

Atomic Structure

Proton	1.67×10^{-27}	1.602×10^{-4}
Neutron	1.67×10^{-27}	0
Electron	9.11×10^{-31}	-1.602×10^{-19}

Specific Charge: e/m .

Energy of photon: $E = h\nu = hc/\lambda$. $\nu = 6.63 \times 10^{24} \text{ Js}$, $c = 3 \times 10^8 \text{ m/s}$

- Photo electric effect: e^- are ejected from metal surface when being hit by photon with energy more than IE.

IE/Work fn! min E req.

$$E = h\nu_0 = hc/\lambda_0 \quad [\text{threshold freq.}]$$

$$KE = E_i - E_f$$

L Einstein's eqn: $KE = h\nu - h\nu_0$

$$\rightarrow E = \frac{1234 \text{ eV}}{\lambda (\text{nm})}$$

L Stopping potential:

$$\lambda_s = \frac{h}{\sqrt{2m_e\varepsilon}} \quad (\text{so that } KE_e = 0)$$

L De-broglie's hypothesis: $(2\pi r = n\lambda)$

$$\frac{h}{P} = \lambda = \frac{h}{mv} = \frac{h}{\sqrt{2m\varepsilon}} = \left(\frac{3.33n}{z} \text{ Å} \right)$$

- Bohr's Model! If e^- transits towards nucleus, it loses energy in the form of photon to give emission spectral line, and vice versa for absorption spectrum.

$$\rightarrow \text{Angular P: } mv\theta = nh/2\pi$$

$$\rightarrow \text{Translational E: } E_f - E_i \quad \Delta E = \frac{hc}{\lambda}$$

$$E_1 < E_2 < E_3 < \dots < E_n$$

$$E_2 - E_1 \propto E_3 - E_2 \propto \dots \propto E_n - E_1$$

- Radius:

$$r = \frac{n^2 h^2}{4\pi^2 m z e^2 k} \approx \frac{0.529}{z} n^2 \text{ Å}$$

$$\rightarrow \text{Velocity: } v = \frac{2\pi k e^2}{h} \left(\frac{1}{n} \right)$$

$$= 2.18 \times 10^6 \left(\frac{1}{n} \right) \text{ cm/s}$$

→ Total Energy:

$$TE = KE + PE = \frac{1}{2} \frac{ze^2 k}{r} - \frac{kze^2}{r} = \frac{1}{2} \frac{kze^2}{r}$$

$$KE = \frac{PE}{2} \Rightarrow TE = -KE$$

$$E_n = -13.6 \left(\frac{z^2}{n^2} \right) \text{ eV/atom.}$$

$$= -2.176 \times 10^{-19} \left(\frac{z^2}{n^2} \right) \text{ ergs/atom.}$$

$$= -2.176 \times 10^{-18} \left(\frac{z^2}{n^2} \right) \text{ J/atom.}$$

$$= -13.12 \left(\frac{z^2}{n^2} \right) \text{ KJ/atom.}$$

$$96.5 \times \left(\frac{n \text{ ev}}{\text{atom}} \right) = 14 \left(\frac{1 \text{ KJ}}{\text{atom}} \right)$$

→ Transition Energy:

$$TE = 13.6 z^2 \left(\frac{1}{n^2} - \frac{1}{m^2} \right) \text{ eV/atom.}$$

→ Rydberg's Eqn:

$$\frac{1}{\lambda} = \frac{2\pi^2 m k e^4}{h^3 c} \cdot z^2 \left[\frac{1}{n^2} - \frac{1}{m^2} \right]$$

$$\nu = 1/\lambda = R_H z^2 \left[\frac{1}{n^2} - \frac{1}{m^2} \right]$$

Spectra:

Lyman ($n_1=1$) → UV

Balmer ($n_1=2$) Visible

Paschen ($n_1=3$) near IR in Lyman

Brackett ($n_1=4$) mid IR

Pfund ($n_1=5$) far IR.

Humphrey ($n_1=6$) IR

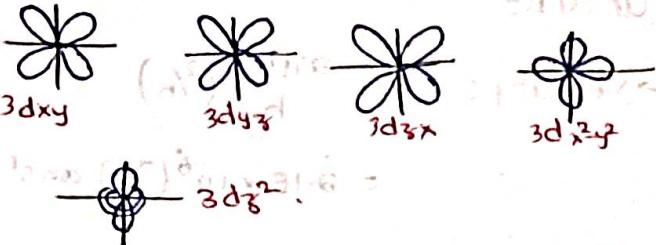
Limit series ($n_2=\infty$)

Heisenberg's uncertainty principle:

$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

Orbital angular momentum-

$$= \sqrt{l(l+1)} \frac{h}{2\pi l}$$



11 Effective nuclear charge:

$$Z_{\text{eff}} = Z - \sigma.$$

Energy of an orbital!

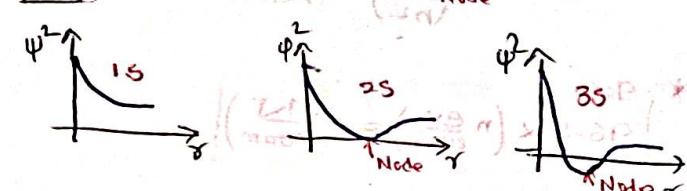
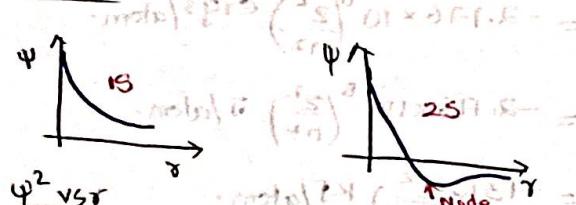
$$E \propto (n+l) ; \text{ if } (n+l) \text{ is same, } E \propto n.$$

Radial node! The region within orbital where probability of $e^- = 0$

- no. of radial nodes = $n-l-1$
- " " ang. nodes = l .
- Total no. of nodes = $n-1$.

Radial node
 $\psi \neq 0 \Rightarrow \psi^2 \neq 0$
 $\psi \neq 0 \Rightarrow \psi^2 = 0$

ψ vs r



Schrodinger wave eqn!

$$\frac{\partial^2 \psi}{\partial r^2} + \frac{\partial^2 \psi}{\partial \theta^2} + \frac{\partial^2 \psi}{\partial \phi^2} + \frac{8\pi^2 m}{n^2} (E - V) \psi = 0.$$

$$\rightarrow \boxed{\nabla^2 \psi = \epsilon \psi} \quad \rightarrow \boxed{H \psi = \epsilon \psi}$$

Hamiltonian rep.

→ Solves gives values of n, l, m .

- $\psi^2 = \text{prob. of finding } e^- [1 > \psi^2 \geq 0]$
- $\psi^2 = 0$ node (no prob. of finding e^-)

Aufbau principle!

Particular order of filling orbitals
 $E \propto (n+l)$ not orbitals.

Pauli's exclusion: $2e^-$ of diff.

orbitals have diff m_l values. not possible

Hund's rule: first half fill then,

fill one by one fully. Exception

Expected: $\uparrow \downarrow \uparrow \downarrow \uparrow \downarrow \uparrow \downarrow \uparrow \downarrow \uparrow \downarrow$ $\uparrow \uparrow \downarrow \downarrow \uparrow \uparrow \downarrow \downarrow \uparrow \uparrow \downarrow \downarrow$

Obs : $\underline{\underline{1 \ 1 \ 1 \ 1 \ 1 \ 1}} \quad \underline{\underline{1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1}}$
 $\underline{\underline{3d^5 \ 4s^1}} \quad \underline{\underline{3d^{10} \ 4s^1}}$
 $Cu (Z=29)$

Paramagnetism! Unpaired es attraction towards mag. field.

$$\mu = \sqrt{n(n+1)} \quad \mu = \sqrt{n(n+2)}$$

→ $n = \text{no. of unpaired es}$

- $\mu = \text{mag. moment}$
- $\mu_0 = \text{diamag. paramag. moment}$
- $H = 0 \text{ diamag.}$

Atomic Species:

- Isotopes same Z diff mass
- Isobars same mass diff Z
- Isotone same no. of neutrons
- Isodisplexes same isotopic no. [same np]
- * Isotopic no. = At. mass - 2 x cat. no.

→ Isoelectronic same e^- (diff. eff. nucl. charge)

→ Isoster same Z & same valence e^-

→ For $n \rightarrow$ principle quantum no.

No. of orbitals = n^2

→ Orbital angular momentum = $\sqrt{l(l+1)} \frac{\hbar}{2\pi}$

$$\text{also } = \sqrt{l(l+1)} \hbar$$

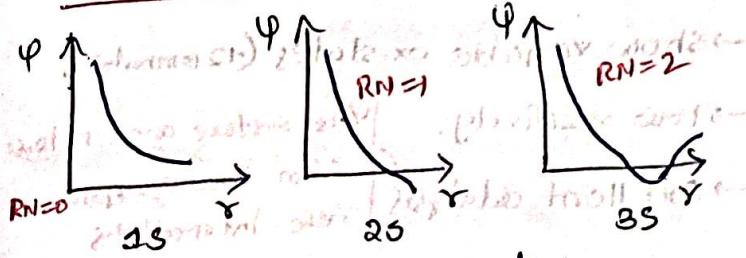
$$\boxed{L = \sqrt{l(l+1)} \frac{\hbar}{2\pi}}$$

→ acc. to plank's theory ad. En is neither emitted nor adsorbed continuously.

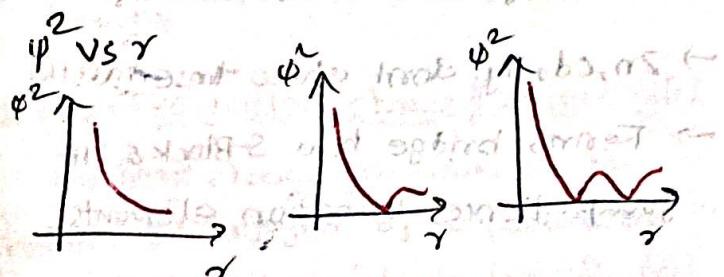
Graphs.

(Ψ vs r)

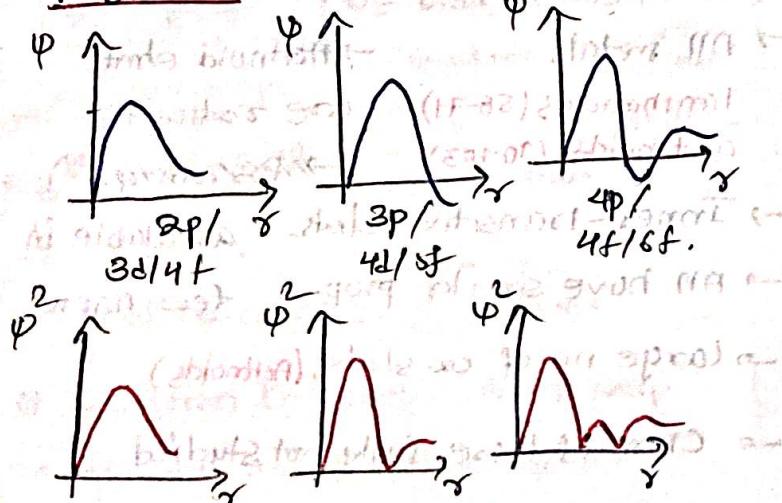
s-orbital!



$$\text{radical node} = n-l-1$$



P-orbital!



Periodic Properties

① S-block:

- Highly electropositive.
- Good metals.
- Good red. agents.
- Strong bases in aq. medium.
- Reacts quickly. (dec. down)
- low IE.

② P-block:

Non-metals					
B	C	N	O	F	Ne
Al	Si	P	S	Cl	N → Pnicogen.
Ga	Ore	As	Se	Br	Ar → Chalcogens.
In	Sn	Sb	Te	I	Kr → Halogens.
Tl	Pb	Bi	Po	At	Xe
metalloids				Metal	Rn → Noble gases

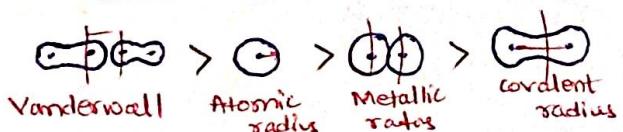
→ Show variable valencies.

→ All nonmetals & P-block.

→ Elements can be melted.

→ Both S&P block are called as Representative Elements.

③ Atomic Size:



Groups → inc. In transition atomic radii doesn't inc (or) dec. by a considerable margin.

few imp. terms:

- Inert gas elements / monoatomic (non rxn); completely filled.
- Rep. Elements / all elmts. of S&P block except Noble gases (Partially filled)
- Transition elements / except Zn, Cd, Hg all D-block; bcz diff e enters penultimate shell.
- Inner trans. elements / diff e's enter anti-penul. shell.
- penultimate shell ← The shell before the valence shell.

• Ionic Radius: In iso elec. species \Rightarrow Radius of cation $<$ atom
the one with less p \rightarrow large radii.
more p \rightarrow less radii.

Radius of anion $>$ atom.

④ D-block: $(n-1)d^{10}ns^2$

→ All metals \rightarrow less electropositive

→ Hard, malleable, Ductile due to strong metallic bonding.

→ High B.p.t & M.p.t:

→ Show variable ox. states (+2 to +6)

→ Low reactivity. Vast surface area + long from low energy

→ Excellent catalysts rise. intermediates

→ Paramagnetic \rightarrow Diff colours.

→ Zn, Cd, Hg don't show these mostly.

→ Forms bridge b/w S-Block & IIIA group. Hence, transition elements.

⑤ F-block: $(n-2)f^{14}, (n-1)d^{10}ns^2$

→ all metals \rightarrow actinoid elmts

lanthanoids (58-71) are radioactive

actinoids (90-103) \rightarrow Plutonium.

→ Inner-Transition elmts. available in

→ All have similar prop. few ngrms

→ Large no. of ox. states (actinoids).

→ Chem. of these fully not studied.

→ Elements after uranium are

transcurium elements.

Nature of Oxides

Basic oxide \rightarrow Metal in +1, +2, +3 O.S.
except: Amph (Cr, O₃)

Acidic oxide \rightarrow Metal in +5, +6, +7 O.S.
ex: Amph (V₂O₅)
 \rightarrow Metalloids ex: Amph. (N₅³⁻, Sb₃³⁺)
 \rightarrow Non-metals.
ex: CO, NO, N₂O

Amphoteric \rightarrow Zn, Be, Al, Ga, Sn, Cr⁺³
oxides V⁺⁵, Sb⁺³, As⁺³, Pb, & +4 O.S.

Neutral oxides \rightarrow CO, NO, N₂O (e₃O₂)

Effective nuclear charge (Slater's rule)

Nuclear charge provided by Nu. couldn't be enjoyed by the particular e⁻ since many are sharing (shielding eff.).

$$Z^+ = Z - \sigma$$

$\sigma = 0.35 \times 0.854 + 1.03$

↓ ↓
eff. nu. charge. no. of neigh
e⁻s. no. of e⁻s in
Permut shell.

Shielding eff $\propto \frac{1}{\text{eff. nu. charge.}}$ all inner e⁻s.

$\hookrightarrow s > p > d > f$

\rightarrow Eff. nu. charge: \downarrow inc
 \rightarrow Eff. nu. charge: \downarrow dec (same).

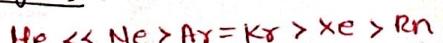
Ionisation Enthalpy: The E req. to uproot 1 e⁻ from atom.

\rightarrow Always at the no.

Excep: (Be, B) (N, O) (Mg, Al) (Ph, S)

Electron gain Enthalpy: Energy released when given extra e⁻ to an atom. Neutral \rightarrow ion. atom

for noble gases: +ve value.



for halogens & chalcogenes: -ve values (large).

Exception! O \rightarrow -142 F \rightarrow -328
S \rightarrow -200 Cl \rightarrow -349.

due to high e⁻ density.

\rightarrow N, P, Mg, Be, Zn, Hg, Cd

have less E_{G.E.}.

* Acidic nature of oxide!

\propto Electro negativity

\propto Non-metallic nature.

\propto +ve charge.

{ Except $\text{H}_3\text{PO}_2 > \text{H}_3\text{PO}_3 > \text{H}_3\text{PO}_4$ due to Tautomer }

Oxide on basis of O₂ content

Normal Oxides	Peroxides	Superoxides
(O ⁻²)	(O ₂ ⁻²)	(O ₂ ⁻)
CaO, MgO, N ₂ O ₃ , SO ₃	H ₂ O ₂ , BaO ₂	KO ₂ , RO ₂

Hygroscopic: Cation of salt crystal

exposed to moist air, if catches H₂O mol. without disturbing crystal lattice.

Deliquescent: Catchup large quantity of H₂O & becomes liquid.

\rightarrow NaOH, NaCl, Alk(CaCl₂, MgCl₂, ZnCl₂, FeCl₃, KCl₃, BeCl₂)

Electro negativity: Prop. of a bonded atom.

\rightarrow Tendency to attract shared pair.

\rightarrow Not measurable quantity physically.

\rightarrow Not fixed but with conditions.

<u>ΔEN</u>	<u>Ex.</u>
$\Delta EN = 0$	100% covalent H ₂
$\Delta EN > 1.7$	Highly ionic Naf
$\Delta EN < 1.7$	Polar covalent H ₂ O

Oxidation
- loss of e⁻

Reduction
- gain of e⁻.

OIL RIG.

Brush up

Li - Strongest reducing agent.

Ca - Most electro positive.

He - Highest IE

Cl - Highest E_{G.E.}

F - Most EN Fr - least EN

\rightarrow Electron affinity: same in mag. with electron gain enthalpy but has only +ve sign

* IUPAC Nomenclature for above 100 at number

No. Root word symbol

0 nil n + suffix

1 un u + suffix

2 bi b + suffix

3 tri t + suffix

4 quad q + suffix

5 pent p + suffix

6 hex h + suffix

7 sept s + suffix

8 oct o + suffix

9 enn e + suffix

101 = unnil unium : Uno

102 = unnil bium = Unb

109 = unnilennium: Une

119 = unanennium: Oo e.

(names of elements)

In iso-electronic species,

Size \propto (charge) $\times \frac{1}{(\text{charge})}$

$\text{Be}^+ < \text{Li}^+$; $\text{N}^3+ > \text{O}^2-$

size decreases towards noble gases

size increases

towards noble gases

size increases

- Atoms are more stabilised in mol. state
- $$X + X \xrightarrow{\text{attract}} X_2 \quad E_a < (E_1 + E_1)$$
- free gaseous atoms Molecule.
- Kossel-Lewis theory:
- Noble gases are monoatomic.
 - Electrovalency - want to acq. by transfer of e^- .
 - Covalency - sharing of e^- pairs.

Electropositive - donates e^- - low IP

Electronegative - withdraws e^- - high EN

Types of Bonds:

- Ionic/electrovalent: Electropositive + Electro-negative
- Covalent: Electroneg + Electronegative less electropositive + Electronegative
- Metallic: Electropositive + Electropositive

- In a molecule least EN atom occupies central position.
- * Formal Charge: Hypothetical charge to have a feel if it actually does have ind. charge.

$$F.C = (\text{no. of valence } e^- \text{ in free atom}) - (\text{no. of } L.P. e^-) - (\text{no. of Bonds})$$

$$F.C = (\text{group no.} - \text{no. of } e^- \text{ in L.P.}) - \left(\frac{1}{2} \text{ no. of } e^- \text{ in B.p.} \right) \quad (\text{OR})$$

Energy of structure & charge (formal).

Limitations of Octet rule:

- Majorly applicable to 2nd period elements.
- Incomplete octet on central atom. Li:cl H:Be:H Cl:B:Cl
- Odd electron molecules $\ddot{N}=\ddot{O}$, $\ddot{O}=\ddot{N}^+-\ddot{O}^-$
- Expanded octet: more than 8 e^- on central atom PF_5, SF_6, H_2SO_4 .
- Noble gases combine with: $KrF_2, XeOF_2$, etc...
- Do not explain shape → Do not explain rel. stability or energy of mol

Ionic Bond:

electrostatic force of attraction b/w opp charges.

$$\% \text{ ionic character} = 16(X_A - X_B) + 3.5(X_A - X_B)^2$$

m.pt of Ionic > covalent

Factors favouring ionic bond formation -

Cation formation:

- Large atomic size of metal.
- Low IP of metals IP of 4D < 5D.
- Low charge on cation. (IE)
- Inert gas configuration.

Overall formation of ionic compound

- Ease of formation of Cation or Anion.

- EN difference should be high.

- High lattice enthalpy. (Low IE) (High EA)

Properties of ionic compounds:

- Hard and posses high M.pt & B.pt.
- Dissolve in polar solvents like H_2O & liq ammonia. Their solubility in nonpolar solvents like Benzene, CCl_4 , Petrol, Kerosine, $DMso$, DCM is negligible.

- In aq./fused state; these acts as cond's formed by non directional bonds (do not exhibit isomerism.)

- Show Isomorphism - The prop. of diff. ionic compounds having similar structures.

Dipole Moment:

(Due to EN diff.)

$$A + \xrightarrow{-6} B \quad \mu = exd$$

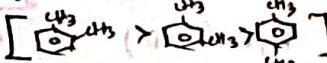
Debye $\mu = 3.33564 \times 10^{-30} \frac{\text{Cm}}{\text{coulomb}}$

$$\mu = 10^{-18} \frac{\text{esu cm}}{\text{coulomb}}$$

DM of dichloro benzene → ortho > meta > para.



DM of xylene → ortho > meta > para.



$$\% \text{ ionic} = \frac{\mu_{\text{act}}}{\mu_{\text{cal}}} \times 100 \quad \% \text{ ionic} = \frac{\mu_{\text{act}}}{\mu_{\text{act}}} \times 100$$

Polarity of Bonds:

1) Electron pair shared equally.

⇒ non-polar covalent bond.

2) Electron pair not shared equally.

⇒ polar covalent bond.

Lattice Energy: $\text{NaCl} + \text{H}_2\text{O} \rightarrow \text{NaCl} + \text{OH}$

→ The enthalpy change when 1 mole of ionic compound dissociates into its ions in gaseous state.

∅ Lattice Energy \propto charge $\times \frac{1}{\text{radius}}$

∅ If solvation $E \geq LE \rightarrow$ then it dissolves.

∅ Polarity \propto Solubility $\propto \Delta H_{\text{m}} \text{ of H}_2\text{O}$

→ Hydration Energy: amt. of E released

when dissolved completely in H_2O

* For greater dissolution $E_{\text{hydr}} > E_{\text{lattice}}$.

Born Haber Cycle: A systematic rep. of

various energy changes take place during the bond formation.

$$\Delta H_f^\circ = \Delta H_1 + \Delta H_2 + \dots + \Delta H_n$$

VSEPR Theory:

- LP occupies more space (due to nucleus)

- BP occupies less space (due to a nucleus)

Repulsion:

$$\text{LP-LP} > \text{LP-BP} > \text{BP-BP} \quad (\equiv > \equiv > \equiv)$$

Steric DO': No. of incoming + no. of LP's on atoms Central atom

(B.P+LP)

Hyb. Geometry IP BP Shape Structure

SP linear 0 2 linear $x-x$

SP² TP 0 3 TP $\begin{array}{c} \diagup \\ \text{---} \\ \diagdown \end{array}$

TP 1 2 Bent. $\begin{array}{c} \diagup \\ \text{---} \\ \diagdown \end{array}$

SP³ Tetrahedral 0 4 Tetrahedral $\begin{array}{c} \diagup \diagdown \\ \text{---} \\ \diagup \diagdown \end{array}$

1 3 Pyramidal $\begin{array}{c} \diagup \diagdown \\ \text{---} \\ \diagup \diagdown \end{array}$

2 2 Angular $\begin{array}{c} \diagup \diagdown \\ \text{---} \\ \diagup \diagdown \end{array}$

1 1 Linear $\begin{array}{c} \diagup \diagdown \\ \text{---} \\ \diagup \diagdown \end{array}$

SP³d TBP 0 5 TBP $\begin{array}{c} \diagup \diagdown \\ \text{---} \\ \diagup \diagdown \end{array}$

1 4 See-saw $\begin{array}{c} \diagup \diagdown \\ \text{---} \\ \diagup \diagdown \end{array}$

2 3 T-shape $\begin{array}{c} \diagup \diagdown \\ \text{---} \\ \diagup \diagdown \end{array}$

3 2 Linear $\begin{array}{c} \diagup \diagdown \\ \text{---} \\ \diagup \diagdown \end{array}$

Octahedral, 0 6 Octahedral $\begin{array}{c} \diagup \diagdown \\ \text{---} \\ \diagup \diagdown \end{array}$

1 5 Sq. Pyramid $\begin{array}{c} \diagup \diagdown \\ \text{---} \\ \diagup \diagdown \end{array}$

2 4 Sq. Planar $\begin{array}{c} \diagup \diagdown \\ \text{---} \\ \diagup \diagdown \end{array}$

3 3 T-shape $\begin{array}{c} \diagup \diagdown \\ \text{---} \\ \diagup \diagdown \end{array}$

Pentaagonal 0 7 PBP $\begin{array}{c} \diagup \diagdown \\ \text{---} \\ \diagup \diagdown \end{array}$

bipyramidal $\begin{array}{c} \diagup \diagdown \\ \text{---} \\ \diagup \diagdown \end{array}$

Dragons Rule: $\text{IF} > \text{XF}$

→ Polarisability \propto s. of anion $\propto \frac{1}{\text{r. of cation}}$

→ Polarisation \propto covalency.

∅ Covalent \propto charge & \propto character

$\text{SnCl}_2 < \text{SnCl}_4$ Guy $> \text{N}_2\text{O}_4$

* Covalency $\propto \frac{1}{\text{Ionic character}}$

* 3rd period atoms possess vacant d orbital hence they can expand their covalency upto 6

Back bonding: When a covalent bond exists b/w two non-metal atoms if one of the atom has a lp and other a vacant orbital.

- for this to happen, atleast one atom should belong to 2nd period.

Valence Bond Theory: Covalent bond formation

takes place due to overlapping of unpaired orbitals.

• Single bond = --- 1s, 1s form σ bonds

• Double bond = $\text{---}=\text{---}$ 1s, 1s forms π bonds

• Triple bond = $\text{---}=\text{---}=\text{---}$ 1s, 1s

due to higher strength } effect of overlapping

Types of overlapping:

(S-S) --- / (S-P) --- / (P-P) ---

(P-P) --- / (P-P) --- due to longer distance

(P-P) --- / (P-P) --- due to longer distance

Hybridisation: process of intermixing of atomic orbitals having comparable energy to produce a new set of orbitals having similar prop.

• SP: linear, 180° OSP²: TP, 120°

• OSPd: TBP, 120°/90° OSP³: Tetrahedral, 109°

• OSP³d: Octahedral, 90°

• OSP³d³: Trigonal bipyramidal

• Bent's rule: ---

→ EN atom induce p-character.

→ LP induce s-character

into its orbitals leaving others with more p-character.

→ Bond length (S < P)

→ Bond angle (S > P)

more EN atoms, greater s-character

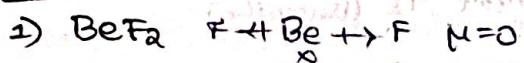
Dipole Moment.

→ Vector quantity measure of bond polarity. → towards -ve ion.

$\mu = 0$ } Non polar , vector quantity.

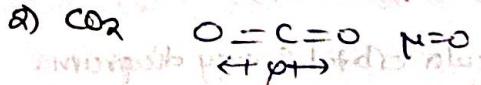
$\mu \neq 0$ } Polar .

Eg:-

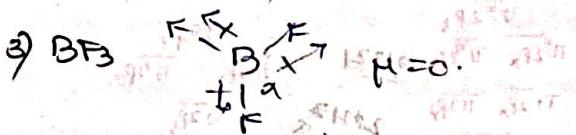


Bent's Rule : (MKA sir)

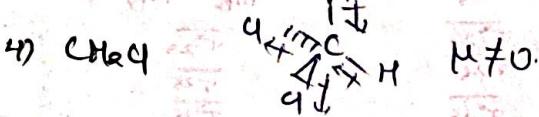
in T,BP structure; lp-equatorial
high CN-axial.



$$\bullet \text{sp}^3\text{d} = \text{sp}^2 + \text{pd} \quad \bullet \cos\theta = \frac{s}{\sqrt{s+1}}$$

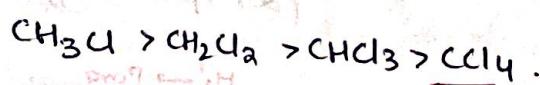
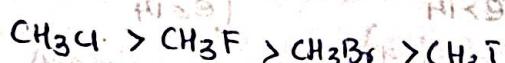


$$eq \quad s = 0.1$$



$$\angle = 33.3^\circ$$

Some imp's



No. of nodal planes:

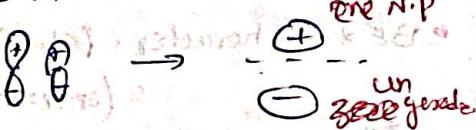
For all σ_{BNLO} , no. of nodal planes = 0

↳ {Gerade} (Symmetry).

For all σ_{ABMO} , no. of nodal plane = 1

(Nodal plane = plane of nodes = plane of zero density)

For π_{BNLO}

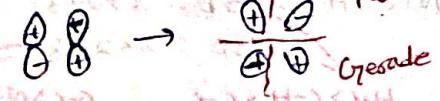


one N.P.

zero N.P.

ungerade

For π_{ABMO} ,



Two N.P.

gerade

London-Dispersion forces:

$$E \propto \frac{1}{r^6}$$

Chemical Bonding Tricks.

→ Find Type of Hyb.?

- Add individual valence electrons

if you get (0-8) divide by 2.

(9-56) divide by 8.

(> 56) divide by 18.

- The value you get is $\frac{sp^2d}{x+y+z}$.

$$\textcircled{1} \quad SO_2 \xrightarrow[6]{} 12 = \underline{\underline{18}}$$

$$\frac{18}{8} = \textcircled{2} \text{ & remainder } = 2$$

$$\text{divide rem } 2 \xrightarrow[2]{} \textcircled{1}.$$

$\therefore \underline{\underline{sp^2}}$ and 2B.P., 1LP

$$\textcircled{2} \quad SF_4 \xrightarrow[6]{} 28 = \underline{\underline{34}}$$

$$\frac{34}{8} = \textcircled{4} \text{ & } r = \frac{2}{2} = \textcircled{1}$$

$\therefore sp^3d$ and 4B.P., 1LP

* Quick points:

v.p. & T.

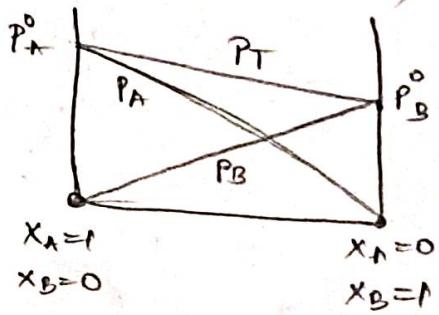
$$v.p. \propto \frac{1}{IMF}$$

Roult's law:

$$P_T = P_A^0 x_A + P_B^0 x_B$$

↓ ↓
Pure A Pure B

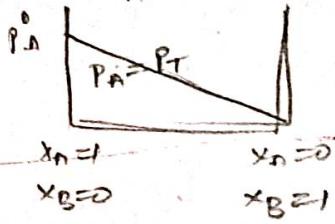
Total v.p. of solution (mix).



A is more volatile than B

$$P_A^0 > P_B^0$$

for non-volatile sub. $P \approx 0$.
Non-volatile.



\Rightarrow Ideal soln.

① follows Raoult's law

\Rightarrow Non-Ideal soln.

doesn't follow Raoult's law

② $(P_T)_{obs} = (P_T)_{cal}$

+ve dev

-ve dev

③ IMF b/w solv-solv

& Solute-Solute are
equal to Solute-Solvent

④ $(P_T)_{obs} > (P_T)_{cal}$

& Solute-Solute are
greater than
Solute-Solvent

⑤ $(P_T)_{obs} < (P_T)_{cal}$

& Solute-Solute are
less than Solute-Solvent

$$\Delta H = 0$$

$$\Delta V = 0$$

$$\Delta S > 0$$

$$\Delta G < 0$$

$$\Delta H > 0$$

$$\Delta V > 0$$

$$\Delta S > 0$$

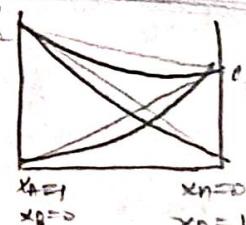
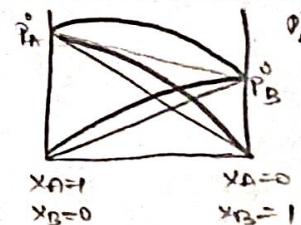
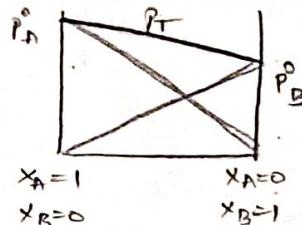
$$\Delta G < 0$$

$$\Delta H < 0$$

$$\Delta V < 0$$

$$\Delta S > 0$$

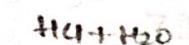
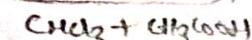
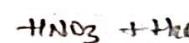
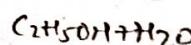
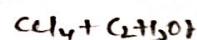
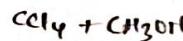
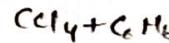
$$\Delta G < 0$$



Bromoethane

Chloroethane

Benzene + Toluene



Trick! $CCl_4 + \dots \rightarrow +ve$ } $CCl_4 + CH_3Cl \rightarrow +ve$
 $CH_3Cl + \dots \rightarrow -ve$ } $CH_3Cl + H_2O \rightarrow -ve$
 Acid + H₂O → -ve

Y 2/7/22

Roult's & Dalton's law

$$\frac{P_A}{P_T} = \frac{y_A}{x_A}$$

$$\frac{P_B}{P_T} = \frac{y_B}{x_B}$$

y_A, y_B in vap.
eqm.

$$P_A = x_A P_A^0 = y_A \cdot P_T$$

$$P_B = x_B P_B^0 = y_B \cdot P_T$$

$$P_T = x_A P_A^0 + x_B P_B^0$$

$$x_A + x_B + \dots = 1$$

$$y_A + y_B + \dots = 1$$

$$\frac{1}{P_T} = \frac{y_A}{P_A^0} + \frac{y_B}{P_B^0}$$

* Solv. of gas in liquid :

→ Polar gases are highly soluble in polar solvents.
eg. SO₂, H₂S etc.

→ Non-polar are better soluble in non-polar solvents.
eg. Br, I₂, CH₄, C₂H₆, etc. soluble in ether, benzene, CCl₄ etc.

→ $\Delta S_{mix} < 0$ (gas diss. in liq.)

→ $\Delta S_{mix} > 0$ (liq./solid dis. in liq.)

Liquid Solution

Binary Soln. - Solut. with only 2 comp.

- non volatile solute + volatile solvent.
[salt/sugar in H_2O]

- volatile solute + volatile solvent.
[Alcohol in H_2O].

$$\begin{matrix} \text{P}_{\text{ATM}} \\ \text{P}_{\text{gas}} \end{matrix}$$

↳ Mass percentage (w/w):

$$\text{Mass \%} = \frac{\text{Mass of the comp.}}{\text{Total mass of soln.}} \times 100.$$



$P = K_H x$ $K_H \rightarrow$ Henry's law const. \propto Temp.
slope = K_H . * Effect of temp: solubility of gas in liq \propto 1/Temp.

↳ Vol. percentage (v/v):

$$\text{Vol.\%} = \frac{\text{Vol. of the comp.}}{\text{Total Vol.}} \times 100.$$

↳ Mass by vol. (w/v):

- used in pharmacy (mass per 100ml)

↳ Parts per million (ppm):

$$\text{PPM} = \frac{\text{No. of parts of comp.}}{\text{Total no. of parts}} \times 10^6.$$

* exp in $\mu\text{g/ml}$ or ppm.

↳ Mole fraction:

$$x = \frac{\text{no. of moles of comp.}}{\text{total no. of moles}} : x = \frac{n_A}{n_A + n_B}$$

for i comp;

$$x_i = \frac{n_i}{n_1 + n_2 + \dots + n_i} ; x_1 + x_2 + \dots + x_n = 1$$

0 Molarity - $M = \frac{\text{moles of solute}}{\text{Vol. of soln. (L)}}$

0 Molality - $m = \frac{\text{moles of solute}}{\text{mass of solvent (kg)}}$

→ only molality is a fn. of temp.

0 Solubility - max. amt. that can be diss.

in a specified amt. of solvent at a specified temp.

Saturated \Rightarrow conc. = solubility.

* **Effect of Temp**: Solute + solvent \rightleftharpoons soln.

→ for endo ($\Delta H > 0$) - solubility \propto Temp.

→ for exo ($\Delta H < 0$) - solubility $\propto 1/\text{temp.}$

* **Effect of P**: no impact on solids & liq.

For gases: Solubility \propto Temp & P.

* **Dalton's law**:

$$P_B = x_B P_T$$

0 Henry's Law: at const T; solubility \propto P_{gas}.

↳ the partial p. of the gas in vap. phase is prop. to the mole fraction of the gas in soln.

$$P = K_H x$$

$K_H \rightarrow$ Henry's law const. \propto Temp.

mole fraction diss. in liq.

slope = K_H .

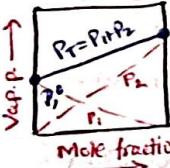
Solubility $\propto \frac{1}{K_H}$.

of gas in liq $\propto 1/\text{temp.}$

0 Raoult's Law: for a volatile soln, the partial p. \propto mole fraction.

$$P_i \propto x_i \Rightarrow P_i = P_i^0 x_i$$

$$\cancel{P_i = P_i^0 + P_{\text{atm}}} \Rightarrow P_i = P_i^0 + P_{\text{atm}} \Rightarrow x_1 P_i^0 + x_2 P_2^0 \Rightarrow P_i^0 + (P_2^0 - P_i^0) x_2$$



$$V.P.A \quad B.P.$$

0 Vap. pressure: P. exerted by the vap. at equil. over surface of liq. $V.P. = \frac{P}{P_{\text{atm}}}$

→ when non-volatile soln. added \downarrow V.P. dec.

↓ bcz the surface area decreases.



V.P. \propto X \propto Volatility.

0 Ideal Solution:

0 Non-ideal soln.:

$\Delta H = 0$ \leftarrow change of soln.

$\Delta V = 0$ \leftarrow change in vol.

Obeys Raoult's law

internal forces of AB $<$ AA + BB

n-hexane, n-heptane $\Delta H > 0$ (-ve dev.)

bromethane, clethane, A-A, B-B $<$ AB

benzene & toluene, .. phenol, acetylene, aniline,

chloroform, acetone, benzene & water, phenol & water, chloroform & water

When $V_1 \text{ ml}$ of A & $V_2 \text{ ml}$ of B are mixed, the vol. of the soln. can be $\langle, = \rangle, (V_1 + V_2)$

$\Delta V < 0$ (-ve dev) $\Delta V = 0$ $\Delta V > 0$ (+ve dev).

[due to strong bond], [ideal] [due to weak bond formation].

Azeotropes - binary comp. having same comp.

at const temp.

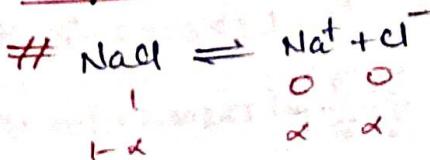
- Min boiling Azeotropes: show large -ve dev.

- Max boiling Azeotropes: show large +ve dev.

Want tafetta factor:

$$i = \frac{\text{total no. of moles after ass/diss}}{\text{total no. of moles before ass/diss}}$$

Deg. of diss! { α }



$$i = \frac{\alpha + 1 - \alpha}{1} = \underline{\underline{\alpha + 1}}$$

if $\alpha = 1$; then $i = 2$ {100%}

Generally: $\text{An} \rightarrow n\text{A}$

$$i = \frac{1-\alpha+n\alpha}{1} \Rightarrow \boxed{\alpha = \frac{i-1}{n}}$$

Deg of Ass! { α }

$$\text{nA} \rightarrow \text{fA}$$

$$\begin{array}{c} \text{n} \\ | \\ \text{f} \\ | \\ 1-\alpha \\ \text{A} \end{array}$$

$$\alpha = \frac{i-1}{(n-1)}$$

$$i = \frac{1-\alpha(n-1)}{1} \Rightarrow \boxed{\alpha = \frac{1-i}{n}}$$

$\propto \Delta T_f (i \times c)$

$\propto \Delta T_b \propto (i \times c)$

Obs CP < Cal CP

$$i = \frac{\text{obs CP}}{\text{cal. CP}} \rightarrow \frac{P^0 - P}{P^0} = x_{\text{solvent}} \cdot i$$

$$\Delta T_b = i K_b M$$

$$\Delta T_f = i K_f M$$

$$\Pi = i c R T$$

Hint: Watch one-shot on PUL channel.

$$\# \text{RLVP: } \frac{P_A^0 - P_S}{P_A^0} = x_B, \quad \frac{P_B^0 - P_S}{P_B^0} = \frac{n_B}{n_A}$$

$$\# \frac{P_A^0}{P_B^0} = \frac{n_B}{n_A}$$

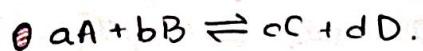
$$\# (\bar{T})_{\text{new}} = \bar{T}_f - \Delta \bar{T}_f$$

$$\begin{matrix} \text{①} & \downarrow & \downarrow \\ \text{②} & \text{mix} \end{matrix}$$

$$\# \frac{y_A}{y_B} = \frac{P_A^0 x_A}{P_B^0 x_B}$$

vap-mol fraction liq.
liq-vap eq in case

Chemical Equilibrium. $\Delta G = \Delta H - TAS$. 13



$$-\frac{1}{a} \frac{dA}{dt} = -\frac{1}{b} \frac{dB}{dt} = \frac{1}{c} \frac{dC}{dt} = \frac{1}{d} \frac{dD}{dt}.$$

$$\rightarrow \text{rate} = k[A]^a [B]^b \text{ active masses}$$

Solids, Pure liq. = 1 ; Gases n/V_A .

$$\theta K_C = \frac{[C]^c [D]^d}{[A]^a [B]^b} = \frac{k_b}{k_f}, \theta K_P = \frac{P_C^a P_D^d}{P_A^a P_B^b}$$

$$\theta Q_c = \frac{[C]^c [D]^d}{[A]^a [B]^b} \rightarrow \text{can be applied at any time in the rxn.}$$

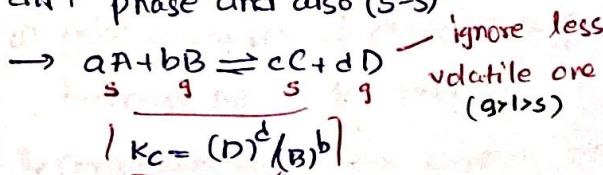
$$\rightarrow Q_c > (K_C)_{eq} \xrightarrow{\substack{\text{backward} \\ \text{forward rxn.}}}$$

$$\rightarrow Q_c < (K_C)_{eq} \text{ forward rxn.}$$

$$\hookrightarrow K_n = \frac{[n_a]^a [n_b]^b}{[n_a]^a [n_b]^b}$$

Homogeneous: all substances in same phase.

Heterogeneous: the substances at diff phase and also (s-s),



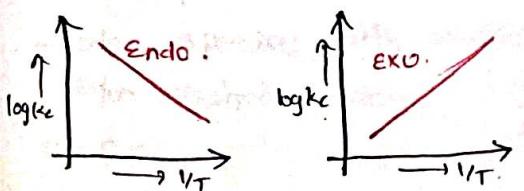
* Effect of temp. on K_C :

$$(AS)_T = (AS)_{sys} = \frac{(AH)_{sys}}{T} \quad \begin{matrix} \text{High temp.} \\ \text{fav.} \end{matrix}$$

→ EXO: $K_C \downarrow$ with $T \uparrow$ ($AH -ve$)

→ Endo: $K_C \uparrow$ with $T \uparrow$ ($AH +ve$)

$$\log \frac{(K_C)_2}{(K_C)_1} = \frac{(AH_f)}{2.303R} \left(\frac{T_2 - T_1}{T_1 T_2} \right)$$



$$* K_P = K_C (RT)^{\Delta n_g}$$

$$* K_C = K_n \left(\frac{1}{V} \right)^{\Delta n_g}$$

→ A Catalyst added at equi shows no effect; however, when added early it makes rxn attain equi fast.

→ At equi. both react. & prod. have

$$* G = G_f^\circ + 2.303 RT \log P^n.$$

$$* \Delta G = \Delta G_f^\circ + 2.303 RT \log \frac{P_C^a P_D^d}{P_A^a P_B^b}.$$

but at equi $\Delta G = 0$. \Rightarrow

$$* \Delta G_f^\circ = -2.303 RT \log Q.$$

\Rightarrow Van't Hoff's eqn:

$$\ln \left(\frac{K_2}{K_1} \right) = \frac{AH}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right). \quad \checkmark$$

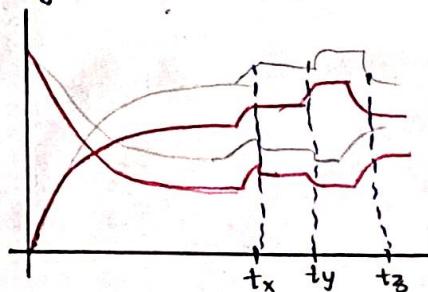
\Rightarrow Le Chatlier's Principle: The equilibrium state readjust itself in such a way that the effect of the change brought in is minimised, nullified (or cancelled).

a) Effect of P -

- if $P \uparrow$ then eqn shifts to less n gaseous moles and vice versa.
- if $\Delta n = 0$ then No Effect of Pressure.

b) Effect of inert gas -

- $\Delta n = 0$; no effect of inert gas.
- at const. vol & at equi, the partial p's of the reactants and products remain unchanged. Hence, eqn isn't disturbed.
- at const. p., the part of react. p \downarrow hence, eqn shifts towards more no. of gaseous moles.



$t_x \rightarrow$ Reactants added

$t_y \rightarrow$ Dec. in p (or inc. in v.) inert gas added at const. p.

$t_z \rightarrow$ P is inc.

- Inc. in temp \Rightarrow Shifts eq. to endo.

Tonic Equilibrium

→ Degree of Dissociation:
 $\alpha = \frac{\text{No. of moles dissociated}}{\text{Total no. of moles of electrolyte}}$

Strong Protic acids/Bases — $\alpha = 1$

Weak acids / Bases — $\alpha \ll 1$

Common ion effect:

The dissociation of a weak acid is suppressed by strong acid or a salt containing common ion. * HCN by HCl/KCN; * NH₄OH by NH₄Cl

Polyprotic weak acid:

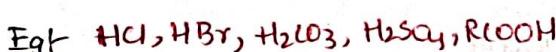
The weak acid that can produce more than 1 H⁺ ion in H₂O.

* also, (K_{a1}, K_{a2}) be of 2 steps of ion then K_a = K_{a1} × K_{a2}.

Modern theories of acids & bases:

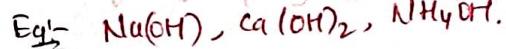
Arrhenius theory:

a) Acid :- species capable of producing H⁺ ions in H₂O.



K_a & acidity.

b) Base :- species capable of producing OH⁻ ions in H₂O.

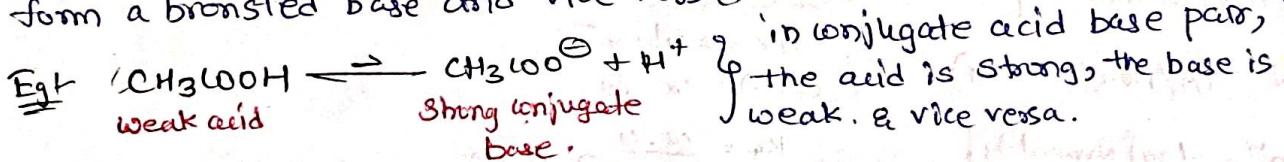


K_b & basicity.

Bronsted - Lowry concept:

a) Acids :- Capable of donating a proton. b) Base :- Capable of accepting a proton
 ↳ must be in the form of HX ↳ must possess lone pair (to accept proton)

↳ Conjugate acid base pair — on removing a proton, a bronsted acid can form a bronsted base and vice versa.



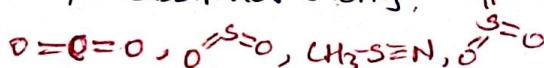
Lewis Theory:

a) Acid :- can accept electron pairs

→ Must possess vacant orbital

- also, species with multiple bonds

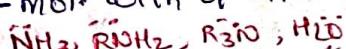
but dissimilar atoms.



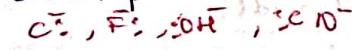
- If VII group atoms are lewis acids O, S.

b) Base :- capable of donating e-pairs

- mol. with LP on central atom.



- all simple anions.



- molecules with one multiple bonds.



Note Worthy pts :-

1) Lewis acids need not be bronsted acids.

2) Lewis base can be bronsted base and vice versa.

3) CCl₄, CH₄ are neither Lewis acids nor base.

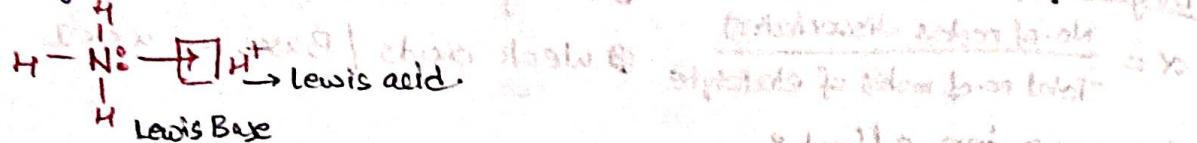
4) SO₂ - both Lewis acid & base.

5) C₂H₂ (carbene) is only Lewis acid

(No multiple bonds are present).

(due to incomplete octet).

6) All oxyacids are bronsted acids.
 7) Formation of a dative bond comes under lewis neutralisation.



\rightarrow Ionic Product of H_2O : H_2O is polar solvent so it can ionise many polar solvents but it itself ionises to a very poor extent.

$$* K_d = \frac{[\text{H}_3\text{O}^{\delta+}][\text{OH}^{\delta-}]}{[\text{H}_2\text{O}]} \rightarrow 1L = \frac{1000}{18} = 55.5 \text{ mol/L}$$

$$\hookrightarrow K_w = [\text{H}_3\text{O}^{\delta+}][\text{OH}^{\delta-}] \rightarrow K_w \propto T \text{ (ionisation of } \text{H}_2\text{O is endo-thermic)}$$

$$K_w = \text{ionic prod. of } \text{H}_2\text{O}. \quad K_w = 1.0 \times 10^{-14} \text{ mol}^2 \text{ (at } 25^\circ\text{C})$$

\rightarrow whether we add acid or base; to H_2O H shifts b/w K_w & H_2O .

$\rightarrow [\text{H}_2\text{O}]$ constant at all cases.

\rightarrow Neutral $\Rightarrow [\text{H}^{\delta+}] = [\text{OH}^{\delta-}] = 10^{-7}$

$$\rightarrow P^H = -\log[\text{H}_3\text{O}^{\delta+}] \quad \# \text{ Mix of St. Acids + Bases}$$

$$P^H = P^H + P^{\text{OH}}$$

$$\Sigma(\text{NV})_{\text{acid}} > \Sigma(\text{NV})_{\text{base}}$$

$$[\text{H}^{\delta+}] = \frac{\Sigma(\text{NV})_a - \Sigma(\text{NV})_b}{V}$$

$$\Sigma(\text{NV})_{\text{acid}} < \Sigma(\text{NV})_{\text{base}}$$

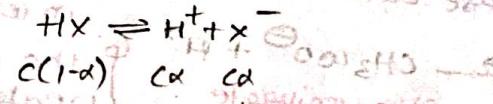
$$[\text{OH}^{\delta-}] = \frac{\Sigma(\text{NV})_b - \Sigma(\text{NV})_a}{V}$$

$\# P^H$ of strong acids.

$[\text{H}^{\delta+}] = \text{Normality}$

$\#$ Weak acids:

$N = \text{m}/\text{No. of H-atoms}$



$$P^H = -\log[\text{Normality}]$$

$$K_a = \frac{c\alpha \cdot \alpha}{c(1-\alpha)} \Rightarrow \alpha = \sqrt{\frac{K_a}{c}}$$

$$(1-\alpha) \approx 1$$

$\#$ Mix of strong acids:

$$[\text{H}^{\delta+}]_{\text{result}} = \frac{N_1 V_1 + N_2 V_2 + \dots}{V_1 + V_2 + \dots (H_2O)}$$

$\#$ Dilution of st. acids:

$$\hookrightarrow \alpha \propto P^H \propto \frac{1}{\sqrt{K_a \cdot c}}$$

$$n = V_f/V_i$$

\Rightarrow Buffer Solutions
Salt hydrolysis

$$P_f^H = P_i^H + \log n$$

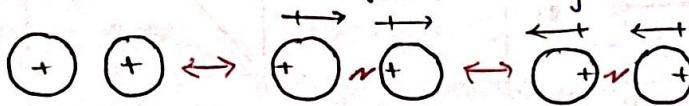
Pending Δ

States of Matter

→ Attractive intermolecular forces are Vanderwaal's forces.

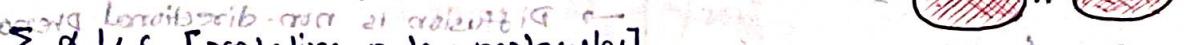
• LONDON FORCE: Force of att. b/w 2 dipoles (Dispersion force).

→ Mag. depends on the polarisability of the particle. $\propto \frac{1}{r^6}$ (Interaction Energy)



• Dipole-dipole forces: b/w the mol. of permanent dipole.

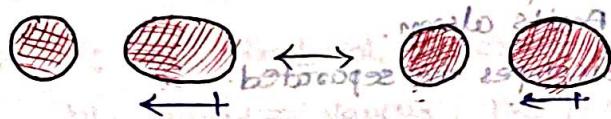
$$\sum \alpha \frac{1}{r^3} \quad [\text{stationary polar molar molecules (solids)}]$$



$$\sum \alpha \frac{1}{r^6} \quad [\text{rotating polar molecules}]$$

• Dipole induced dipole forces: b/w mol. of Permanent & non-p. dipole.

↳ Permanent dipole on the polar mol. induces the dipole on electrically neutral mol. by deforming its elec. cloud. $\propto \frac{1}{r^6}$ (attract. \rightarrow Solids & liquids are hard to compress.)



$$\text{repulsion} \propto \frac{1}{r^3} \quad \rightarrow \text{hard to compress.}$$

* Thermal Energy & Temperature.

Gaseous State.

Thermal E dominate IMF



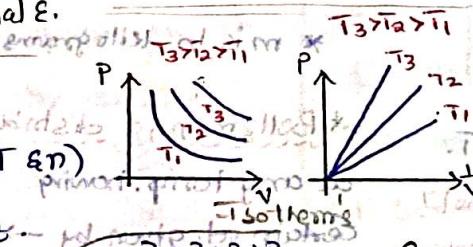
Characteristics: • Highly compressible || vol and shape not fixed.
• Exert p. equally || lower density || not fixed.

IMF dominate thermal E.

→ Boyle's law —

$$P \propto \frac{1}{V} \quad (\text{at const. } T \& n)$$

$$P_1 V_1 = P_2 V_2 = \text{const.}$$

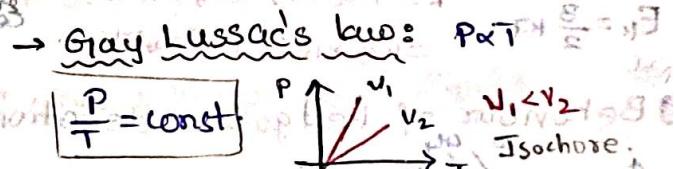
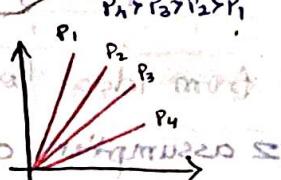


— at a const. temperature, p. is directly prop. to densit. of a fixed mass of the gas.

→ Charles's law —

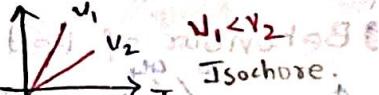
$$V \propto T \Rightarrow \frac{V}{T} = \text{const.}$$

* all gases obey Charles

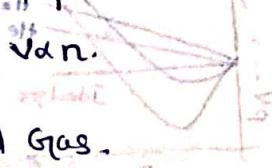


→ Gay Lussac's law: $P \propto T$

$$\frac{P}{T} = \text{const.}$$



→ Avgagedo's law: Van.



→ No intermolecular forces (assumption)

• Ideal Gas Eqn: $R = \frac{(10^5 J_A)}{(kgm)} \cdot \frac{(22.4 \times 10^3 m^3)}{(mol \cdot K)}$

$$PV = nRT$$

$$\frac{P}{V} = \frac{nR}{T} \quad (\text{constant independent of gas})$$

$$\text{atm} \quad 1t \quad 0.0821 \text{ J atm}^{-1} \text{ mol}^{-1}$$

$$\text{dyne/cm}^2 \quad \text{cm}^3/\text{sec} \quad 8.314 \times 10^7 \text{ erg K}^{-1} \text{ mol}^{-1}$$

$$\text{Newton/m}^2 \quad \text{m}^3 \quad 8.314 \text{ J K}^{-1} \text{ mol}^{-1} \approx 2 \text{ cal/mol}$$

• Density and molar mass:

$$\rightarrow PV = nRT \quad (n = \frac{M}{M}, \rho = \frac{M}{V})$$

$$\rightarrow PV = \frac{M}{M} RT \quad \text{Law says no molar}$$

$$\rightarrow PV = \frac{dV}{M} RT \quad \text{dr pressure part is}$$

$$\rightarrow M = \frac{dRT}{P} \quad \text{dr v = (dV - V) / V}$$

$$\rightarrow M = (dV - V) / (P/V)$$

Graham's law of Diffusion

The prop. of gas to occupy all space surround them.

$$\text{at } \frac{d}{dt} \frac{1}{V} = \frac{V_1}{\text{time}} \quad (\text{open})$$

$$\frac{n_1}{n_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{m}{M}} = \sqrt{\frac{V_2}{V_1}} = \frac{T_2}{T_1} = \frac{V_1}{V_2}$$

Ans -

Dalton's law of Partial P:

$$P_{\text{total}} = P_1 + P_2 + P_3 + \dots$$

$$P_i = x_i P_{\text{total}} \quad (x_i \rightarrow \text{mole fraction})$$

Kinetic mol. theory of gases:

- actual mol. vel. is negligible b/w mol.
- no force of att. b/w mol.
- const. and random motion.
- move in all directions in straight lines.
- perfectly elastic collisions.

$$PV = \frac{1}{3} m n u_{\text{rms}}^2$$

$$\text{Boyle's law} - PV = \frac{2}{3} kT$$

$$\text{Charles's law} - V = \frac{2}{3} kT/P$$

$$\text{Avogadro's law} - \frac{1}{2} m_1 u_1^2 = \frac{1}{2} m_2 u_2^2$$

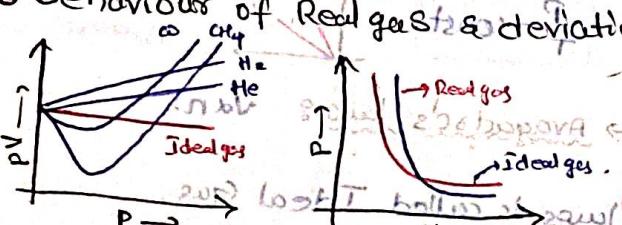
$$\text{Graham's law} - U_{\text{avg}} = \frac{1}{3} P = \frac{1}{3} \frac{kT}{m}$$

Kinetic Energy

$$E_k = \frac{1}{2} m u^2 \quad E_k = \frac{3}{2} n R T \quad E_k \propto T$$

$$E_k = \frac{3}{2} k T \times n \quad E_k = 1.38 \times 10^{-23} J \text{ K}^{-1} \text{ mol}^{-1}$$

Behaviour of Real gases & deviation from ideal behavior:



Due to high p & att ($P_{\text{real}} < P_{\text{ideal}}$)

$$P_{\text{ideal}} = P_{\text{real}} + \frac{an^2}{V^2} \quad a \text{ is independent of } T \text{ & } P$$

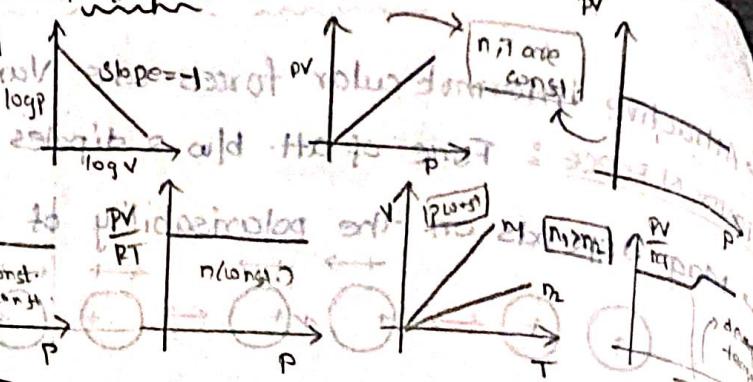
Since we gave mol. also size?

let they occupy nb space

$$\therefore V_T = (V-nb) \quad \text{Van der Waal's eq.}$$

$$\left(P_1 \frac{an^2}{V^2} \right) (V-nb) = nRT$$

* Graphs:-



Diffusion & effusion of a gas

high pressure into space through a fine hole

Diffusion is non-directional phenomenon.

Effusion is unidirectional phenomenon.

Applications of diffusion:

In the sep. of U^{235} & U^{238} by forming volatile solids $U^{235}F_6$ & $U^{238}F_6$.

- Ansil's alarm.

- Isotopes are separated.

Speeds:

$U_{\text{rms}} > U_{\text{avg}} > U_{\text{imp}} \rightarrow U_{\text{imp}} : U_{\text{avg}} : U_{\text{rms}}$

$$U_{\text{rms}} = \sqrt{\frac{3RT}{M}} \quad U_{\text{imp}} = \sqrt{\frac{2RT}{M}} = 0.8166 \times U_{\text{rms}}$$

$$U_{\text{avg}} = \sqrt{\frac{RT}{M}} = 0.9213 \times U_{\text{rms}}$$

m is in kilograms.

Boltzmann's distribution:

at any temp. having certain vel. given by

$$\frac{n_i}{n} = e^{-\frac{mv^2}{2kT}}$$

assumptions of KTG are False.

There is no force of att. b/w molecules.

val. of mol. of a gas. is neg. small.

at high temp. $P \approx$ mol. intercets \Rightarrow liquifies

$$t_{\text{ref}} = \frac{V}{T} \approx T \times b$$

unit of $a \equiv \frac{\text{P atm}}{\text{mol}^2}$; $b \equiv \frac{\text{mol}}{\text{L}}$

$a \equiv$ related forces of interaction b/w mol.

($a \propto$ attractive forces)

$b \equiv$ nb occupied. [$b = 4 \times \text{vol. (mol. of gas)}$]

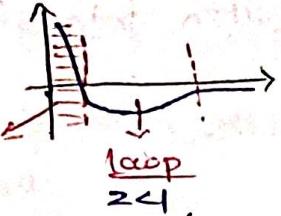
for a given van der waal's cons $a \propto b$

\therefore higher $a \propto$ can be easily liquified.

Compressibility factor:

$$Z = \frac{PV}{nRT}$$

high P
 $Z > 1$



Boyle Temperature: The temp. at which real gas behaves as ideal over app. range of P.

$$Z = \frac{V_{\text{real}}}{V_{\text{ideal}}} \quad \text{see graph in Pg. 132.}$$

→ Liquefaction of gases - Liquid = Dense gas.

- Critical temp. (T_c): The temp. at a real gas above which it can't be liquefied. $|T_c = 8a/(27Rb)|$

- Critical pressure (P_c): The min. p. req. for liquefaction to take place at critical temp. $|P_c = a/(27b^2)|$

- Critical vol. (V_c): Vol. occupied by 1mol. of a gas under critical temp. and P. $|V_c = 3b|$

* The value of $|Z = 0.375|$ is const. for all gases at critical point.

→ Vapour: A gas below critical temp. can be liquefied by app. pressure.

→ Vap. p.: In a fixed vol. liq. evaporates into vapour and attains equilibrium b/w liquid \rightleftharpoons vapour, the p. at this stage is Vapour p.

⦿ Free vapourisation \approx Boiling (Vap. p = ext. p.)

normal B.pt = at $p = 1 \text{ atm.}$

standard B.pt = at $p = 1 \text{ bar.}$

$$|1 \text{ bar} < 1 \text{ atm}|$$

Surface Tension: Liquids tend to minimise surface area.

- The force acting per unit length \perp to the line drawn on the surface

$$(1) \text{ kg s}^{-1} \in \text{N m}^{-1}$$

→ gives stretching prop. $F_{\text{net}} = 0$ $F_{\text{ext}} = \text{down.}$

$$\text{Temp} \propto K \varepsilon \propto \frac{1}{\text{inter mol att}} \propto \frac{1}{\text{Surface tension}} \propto \frac{1}{\text{viscosity}}$$

o at very high P for a real gas,

$$\rightarrow Z > 1$$

→ Z varies linearly with P.

→ Molar vol. occupied by gas is more compared to ideal gas at similar temp. & p.

→ Gas is less compressible

$$\rightarrow Z = 1 + Pb/RT$$

Viscosity:



$$F = \eta A \frac{du}{dz}$$

$$|\underline{\underline{\sigma}}| (\text{N m}^{-2}) = \text{Pascal} ; S = \text{kg m}^{-1}\text{s}^{-1}$$

$$\underline{\underline{\text{CGS}}} \text{ poise} = 1 \text{ g cm}^{-2}\text{s}^{-1} = 10^3 \text{ kg m}^{-1}\text{s}^{-1}$$

* H-bonding & van der waal forces etc support viscosity.

* Glass is highest viscous liquid.

$$T_B = \frac{a}{bR}$$

At high-temp & low p. real gas behaves as an ideal gas.

$$\text{Mean free path } (\lambda) = \frac{RT}{\sqrt{2} N \sigma^2 P}$$

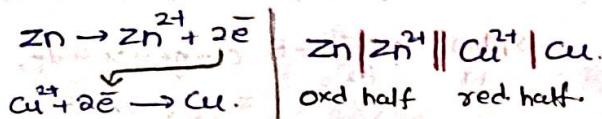
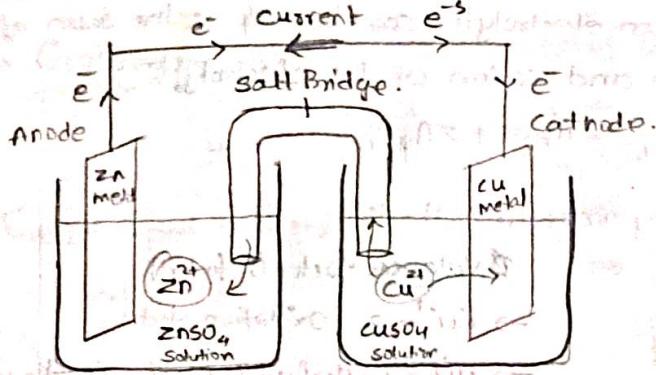
Electrochemistry.

⇒ also voltaic.

① Galvanic Cell: Chemical E → Elec. E. * OIL RIG

② Electrolytic cell's: Elec. E → Chem. E. (ox. is loss (e) red is gain (e⁻))

③ Daniel cell:



$E_{\text{cell}} = 1.1 \text{ V}$.

The complete rxn. is reversed

Anode ⇌ Cathode.

• Electros flow from Cu to Zn.

• Zn deposited at Zn²⁺ electrode

Cu deposited at Cu electrode.

$\Delta G = -nFE_{\text{cell}}$.

ΔG	E_{cell}	Condition of Process
-Ve	+Ve	Spontaneous
+Ve	-Ve	Non-spont.
0	0	equilibrium.

for standard condition, $\Delta G^\circ = -nFE_{\text{cell}}^\circ$

$$10KT \quad \Delta G = \Delta G^\circ + RT \ln Q$$

$$\rightarrow -nFE = -nFE^\circ + RT \ln Q$$

$$\rightarrow E = E^\circ - \frac{RT}{nF} \ln Q$$

④ Nernst Equation: $aA + bB \xrightarrow{nF} cC + dD$.

$$E_{\text{cell}} = E_{\text{cell}}^\circ - \frac{RT}{nF} \ln \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

$F = 96450$

$F = 96487$

$$E = E^\circ - \frac{0.059}{n} \log Q$$

$$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$T = 298 \text{ K}$$

⇒ at equilibrium: $E_{\text{cell}} = 0$

$$\phi E^\circ = \frac{2.303RT}{nF} \log K_c$$

$$\lambda_m = \frac{K(\text{scm}^{-1})}{1000 \text{ cm}^3 \times \text{molarity (mol/L)}} = \frac{K(\text{scm}^{-1}) \times 1000 (\text{cm}^3/\text{L})}{\text{molarity (mol/L)}}$$

$(\text{scm}^2 \text{ mol}^{-1})$

Oxidation → Anode

Reduction → Cathode

⑤ Electrode potential: Tendency of an element; when placed in contact with its own ions to either lose or gain e⁻ & in turn become positively or negatively charged
⇒ When oxidation = Ox. red. potential.
⇒ When reduction = red. potential.

⑥ Standard electrode potential: (E°)

electrode potential determined relative to standard hydrogen electrode under standard conditions.

i, 1M conc. of each ion in the soln.

ii, 298 K, 1 bar p. for each gas.

→ The potential of individual half cell cannot be measured but only the diff. b/w a half cells.

→ If SEP > 0, then its reduced form is more stable than H₂ gas.

⑦ Conductance:

base with which I flows through a conductor

$$G = \frac{I}{R} \Rightarrow g = \frac{1}{R} = \frac{A}{Rd} \quad \text{P} \rightarrow \text{ho} \quad \text{R} \downarrow \frac{1}{d}$$

$$\text{Conductivity} - G = \frac{A}{Rd} = \frac{KA}{d} \quad \downarrow \text{Kappa (scm)}$$

→ Conductivity of Ionic solids is measured in conductivity cell.

$$\frac{1}{A} = \text{cell const} (G^*) \quad G^* = \frac{1}{A} = KR$$

⑧ Molar conductivity: conducting power of all the ions produced by dissolving one mole of an electrolyte placed b/w 2 large electrodes at 1 cm apart

$$\lambda_m = \frac{K}{a}$$

$$1 \text{ mol m}^{-3} = 1000 (\text{L m}^{-3}) \times \text{molarity (mol/L)}$$

$$\lambda_m = \frac{K(\text{scm}^{-1})}{1000 \text{ cm}^3 \times \text{molarity (mol/L)}} = \frac{K(\text{scm}^{-1}) \times 1000 (\text{cm}^3/\text{L})}{\text{molarity (mol/L)}}$$

and $\Lambda_m \propto \frac{1}{[C]}$ when $[C] \rightarrow 0$ $\Lambda_m \rightarrow \Lambda_m^{\circ}$ (limiting molar conductivity).

* for strong electrolytes, Λ_m increases slowly with dilution. $\Lambda_m = \Lambda_m^{\circ} - A C^2$

Kohlrausch law of independent migration of ions:

The limiting molar conductivity of an electrolyte can be exp. as the sum of the individual contributions of the anion and cation of the electrolyte.

$$\Lambda_m^{\circ}(\text{NaCl}) = \Lambda_{\text{Na}^+}^{\circ} + \Lambda_{\text{Cl}^-}^{\circ} \quad \text{for MgCl}_2 \quad \Lambda_m^{\circ}(\text{MgCl}_2) = \Lambda_{\text{Mg}^{2+}}^{\circ} + 2 \Lambda_{\text{Cl}^-}^{\circ}$$

Weak electrolytes: cannot be predicted by general methods.

$$\text{deg. of dissociation} - \alpha = \frac{\Lambda_m}{\Lambda_m^{\circ}}$$

$$(a) \quad K_a = \frac{C \alpha^2}{(1-\alpha)} = \frac{C \Lambda_m^{\circ}}{\Lambda_m^{\circ} (\Lambda_m^{\circ} - \Lambda_m)}$$

Electrolyte: substance that dissociates

in solution to produce ions.

→ interionic attractions \propto 1/conductance.

→ Solvation of ions \propto 1/conductance.

→ viscosity \propto 1/conductance.

→ Temp. \propto conductance.

Ø Valence factor (n-factor)

$\rightarrow \text{Cu}^{2+} = 2$ oxidation state

$\rightarrow \text{HCl} = 1; \text{H}_2\text{SO}_4 = 2$ no. of replacef.

$\rightarrow \text{MnO}_4^- \rightarrow \text{Mn}^{+4} = 5$ charge in ox. st.

H.D.P \Rightarrow Easily (oxidisable/reducf.)

Discharge potential - $\text{Li}^+ > \text{K}^+ > \text{Na}^+ > \text{Ca}^{2+} > \text{Mg}^{2+}$

$> \text{Al}^{3+} > \text{Mn}^{2+} > \text{Zn}^{2+} > \text{Cr}^{3+} > \text{Fe}^{2+} > \text{H}^+ > \text{Cu}^{2+} > \text{Hg}^+ > \text{Ag}^+$

$\text{Au}^{3+} > \text{F}^- > \text{SO}_4^{2-} > \text{NO}_3^- > \text{OH}^- > \text{Cl}^- > \text{Br}^- > \text{I}^-$

Faraday's laws of Electrolysis:

1. First law - The amt. of Chem. rxn by a i is prop. to the quantity of electricity passed.

• The amt. of substance that is deposited or liberated at an electrode is directly prop. to the quantity of charge passed through electrolyte.

$$\Rightarrow W \propto Q \quad \left\{ \begin{array}{l} Z = W/Q \\ W = Zit \end{array} \right. \quad \Rightarrow Z = \frac{E}{F} \quad \Rightarrow \frac{W}{Q} = \frac{Eit}{F} \quad \text{Mol wt.} \quad \text{n-factor} \quad \text{lit} \quad \boxed{W = E/F}$$

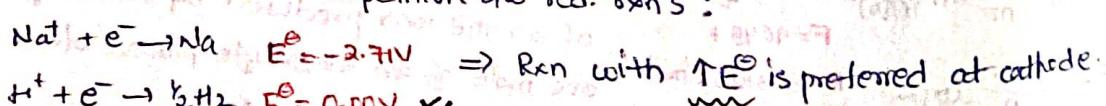
2. Second law: When the same quantity of i is passed by diff. electrolytes, that are connected in series, is prop. to eq. wt.



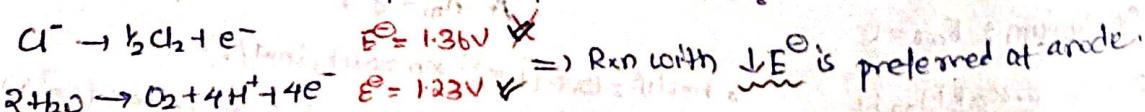
$$\frac{W_1}{E_1} = \frac{W_2}{E_2} = \frac{W_3}{E_3} = \text{const.}$$

Products of Electrolysis:

at cathode there is competition b/w red. rxn's:



at anode there is competition b/w ox. rxn's:



↳ but here due to overpotential of O_2 that isn't preferred.