	XeF_4

06 Valence bond theory & hybridisation

Bond half-filled orbitals ke **overlap** se banta. Aamne-saamne overlap ⇒ **σ bond** (mazboot); bagal se p–p overlap ⇒ **π bond**. Double bond = 1σ + 1π; triple = 1σ + 2π.

HYBRIDISATION SHORTCUT

$$H = \tfrac{1}{2}(V + M - C + A)$$

V = central atom ke valence e^-, M = monovalent atoms, C = cation charge, A = anion charge. 2 = sp, 3 = sp^2, 4 = sp^3, 5 = sp^3d, 6 = sp^3d^2.

Hybrid	Geometry	Examples
sp	Linear 180°	$BeCl_2$, C_2H_2
sp^2	Trigonal planar 120°	BCl_3, C_2H_4
sp^3	Tetrahedral 109.5°	CH_4, NH_3, H_2O
sp^3d	Trigonal bipyramidal	PCl_5 (axial bonds lambe)
sp^3d^2	Octahedral	SF_6

% s character: sp 50 > sp^2 33 > sp^3 25 ⇒ zyada s character, chhota aur zyada electronegative orbital.

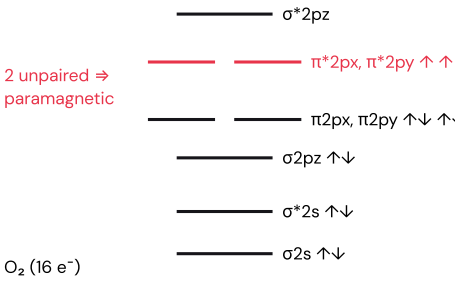
07 Molecular orbital theory

Atomic orbitals milke (LCAO) **bonding** (kam energy) aur **antibonding** (zyada, *) MOs banate.

$$\text{Bond order} = \tfrac{1}{2}(N_b - N_a)$$

BO = 0 ⇒ molecule nahi banta (He_2). BO zyada ⇒ zyada stable, chhota bond. Unpaired electrons ⇒ paramagnetic.

N_2 tak (14 e^-) order: σ1s σ*1s σ2s σ*2s ($\pi 2p_x = \pi 2p_y$) $\sigma 2p_z$ (π*) σ*.
O_2 se aage: $\sigma 2p_z$ π2p pair se pehle aata.



O_2 ka MO filling: BO = 2, paramagnetic

Species	BO	Magnetic
H_2	1	Dia
N_2	3	Dia
O_2 / O_2^+ / O_2^- / O_2^{2-}	2 / 2.5 / 1.5 / 1	Para / para / para / dia
B_2 / C_2	1 / 2	Para / dia

08 Hydrogen bonding

Chhote, bahut electronegative atom (F, O, N) se juda H doosre aise atom ki taraf kheencha jaata. Strength: ~10–40 kJ/mol (covalent se kamzor).

- **Intermolecular** (molecules ke beech): H_2O, HF, NH_3 ⇒ zyada b.p.; barf paani se halki (khuli cage structure).
- **Intramolecular** (ek hi molecule ke andar): o-nitrophenol, salicylaldehyde ⇒ kam b.p., steam volatile.

09 JEE Extra + Tricks

JEE LEVEL

- Hybridisation shortcut: $H = \frac{1}{2}(V + M - C + A)$ (V = central atom ke valence e^-, M = monovalent atoms, C = cation charge, A = anion charge). H = 2 sp, 3 sp^2, 4 sp^3, 5 sp^3d, 6 sp^3d^2.
- Lone pairs ke saath shapes: SF_4 see-saw, ClF_3 T-shaped, XeF_2 linear, XeF_4 square planar, BrF_5 square pyramidal, XeF_6 distorted octahedral.
- MOT se bond order: $\frac{1}{2}(N_b - N_a)$. O_2 (BO 2) paramagnetic; N_2 BO 3; 14 electrons tak $\sigma 2p_z$ $\pi 2p$ ke upar (s–p mixing).
- Bond length $\propto$ 1/bond order; bond energy $\propto$ bond order.
- Symmetric molecules ka dipole zero: CO_2, BF_3, CH_4, CCl_4, PCl_5, SF_6; NH_3 (1.47 D) > NF_3 (0.23 D).
- Fajans rules: chhota cation, bada anion, zyada charge $\Rightarrow$ covalent character zyada; Cu^+, Ag^+ zyada covalent.

10 Solved questions

Q1. XeF_4 ki shape aur hybridisation?

Xe: 8 valence e^-, 4 F ⇒ H = ½(8 + 4) = 6 ⇒ sp^3d^2, 4 bp + 2 lp ⇒ **square planar**.

Q2. BF_3 ka dipole moment zero par NH_3 ka nahi, kyun?

BF_3 trigonal planar; teeno bond moments cancel. NH_3 pyramidal aur lone pair; moments jud jaate.

Q3. N_2^+ ka bond order aur magnetism.

13 e^-: N_b = 9, N_a = 4 ⇒ BO = 2.5; ek unpaired ⇒ paramagnetic.

Q4. CH_2=CH–C≡N me σ aur π bonds?

σ: 3 C–H + C=C(1) + C–C + C≡N(1) = **6σ**; π: 1 + 2 = **3π**.

11 Mistakes & practice

- Shape ke naam me lone pairs gin lena (shape = sirf atoms ki arrangement).
- O_2 aur F_2 ke liye N_2 wala MO order lagana.
- Kehna ki CO_2 polar hai kyunki C=O polar (moments cancel ho jaate).
- Sochna ki π bond bina σ ke ho sakta.

1. ClF_3 ki shape?
2. Kiska dipole moment zyada: NH_3 ya NF_3?
3. CO_2 me C ka hybridisation?
4. He_2^+ ka bond order?
5. Barf paani se halki kyun?

ANSWERS

1) T-shaped · 2) NH_3 · 3) sp · 4) 0.5 · 5) H-bonding se khuli cage structure, beech me khaali jagah

12 Quick revision: exam se 5 minute pehle

BASICS

- FC = V − L − ½B.
- Fajans: chhota cation, bada anion ⇒ covalent.
- μ = q × d; symmetric ⇒ 0.

VSEPR

- lp–lp > lp–bp > bp–bp.
- NH_3 107°, H_2O 104.5°.
- XeF_2 linear, XeF_4 square planar.

HYBRIDISATION

- H = ½(V + M − C + A).
- sp 180°, sp^2 120°, sp^3 109.5°.
- Double = σ + π.

MOT

- BO = ½(N_b − N_a).
- O_2: BO 2, paramagnetic.
- N_2: BO 3, diamagnetic.

Koi doubt? padhaiadda.netlify.app pe AI Doubt Solver se poocho, ya is chapter ka mock test do.