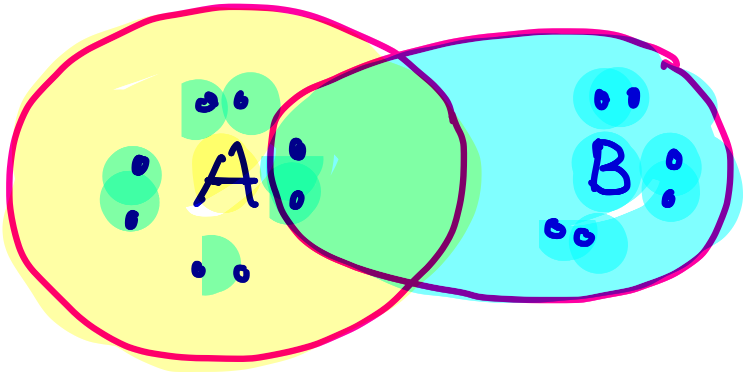
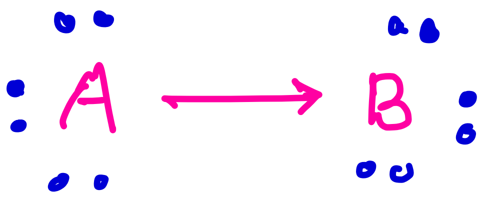
CHEMICAL BONDING

Co-ordinate Bond

It is a special type of Co-valent bond in which shared electron pair of electrons is from one atom Called donor atom and other is Called acceptor atom and formed Bond called co-ordinate bond.



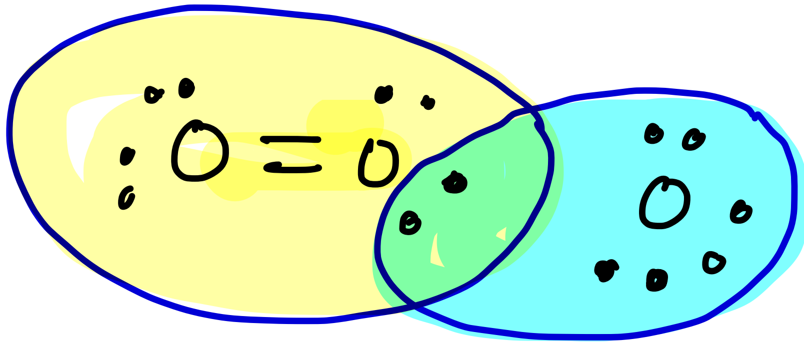


modern $\overset{+}{A} — \overset{-}{B}$

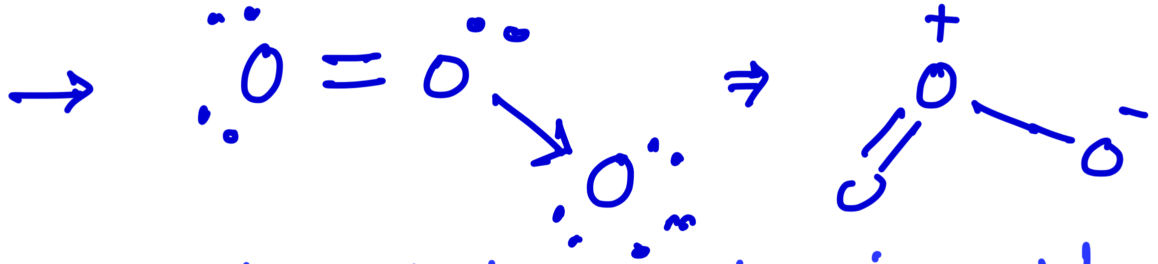
↳ After sharing no of $\bar{e}$ of A = 8

↳ After sharing no of $\bar{e}$ of B = 8

Ex. O_3



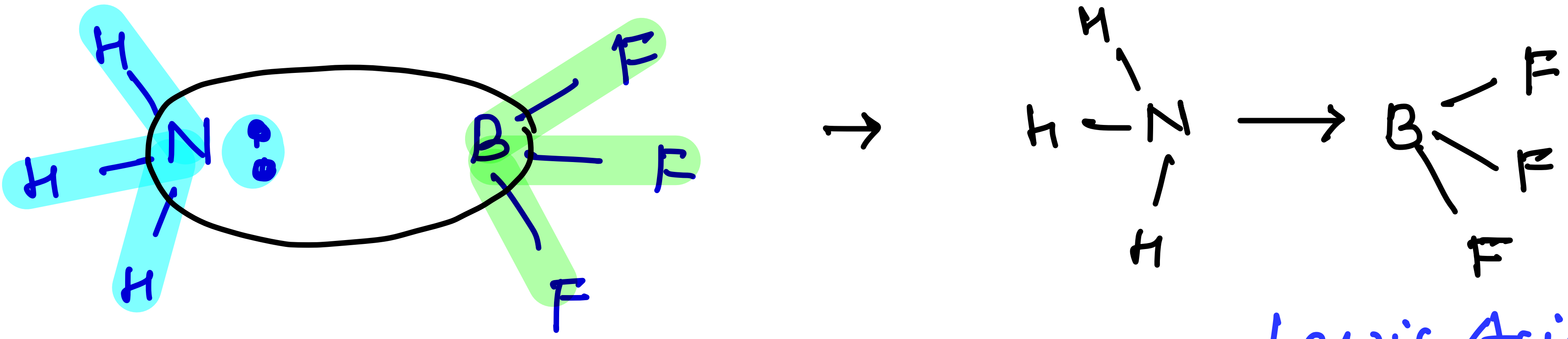
$O_2 + O \rightarrow O_3$



↳ Vacant orbital = Lewis acid

↳ lone pair = Lewis base

CHEMICAL BONDING

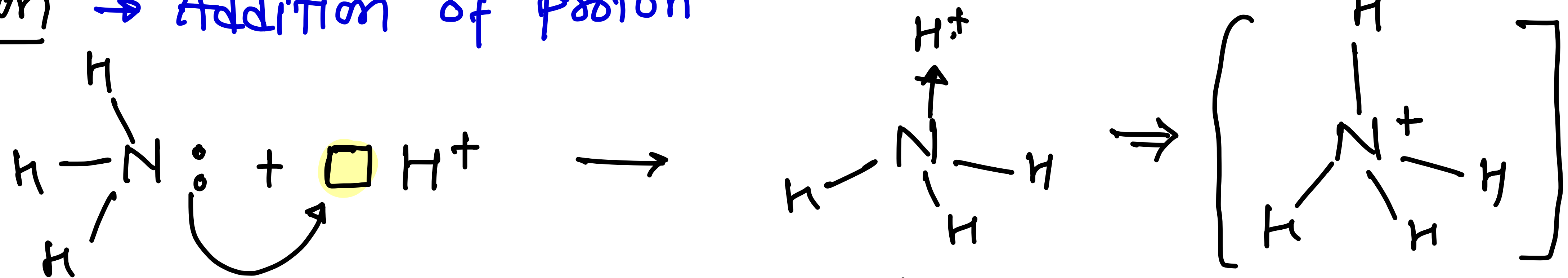


Lewis Acid : BF_3

Lewis Base : NH_3

proton (H^+) $1s^0$ □

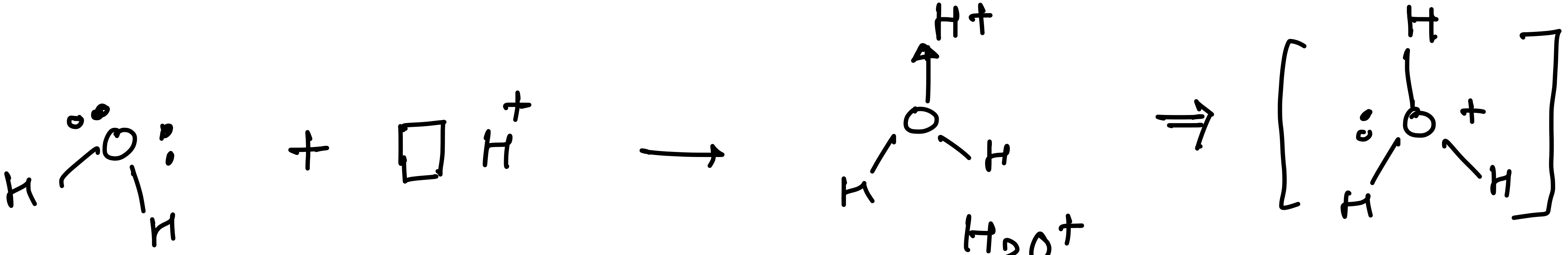
Protonation → Addition of proton



NH_4^+

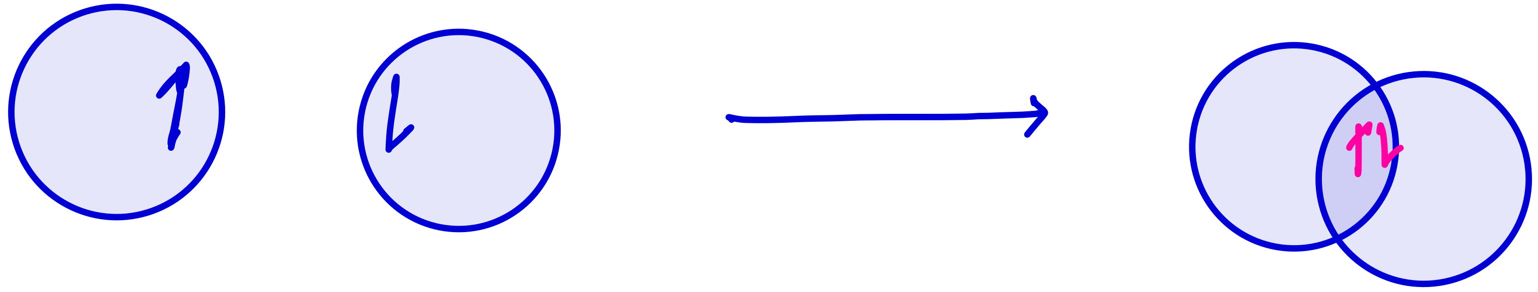
Lewis Acid = H^+

Lewis Base : NH_3

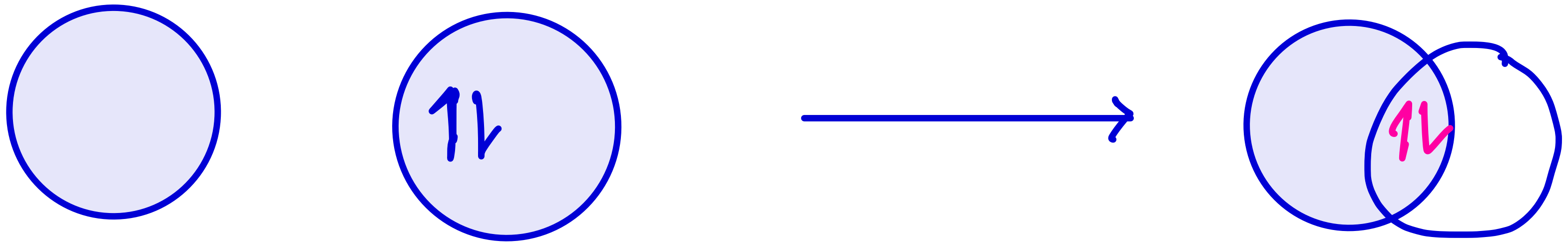


H_3O^+

CHEMICAL BONDING



Co-valent bond



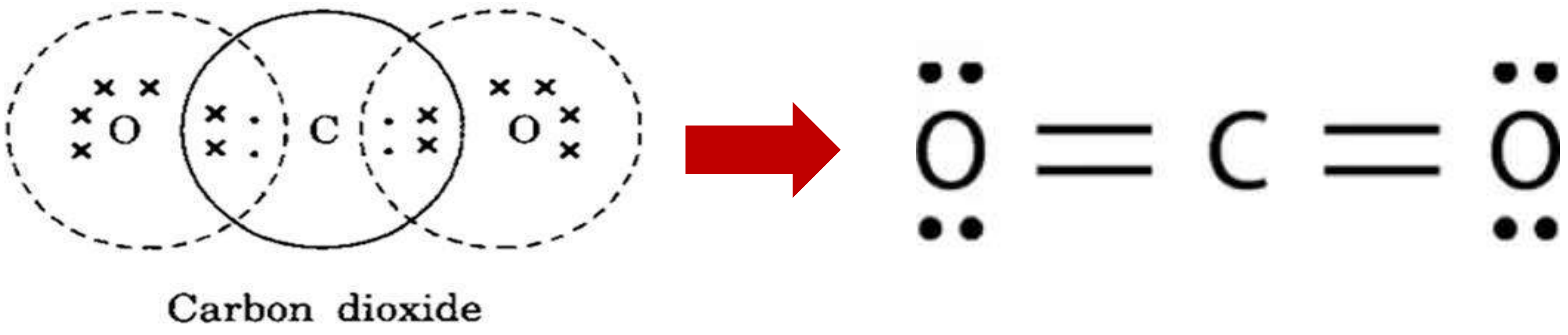
Co-ordinate bond

Once a co-ordinate bond is formed it behave as single co-valent bond [σ bond]

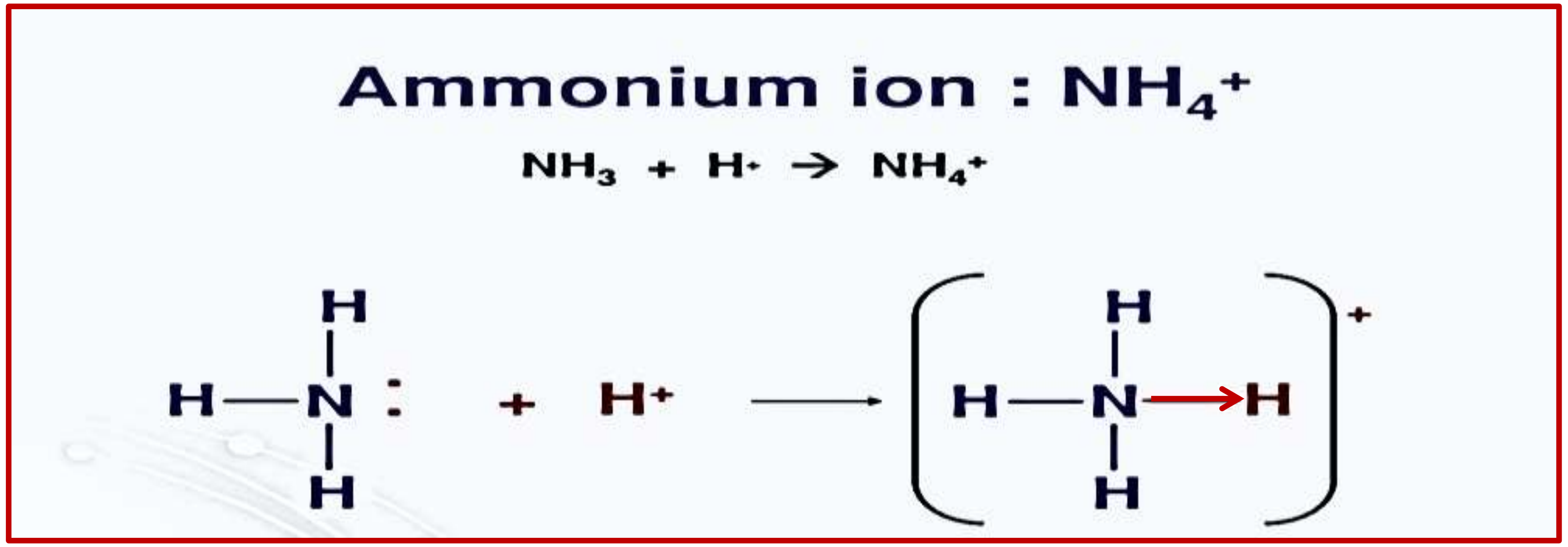
CHEMICAL BONDING

CHEMICAL BONDING

(ii) By equal contribution(sharing) of electrons:- Covalent bond is formed.



(iii) By unequal contribution(sharing) of electrons:- Coordinate bond is formed.



CHEMICAL BONDING

IONIC BOND/ELECTROVALENT BOND

- It is the electrostatic force of attraction between cation and anion .
- The chemical bond formed between two or more atoms as a result of the complete transfer of one or more electrons from one atom to another is called Ionic or electrovalent bond.
- Total number of electron lost or gained is called electro valency.

Example :

$$\underset{2,\ 8,\ 2}{Mg} \xrightarrow{2e^-} \underset{2,\ 6}{O}$$

electro valency of Mg = 2
electro valency of O = 2

Mg^{+2} (2,8) ... O^{-2} (2,8)

they form ionic bond

$$\underset{2,8,8,2}{Ca} \xrightarrow{\text{One } e^-} \underset{2,8,7}{Cl}$$

$$\underset{2,8,8,2}{Ca} \xrightarrow{\text{One } e^-} \underset{2,8,7}{Cl}$$

electro valency of Ca = 2
electro valency of Cl = 1

Cl^- 2,8,8 ... Ca^{+2} 2,8,8 ... Cl^- 2,8,8

CHEMICAL BONDING

- Favourable Condition for fomation of Ionic Bond.

- One atom must be electropositive can easialy loose electrons that means that have very low IE

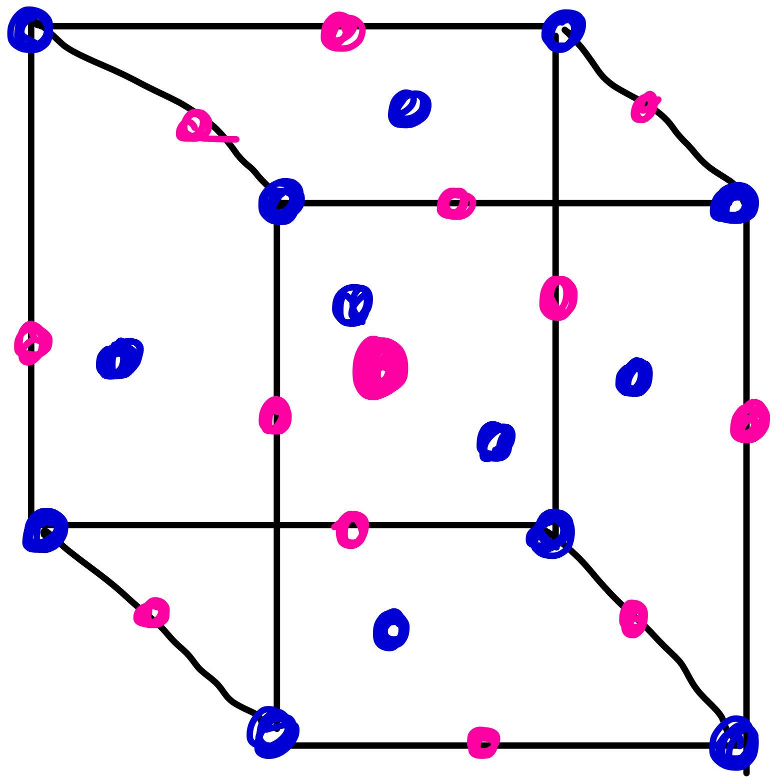
- Other atom must be Electronegative can easialy gain electrons that means high electron affinity

- $|\Delta EN| > 1.9$

- Energy released during formation of bond must be very high.

CHEMICAL BONDING

Crystal Lattice ÷ A regular 3D arrangements of ions (Cation/Anion) called crystal lattice.



● Na^+
● Cl^-

→ Crystall Lattice of NaCl.

CHEMICAL BONDING

Lattice energy ⇒ when 1 mole of Ionic solid is formed from its gasseous ions the amount of energy released is called Lattice energy.

Ex $Na^+(g) + Cl^-(g) \longrightarrow NaCl(s)$ (Exothermic) (−ve)

energy released = LE(NaCl)

Ex. 2 $Mg^{+2}(g) + 2F^-(g) \longrightarrow MgF_2(s)$

energy release = LE($MgF_2(s)$)

Ex. $2Na^+(g) + 2F^-(g) \longrightarrow 2NaF(s)$

energy released = 2 LE($NaF(s)$)

CHEMICAL BONDING

(OR)

Energy absorbed when 1 mole of Ionic solid is converted into gasseous ions called lattice energy

(endothermic)
(+ve)

- $NaF(s) \longrightarrow Na^{+}(g) + F^{-}(g)$

Energy required is called = LE(NaF)

- $Al_2O_3(s) \longrightarrow 2Al^{+3}(g) + 3O^{-2}(g)$

energy absorbed = $LE[Al_2O_3]$

CHEMICAL BONDING

Factors Affecting LE :

$$U = \frac{K\, q_1 q_2}{r}$$

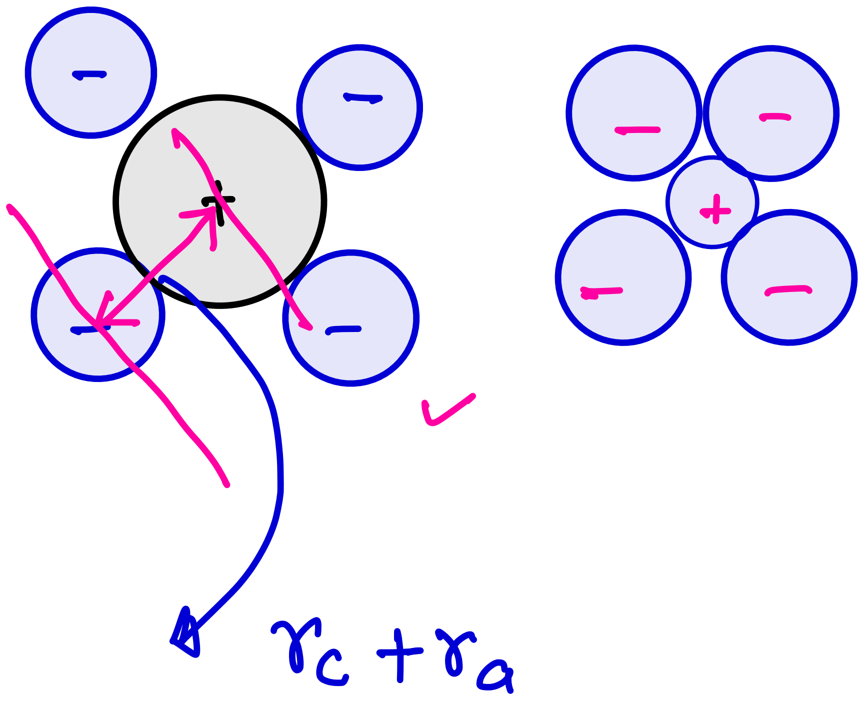
q_1 = charge of cation

q_2 = charge of Anion

r_c = radius of cation

r_a = radius of Anion

A → packing cofficient.



$$\boxed{LE \propto \frac{q_c q_a}{r_c + r_a} \cdot A}$$

CHEMICAL BONDING

(1) $|q_c \cdot q_a|$ increase then lattice increases.

(2) $|q_c|$ increases lattice energy increases

(3) $|q_a|$ increases lattice energy increases

(4) r_c increases lattice energy decrease

(5) r_a increases lattice energy decreases.

(6) A increases lattice energy increases

A → has higher value if cation and anion have almost same size.

CHEMICAL BONDING

Ex. Arrange the following in increasing order of lattice energy

(i) $\overset{+1}{Na}F$ < $\overset{+2}{Mg}F_2$ < $\overset{+3}{Al}F_3$ (Anion is same)

$q_c \uparrow$ LE $\uparrow$

(ii) $\overset{+1}{Na}\overset{-1}{F}$ < $\overset{+2}{Mg}\overset{-2}{O}$ < $\overset{+3}{Al}\overset{-3}{N}$

$|q_c \cdot q_a| \uparrow$ LE $\uparrow$

(iii) $Na\overset{-1}{F}$ < $Na_2\overset{-2}{O}$ < $Na_3\overset{-3}{N}$

$|q_a| \uparrow$ LE $\uparrow$

(iv) $\underline{Be}SO_4$ < $\underline{Ba}SO_4$ [$\underline{SO_4^{-2}}$ large Anion]

because Ba^+ has large size (similar size)

(v) $BeCO_3$ > $BaCO_3$ [CO_3^{-2} small Anion]

Extra

LiF > CsF

LiI < CsI

CHEMICAL BONDING

Calculation of Lattice energy

Enthalpy of Formation : Formation of 1 mole compound from its elemental constituent.

Ex i) $Na(s) + \frac{1}{2}Cl_2(g) \longrightarrow NaCl(s)$, Energy released is called enthalpy of formation (NaCl(s))

$\Delta H_f(NaCl)$

ii) $2Al(s) + \frac{3}{2}O_2(g) \longrightarrow Al_2O_3(s)$

Energy released will be enthalpy of formation of $Al_2O_3(s)$

or $\Delta_f H(Al_2O_3(s))$

CHEMICAL BONDING

iii) $Mg_{(s)} + F_{2}(g) \longrightarrow MgF_{2}(s)$

energy released = Enthalpy of formation $(MgF_{2}(s))$

$\Delta H_f (MgF_{2}(s))$

iii) $H_2(g) + S_{(s)} + 2O_2(g) \longrightarrow H_2SO_4(aq.)$

energy released = $\Delta H_f (H_2SO_4(aq.))$

BORN HABER cycle ÷ this is based on Hess's law.

which says that enthalpy change in a multistep chemical reaction is algebric sum of enthalpy of each step reaction.

$$
\begin{tikzcd}
A \arrow[rr, "\Delta H"] \arrow[d, "\Delta H_1"'] & & D \\
B \arrow[r, "\Delta H_2"'] & C \arrow[ur, "\Delta H_3"'] &
\end{tikzcd}
$$

$$\Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3$$

CHEMICAL BONDING

BORN HABER CYCLE For NaCl(s)

$$Na(s) + \frac{1}{2}Cl_2(g) \longrightarrow NaCl(s) \quad \Delta H_f(NaCl(s))$$

$$Na(s) \xrightarrow{\Delta H_{sub}(Na(s))} Na(g) \xrightarrow[-e]{\Delta H_{IE_1}(Na)} Na^+(g)$$

$$\frac{1}{2}Cl_2(g) \xrightarrow{\frac{1}{2}\Delta H_{BD}(Cl-Cl)} Cl(g) \xrightarrow[+e]{\Delta H_{eg_1}(Cl)} Cl^-(g)$$

BD ↳ bond dissociation

$$Na^+(g) + Cl^-(g) \xrightarrow{\text{Lattice energy}} NaCl(s)$$

$$\Delta H_f(NaCl(s)) = \overbrace{\Delta H_{sub}(Na(s)) + \Delta H_{IE_1}(Na) + \frac{1}{2}\Delta H_{BD}(Cl-Cl)}^{\text{endothermic}} + \overbrace{\Delta H_{eg_1}(Cl) + LE(NaCl)}^{\text{exothermic}}$$

Q. In how many of following compound the enthalpy of formation is −ve only due to lattice energy

MgO, $NaCl$, Na_3N, CaF_2, Ca_3N_2, $CaCl_2$,

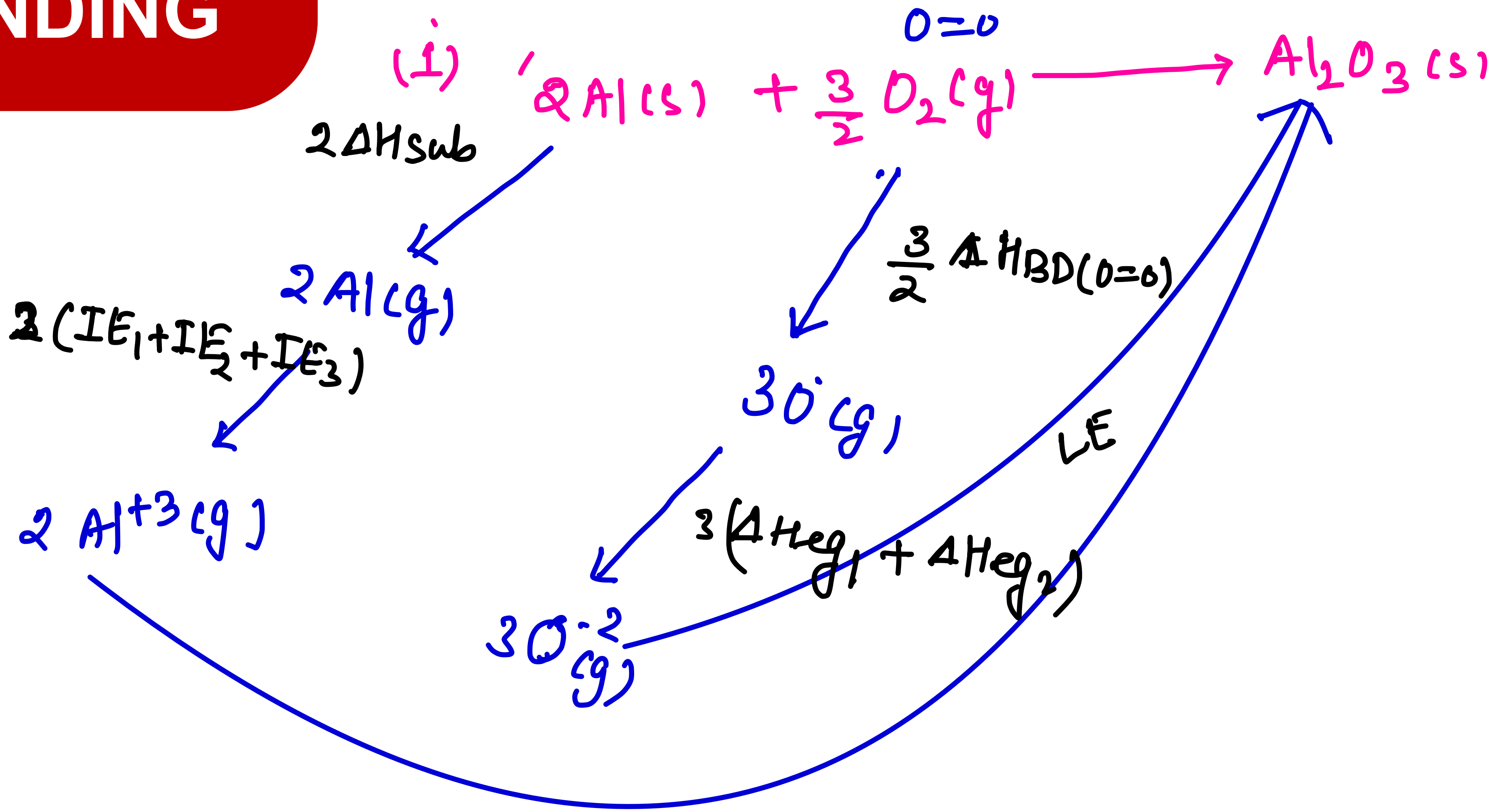
SiF_4, CaO. Na_2S

ΔH_{eg} for polyvalent Anions is endothermic

CHEMICAL BONDING

Q. draw Born Haber cycle for $MgCl_2$, Al_2O_3, $NaBr$
MgF_2, AlF_3, Ca_3N_2, CaO,

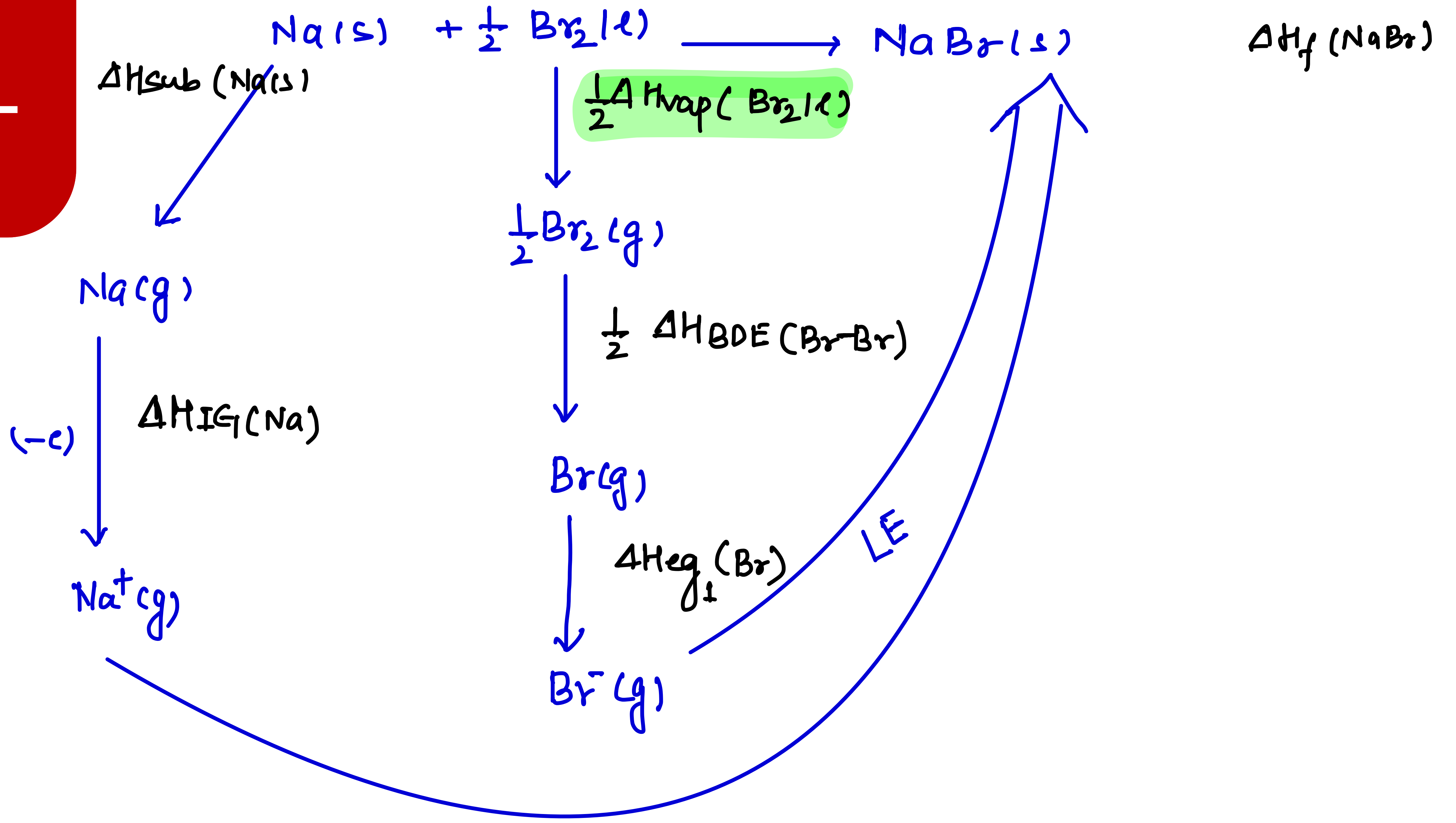
(i)



$\underline{\Delta H_f\ (Al_2O_3(s))}$

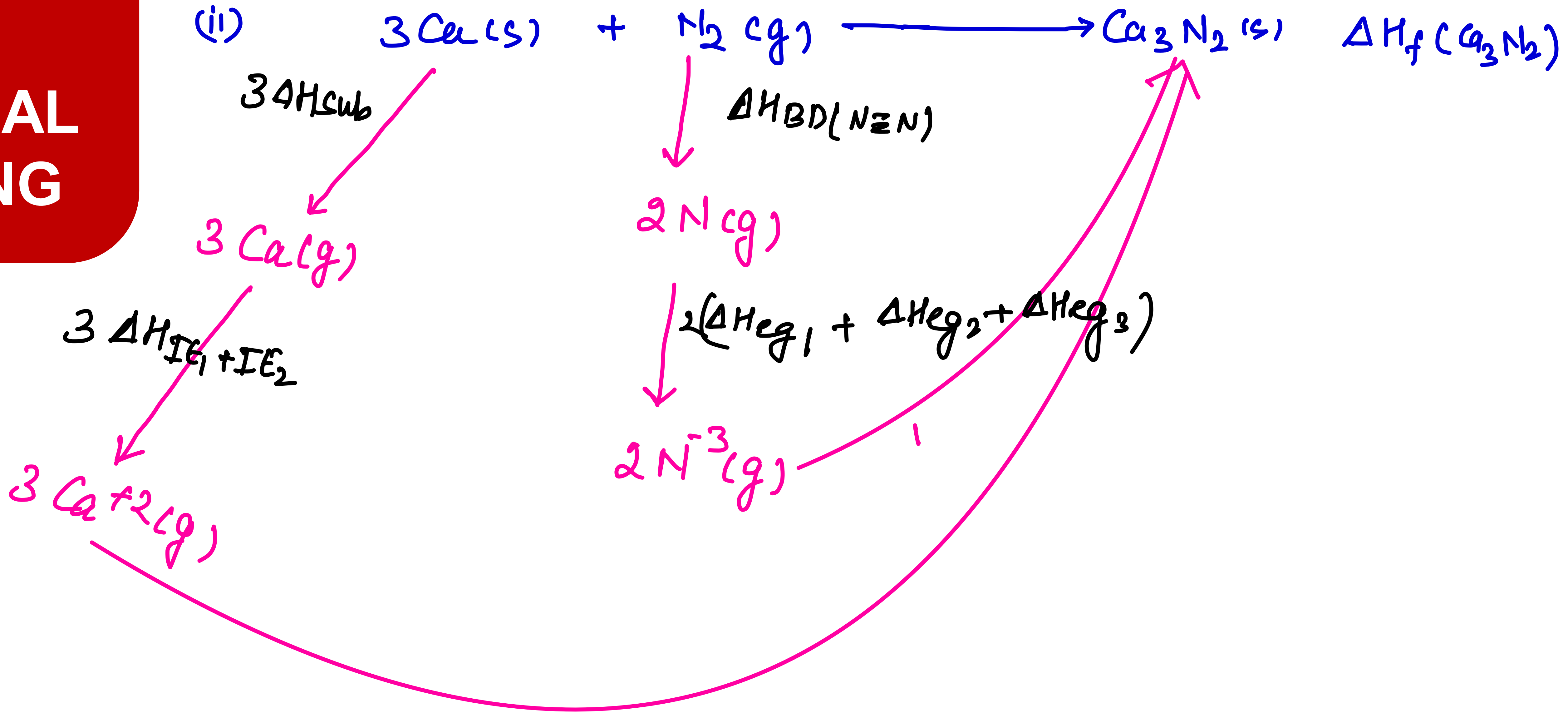
$$\Delta H_f(Al_2O_3(s)) = 2\,\Delta H_{sub}(Al(s)) + 2(\Delta H_{IE_1} + \Delta H_{IE_2} + \Delta H_{IE_3}) + \frac{3}{2}\Delta H_{BD(O=O)} + 3(\Delta H_{eg_1} + \Delta H_{eg_2}) + LE$$

CHEMICAL BONDING



$$\Delta H_f(NaBr(s)) = \Delta H_{sub}[Na(s)] + \Delta H_{IE_1}(Na) + \frac{1}{2}\Delta H_{vap}(Br_2(l)) + \frac{1}{2}\Delta H_{BDE}(Br\text{-}Br) + \Delta H_{eg_1}(Br) + LE(NaBr)$$

CHEMICAL BONDING



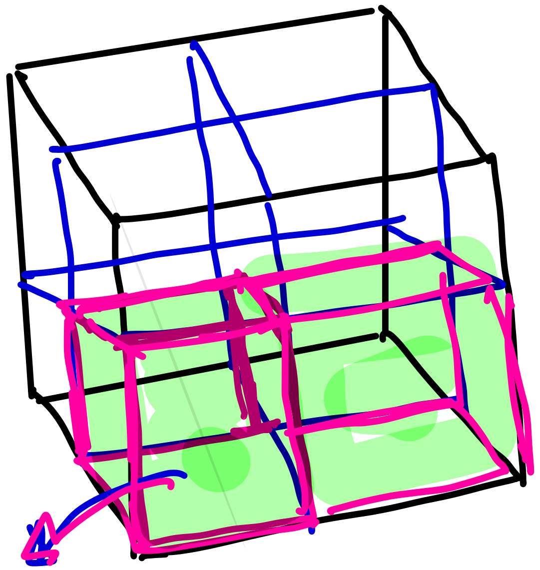
$$\Delta H_f(Ca_3N_2) = 3\Delta H_{sub}(Ca,s) + 3(\Delta H_{IE_1} + \Delta H_{IE_2}) + \Delta H_{BD}(N\equiv N) + 2(\Delta H_{eg_1} + \Delta H_{eg_2} + \Delta H_{eg_3}) + LE$$

CHEMICAL BONDING

PROPERTIES OF IONIC COMPOUND

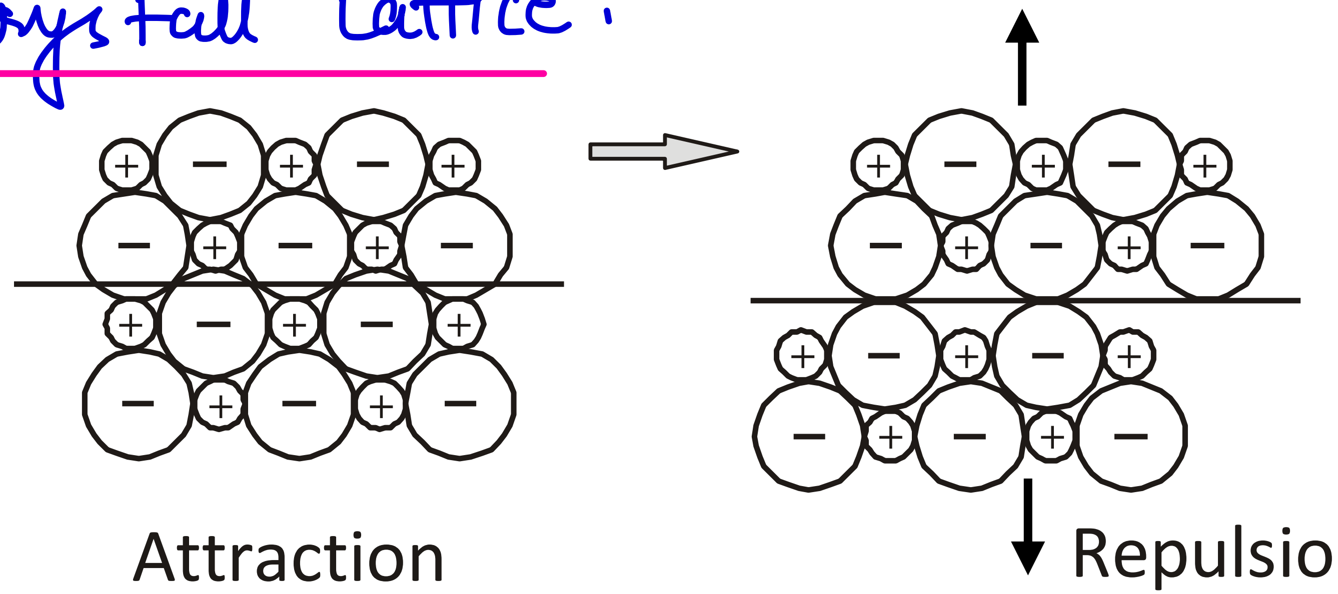
Physical state :-

- Ionic compounds are hard, crystalline due to strong electrostatic force of attraction .
- They are brittle in nature.
- Ionic compound do not form molecul they form Crystall Lattice.



4NaCl

Brittleness



{ Same charged ions come closer. So they repel each other.}

* Ionic bonds are nondirectional nature.

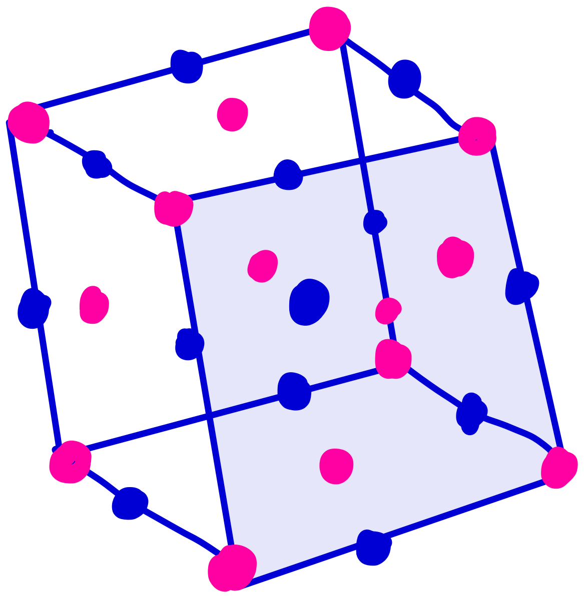
IONIC BOND/ELECTROVALENT BOND

Isomorphism :–

(1) Two compounds are said to be isomorphous if they have similar no. of electrons i.e. similar configuration of their cation and anion.

(2) They have similar crystal structure.

MgO / NaCl
Isoamorphous



Cl^- → ● (pink), Na^+ → ● (blue) | ● (pink) → O^{-2}, ● (blue) → Mg^{+2}

Example :-	Na^+	F^-	Mg^{2+}	and	O^{2-}	
Valency	+1	–1	+2		–2	
Electronic configuration		(2,8)	(2,8)	(2,8)		(2,8)

Isomorphous pair

similarly	Ca^{+2}	$2Cl^-$	$2K^{+1}$	and	S^{-2}
	(2,8,8)	(2,8,8)	(2,8,8)		(2,8,8)

Isomorphous pair

Polyamorphous · $\boxed{ZnS}$ → Wurtzite structure
→ Sphalerite structure