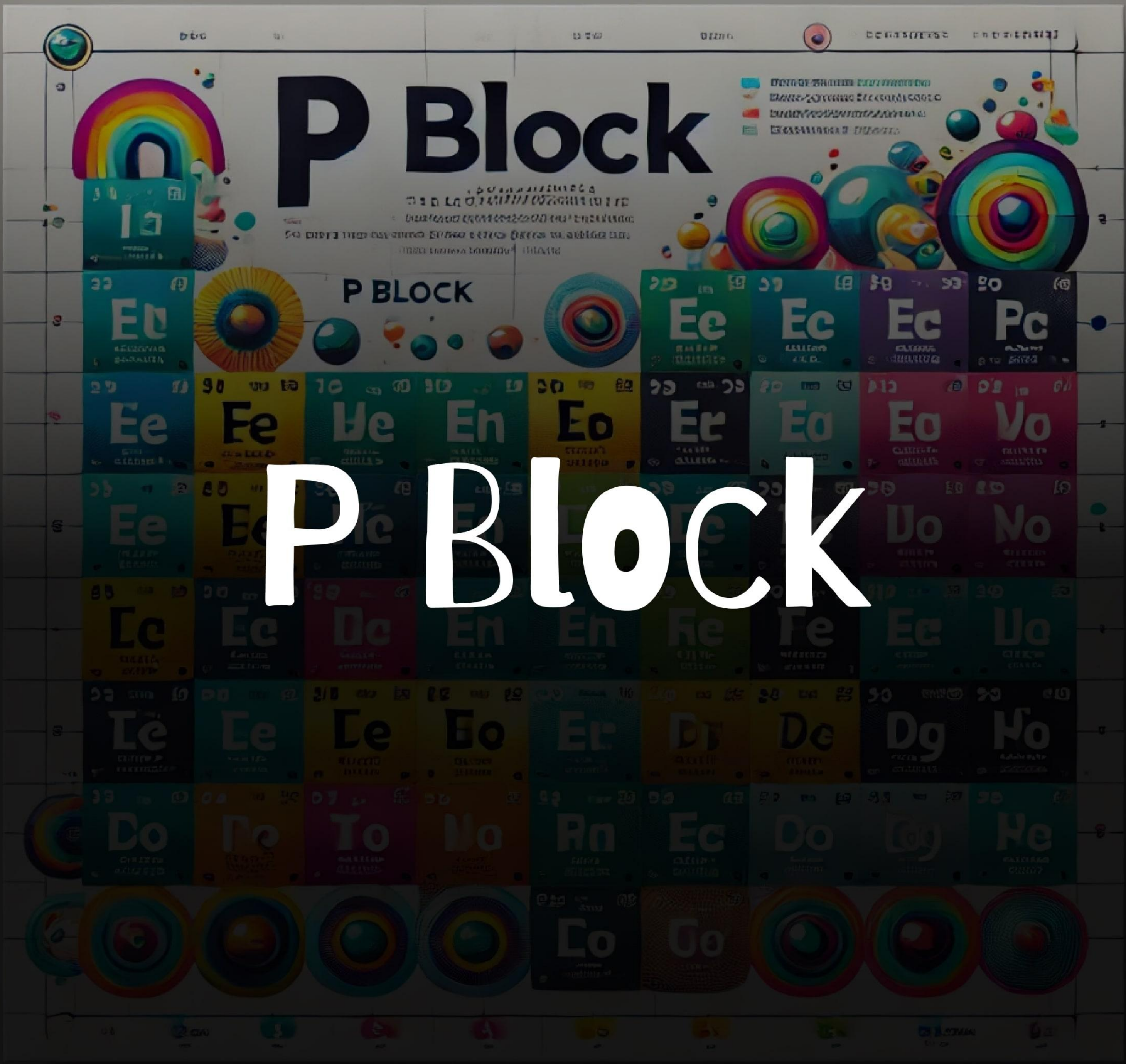


P Block

* P-Block *

* Introduction of P-Block

→ last electron enters into outermost P subshell, called P block element

→ There are 3 P orbitals → max. 6 e⁻ can be accomodated → Therefore 6 grps in P-Block

→ General electronic configuration - [IG] $ns^2 np^{1-6}$

	G13	G14	G15	G16	G17	G18
	[IG]$ns^2 np^1$	[IG]$ns^2 np^2$	[IG]$ns^2 p^3$	[IG]$ns^2 np^4$	[IG]$ns^2 np^5$	$ns^2 np^6$
	→ Boron family	Carbon Family	Nitrogen Family	Oxygen Family	Halogen Family	Inert gas or Noble gas
Grp oxdⁿ no →	+3	+4 -4	+5 -3	+6 -2	+7	+8
	+1	+2	+3	+4 +2	+5	+6

↳ Sum of valence electron or sum of s & p electrons

G13 $<^{+3}_{+1}$	G14 $<^{+4}_{+2}$	G15 $<^{+5}_{+3}$	G16	G17	G18
$ns^2 np^1$	$ns^2 np^2$	$ns^2 np^3$	$ns^2 np^4$	$ns^2 np^5$	$ns^2 np^6$
					He
B +3	C +4	N +5	O	F	Ne
Al +3	Si +4	P +5	S	Cl	Ar
Ga $<^{+3}_{+1}$	Ge $<^{+4}_{+2}$	As $<^{+5}_{+3}$	Se	Br	Kr
In $<^{+3}_{+1}$	Sn $<^{+4}_{+2}$	Sb $<^{+5}_{+3}$	Te	I	Xe
Tl $<^{+3}_{\textcircled{+1}}$	Pb $<^{+4}_{\textcircled{+2}}$	Bi $<^{+5}_{\textcircled{+3}}$	Po	At	Rn

Innert pair effect- G13, G14, G15 → For heavier element lower oxidation number is stable due to inert pair effect

$Be^{+3} > Al^{+3} > Ga^{+3} > In^{+3} > Tl^{+3}$ (stability)

$B^{+1} < Al^{+1} < Ga^{+1} < In^{+1} < Tl^{+1}$ (stability) - inert pair effect

→ P Block has all 3 types of element → metal, nonmetal, metalloid.

→ down the group → size ↑ → metallic character ↑ and non-metallic character ↓.

→ Metal → tendency → Formation of cation.

→ non-metal → tendency → formation of anion

→ Highly reactive metal & higly reactive non-metal → ionic bond due to differenced in Electronegativity.
cation anion

→ Bond betn non-metal & non-metal → covalent bond.

→ metal oxide → Basic

→ non metal oxide - Acidic / neutral → $\boxed{NO, CO, N_2O, H_2O}$
neutral oxide

→ First member of each grp differs from other member

① Size less → IE more - absence of d orbital

② First member of each grp. has maximum covalence of ($\overset{1}{s}+\overset{3}{p}$) other member have vacant d orbital & hence form covalence of more than 4.

$B \rightarrow [BF_4]^-$ and $Al\ [AlF_6]^{-3}$

③ First member of each grp form pπ - pπ multiple bond
C=C, C≡C, N≡N, C=O, C=N, C≡N, N=O
other members form dπ - pπ or dπ - dπ multiple bond

④ $\underset{+5}{NO_3^-}$ & $\underset{+5}{PO_4^{-3}}$ → dπ - pπ
↳ only pπ - pπ bonds are possible

* Group-13 Boron Family.

Introduction

B - nonmetal $\xrightarrow[\text{as}]{\text{occurs}}$ H_3BO_3 (Boric Acid), Borax ($Na_2B_4O_7$ $\cdot 10H_2O$), kernite ($Na_2B_4O_7 \cdot 4H_2O$)

B^{10} (19%) B^{11} (81%)

Al metal $\xrightarrow{\text{occurs as}}$ $\underbrace{\text{Bauxite } (Al_2O_3 \cdot 2H_2O) \text{ 4 Cryalite } (Na_3AlF_6)}_{\text{minerals}}$

→ shows many chemical similarity to Boron

Ga metal

In metal

Tl metal

* Electronic Configuration.

2nd P → B [He] $2s^2\ 2p^1$] Core → inert gas.

3rd P → Al [Ne] $3s^2\ 3p^1$]

4th P → Ga [Ar] $3d^{10}\ 4s^2\ 4p^1$] Core → inert gas + d^{10}

5th P → In [Kr] $4d^{10}\ 5s^2\ 5p^1$]

6th P → Tl [Xe] $4f^{14}\ 5d^{10}\ 6s^2\ 6p^1$] Core → inert gas + $d^{10} + f^{14}$

* Atomic Size.

B

∧

Ga — Poor Shielding of d electrons (Lanthanide contraction) { Z eff ↑ }

∧

Al

∧

In

∧

Tl

{ Z eff ↑ }

↓

nucleus का attraction ↑

↓

size ↓

* Ionisation Energy.

Be
$>$
Tl → poor shielding of f-orbital (size become less)
$>$
Ga → Poor shielding of d-orbital (" " ")
$>$
Al
$>$
In

* Electronegativity

B
$>$ } First decreases
Al
$<$
Ga
$<$ } marginal increase after (Al)
In
$<$
Tl

* Oxidation state

B +3 | → Due to small size of Boron the sum of first 3 ianisation energy is very very high

Al +3 | → So Boron do not form +3 ion & hence forms mostly covalent compound

Ga — +3, +1 | → But in case of Al the sum of IE_1 & IE_2 & IE_3 is very less so it forms Al^{+3} ion

In — +3, +1 | $B^{+1} < Al^{+1} < Ga^{+1} < In^{+1} < Tl^{+1}$ (stability)

Tl — +3, $\textcircled{+1}$ | $Tl^{+3} \longrightarrow Tl^{+3}$

Oxidising nature → Self Reduction

due to inert pair effect

* Physical Properties

Boron - non metal ; → extremely hard ; Black coloured Solid

→ strong crystalline lattice → icosahedron str → 12 corner point; 20 faces

↓

High Melting point

→ Rest members → soft metals → low melting point & high electrical conductivity.

→ Gallium - Low melting point → 303 K

↳ exist as liquid in summer.

→ Density ↑ down the grp B < Al < Ga < In < Tl

* Chemical Reactivity.

→ valence e^- = 3

→ In trivalent state = no. of electron on central atom = 6.

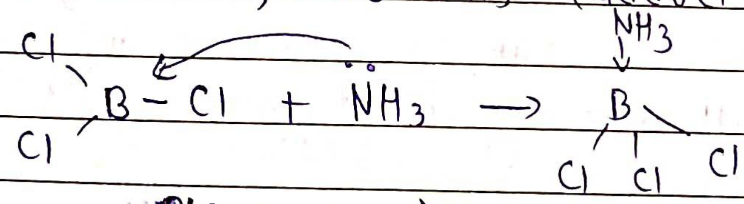
= electron deficient

→ BF_3, BCl_3, BBr_3, BI_3

→ So it accepts lone pair to become stable (noble / Inert gas)

↳ lewis acid

→ BF_3 and BCl_3 accepts lonepair from $\ddot{N}H_3$ and forms $BF_3 \cdot NH_3$, $BCl_3 \cdot NH_3$ (adduct)



Planar (sp^2)

4 bond Tetrahedral & non planar

$BF_3 + NH_3 \longrightarrow BF_3 \cdot NH_3$

Lewis Acid order $BX_3 > AlX_3 > GaX_3 > InX_3 > TlX$

↳ decreases down the grp.

Size less
nucleus near
lone pair easily accept

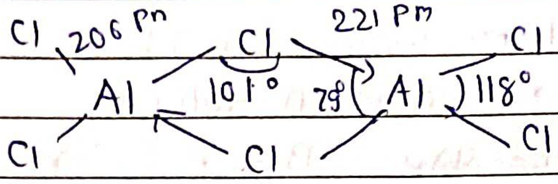
Size more nucleus
Far lone pair
can't easily accept

$AlCl_3$ → e^- deficient

→ do not form adduct because Al का size ↑
(do not behave as lewis acid)

→ so it become stable by forming dimer

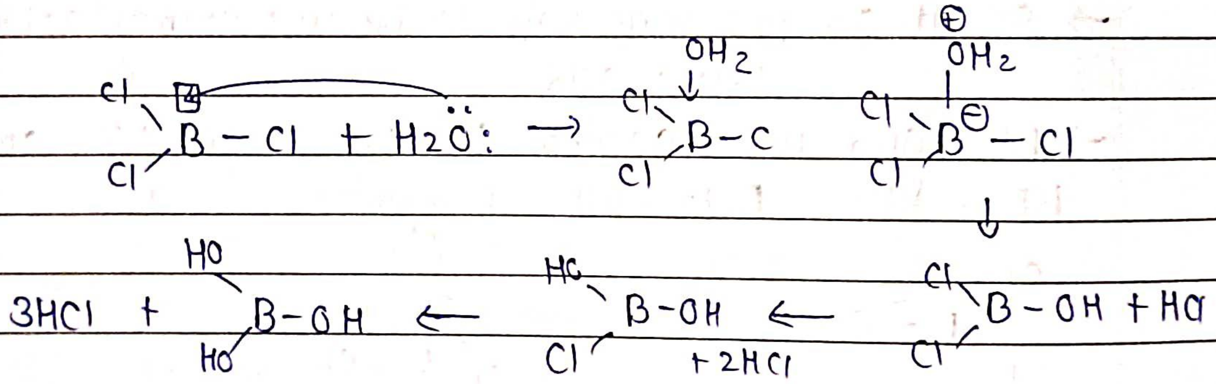
→ 3 center $4e^-$ banana bond

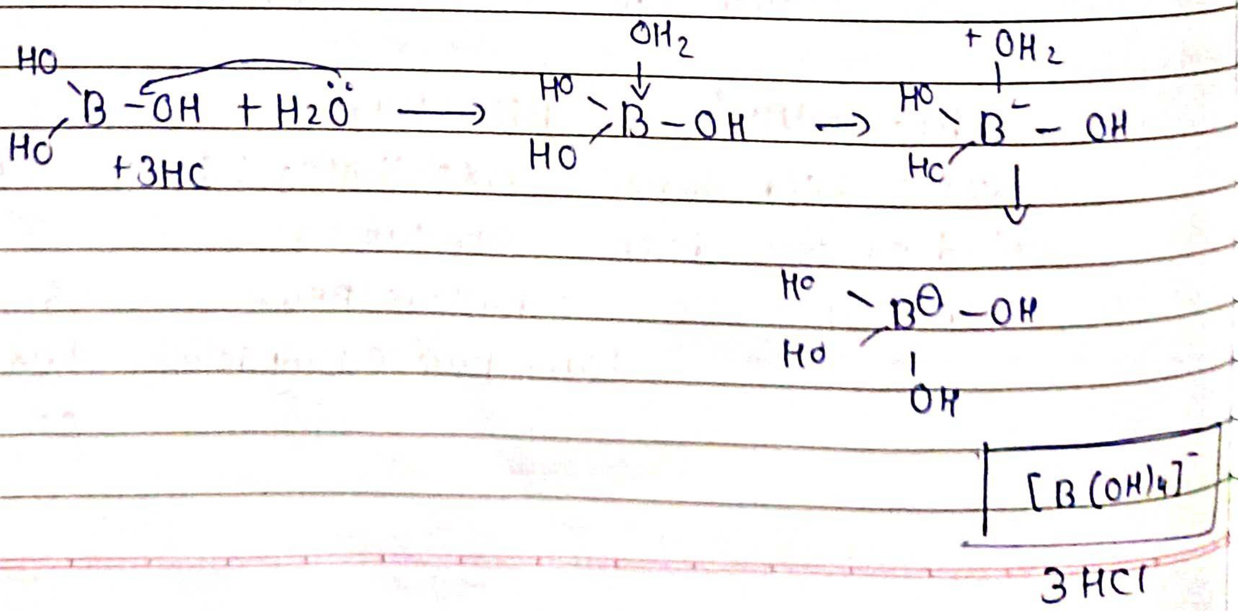


* Hydrolysis Of Trihalides

$BF_3 + H_2O$ → Partial hydrolysis (only few molecules react with H_2O)

BCl_3
$BBr_3 + H_2O$ → Complete hydrolysis
BI_3
(all molecules with water)





$$\left.\begin{array}{l} BeCl_3 \\ BBr_3 \\ BI_3 \end{array}\right\} + H_2O \begin{array}{l} \rightarrow B(OH)_3 + 3HCl \\ \rightarrow B(OH)_3 + 3HBr \\ \rightarrow \underline{B(OH)_3} + 3HI \\ \quad H_3BO_3 \end{array}$$

$BF_3 + H_2O \longrightarrow B(OH)_3 + 3HF$ (BF_3 remaining/

$HF + BF_3 \longrightarrow BF_4$

$BF_3 + H_2O \longrightarrow B(OH)_3 + HF + BF_4^-$

$B(OH)_4^- + HF + BF_4^-$

$AlCl_3 + H_2O \longrightarrow [Al(H_2O)_6]^{+3}$

$\downarrow$

$\boxed{sp^3d^2}$

(d orbita of Al is involved]

* Reaction with air

Reaction with O_2	Reaction with N_2
→ crystalline Boron → no Rxn.	→ crystalline Boron + N_2 → no rxn
→ Amorphous Boron + O_2 → B_2O_3	→ Amorphous Boron + N_2 → BN.
Al + O_2 → Al_2O_3	Al + N_2 → AlN
Ga + O_2 → Ga_2O_3	
In + O_2 → In_2O_3	
Tl + O_2 → TL_2O	

→ 'Al' forms thin layer of oxide (Al_2O_3) and prevents it from further attack

→ Therefore 'Al' becomes possive (non reactive)

* Reaction with Acid - Base

\# Boron - no rxn with acid base → even at high temp.

\# But Boron reacts with oxidizing acids (conc. HNO_3 & conc. H_2SO_4

$B + conc.\ HNO_3 / conc.\ H_2SO_4 \rightarrow H_3BO_3 + NO_2 / SO_2$

\# Al reacts with acid & base

$Al + dil.\ HCl \rightarrow AlCl_3 + H_2\uparrow$

$Al + dil.\ NaOH \rightarrow NaAlO_2 + H_2\uparrow$

or

$Na[Al(OH)_4] + H_2\uparrow$

Sodium tetrahydroxo Alumate

\# Conc. HNO_3 oxidizes Al and forms Al_2O_3. Al becomes passive

$Al + conc.\ HNO_3 \rightarrow Al_2O_3$

* Reaction with Halogen

$E + X_2 \rightarrow EX_3$ $(Tl \rightarrow TlX)$

$B + X_2 \rightarrow BX_3$

$Al + X_2 \rightarrow AlX_3$ $\boxed{X = F, Cl, Br, I}$

$Ga + X_2 \rightarrow GaX_3$

$In + X_2 \rightarrow InX_3$

$Tl + X_2 \rightarrow TlX$

* Reaction with Water

B → no rxn

Al → "

Ga $+ H_2O$ → "

In → "

Tl → "

$Al + H_2O \rightarrow Al_2O_3 + H_2\uparrow$

(hot) (Al becomes passive)

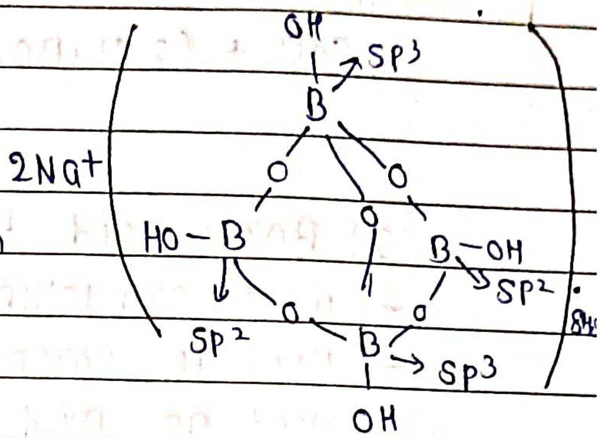
Al^{+3} OH^-

$Al(OH)_3 \xrightarrow{\Delta} Al_2O_3$

* Important Compounds of Boron

1) Borax.

- → White crystalline solid
- → $Na_2B_4O_7 \cdot 10\,H_2O$
- → $Na_2[B_4O_5(OH)_4]\,8\,H_2O$
- → It has 8 water of crystallization
- → 5 B-O-B linkage
- → 2 sp^3 Boron & 2 sp^2 Boron



Temp

HAWT Sindoor wali ladki ki kahani

Heat Acid water Borax

$$Na_2B_4O_7 \cdot 10\,H_2O \xrightarrow{\Delta} Na_2B_4O_7 + 10\,H_2O$$

$$Na_2B_4O_7 + HCl \longrightarrow H_2B_4O_7 + NaCl$$

$$H_2B_4O_7 + H_2O \longrightarrow H_3BO_3 \text{ (Boric acid)}$$

$$H_3BO_3 \xrightarrow{\Delta} B_2O_3 \text{ (Boric Oxide)}$$

(Boric anhydride)

Reaction of Borax water

$$Na_2B_4O_7 + \underset{\text{excess}}{H_2O} \longrightarrow H_2B_4O_7 + \boxed{NaOH}$$

$H_2B_4O_7$ ↓ $\boxed{H_3BO_3 \text{ (weak acid)}}$

NaOH (Basic soln) Strong base

Heating of Borax

$$Na_2B_4O_7 \cdot 10\,H_2O \xrightarrow{\Delta} Na_2B_4O_7 \xrightarrow{\Delta} \boxed{2NaBO_2 + B_2O_3}$$

Borax Bead → Boric Oxid or Boric anhyd

Sodium meta borate (swells up)

First it is liquid (transport)

↓

Solidifies into glass like material called Borax bead

↓

It identifies transition meta on the basis of colour

→ Borax heated in Bunsen Burner flame with cobalt oxide on an loop of platinum wire, a blue coloured bead is formed

$CoO + (2NaBO_2 + B_2O_3) \longrightarrow Co(BO_2)_2$

Blue colour

2) Boric acid H_3BO_3

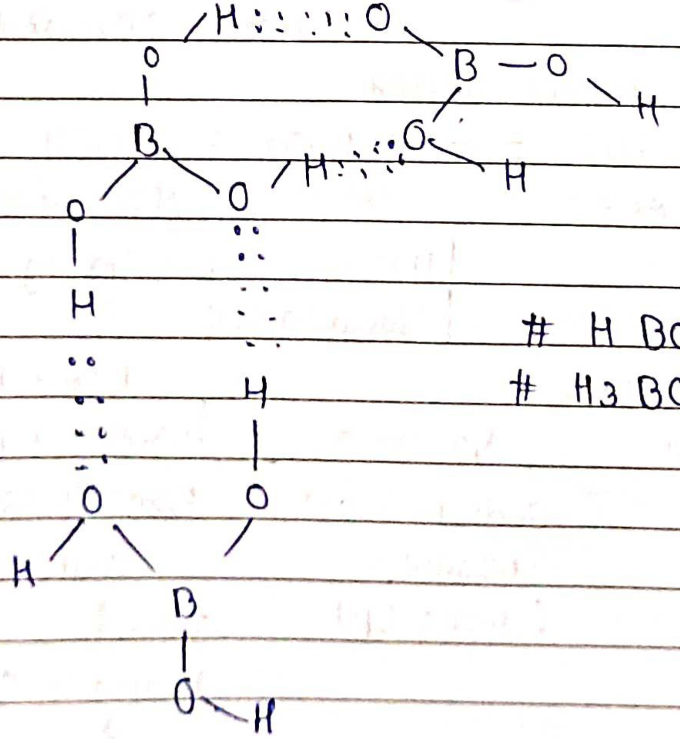
→ White crystalline solid (soapy touch)
→ Used in Carom powder.
→ Used as mild antiseptic.
→ Hot water - Highly soluble
→ Cold water - Sparingly soluble (less soluble)

Preparation ① $Na_2B_4O_7 + HCl + H_2O \longrightarrow NaCl + H_3BO_3$

(neutral) (weak acid)

② $BCl_3 + H_2O \longrightarrow B(OH)_3 + 3HCl$

It has Layer structure, (planar BO_3 units are joined by H bond)

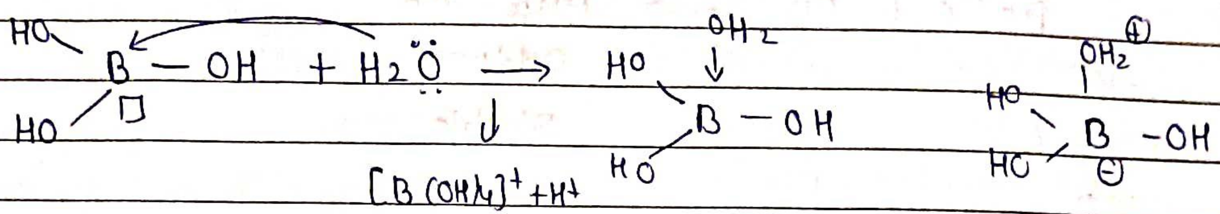


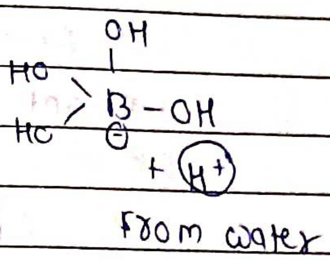
H Bond (weak bond)
H_3BO_3 is slippery in nature

H_3BO_3 → weak monobasic acid (one H^+ release)

→ not a protonic acid ↳ but from H_2O

→ Lewis acid (3 bond → 6e⁻ → e⁻ deficient)





Heating of Boric Acid

$$H_3BO_3 \xrightarrow[\text{370 K \& above}]{\Delta} HBO_2 + H_2O$$

metaboric acid

↓ Δ

B_2O_3

Boric oxide / Boric anhydride

3) Di-borane (B_2H_6)

→ colourless, highly toxic, catches fire on exposure to air

$B_2H_6 + O_2 \longrightarrow B_2O_3 + H_2O$ $\Delta H = -1976$ kJ/mol

$B_2H_6 + H_2 \longrightarrow H_3BO_3 + H_2\uparrow$

Preparation - $BF_3 + LiAlH_4 \xrightarrow[\text{ether}]{\text{diethyl}} LiF + AlF_3 + B_2H_6$

Lab prep^n — $NaBH_4 + I_2 \longrightarrow B_2H_6 + NaI$

Industrial prep^n - $BF_3 + NaH \longrightarrow B_2H_6 + NaF$

→ Cleavage of B_2H_6

$B_2H_6 + \ddot{N}(Me)_3 \longrightarrow BH_3 \cdot N(Me)_3$ (adduct)

$B_2H_6 + \ddot{C}O \longrightarrow BH_3 \cdot CO$ <u>adduct</u> stable

3) Borazine

Reaction of NH_3 with B_2H_6

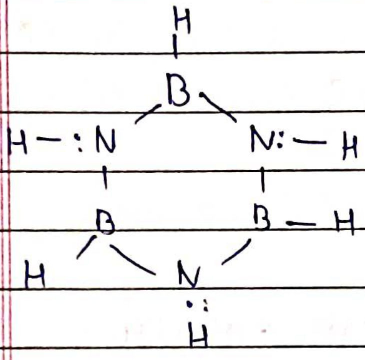
$B_2H_6 + \underset{\cdot\cdot}{NH_3} \longrightarrow BH_3 \cdot NH_3$ or $B_2H_6 \cdot 2NH_3$ or $[BH_2(NH_3)_2]^+ [BH_4]^-$

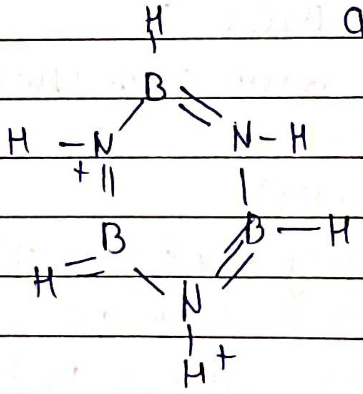
$\downarrow \Delta$

$B_3N_3H_6$ (Borazine) + H_2

inorganic Benzene

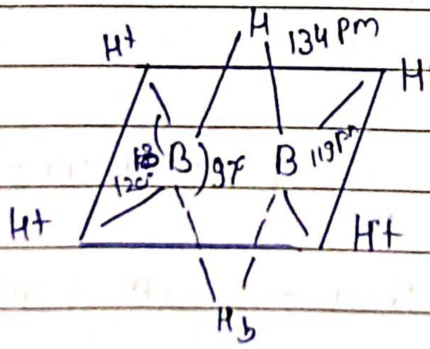
all N and all B → sp^2 & planar





→ Inorganic Benzene is more reactive than organic Benzene because inorganic Benzene is polar

Structure of B_2H_6 (Diborane)



→ Banana Bond

→ 4 terminal H & 2 bridge Hydrogen

→ 4 terminal H & 2 Boron are in same plane

→ max no. of in atom in same plane = 6

→ 3 center $2e^-$ bond

→ Uses of Boron

Bullet proof vest & Aircraft

Group - 14

*Carbon Family.

C non metal
- → elemental state- coal, graphite, diamond
- → combined state- metal carbonate, Hydrocarbon, CO_2.
- → 3 isotopes → $\underbrace{C^{12}\ \ C^{13}}_{\text{Two stable isotopes}}\ \ C^{14} \rightarrow$ Radioactive

Si non metal → Found in the Form of Silica & silicates (ceramic, glass cement)

Ge- metalloid → Found in traces

Sn Metal → occurs as SnO_2 (cassiterite)

Pb metal → occurs as PbS (Galena)

* Electronic configuration. [IG] $ns^2\ np^2$

C → 2nd p → [He] $2s^2\ 2p^2$

Si → 3rd p → [Ne] $3s^2\ 3p^2$

Ge → 4th p → [Ar] $3d^{10}\ 4s^2\ 4p^2$

Sn → 5th p → [kr] $4d^{10}\ 5s^2\ 5p^2$

Pb → 6th p → [xe] $4f^{14}\ 5d^{10}\ 6s^2\ 6p^2$

Since the inner core electronic configuration is diff. so their physical and chemical properties are different

* Oxidation state (+4, +2, -4)

→ The sum of first 4 IE is very high so it cannot form C^{+4} ion. So can't form ionic bond. Therefore Carbon usually forms covalent bond.

C +4

Si +4

Ge $<^{+4}_{+2}$

Sn $<^{+4}_{+2}$

Pb $<^{+4}_{\textcircled{+2}}$ → inert pair effect

Show the stability order

$C^{+4} > Si^{+4} > Ge^{+4} > Sn^{+4} > Pb^{+4}$

$C^{+2} < Si^{+2} < Ge^{+2} < Sn^{+2} < Pb^{+2}$

inert pair effect
↳ stability of lower oxidation state ↑ down the grp

* Covalent Radius.

$$\underbrace{C < Si}_{\text{good amount of } \uparrow \text{ in radius}} \underbrace{< Ge < Sn < Pb}_{\text{small } \uparrow \text{ in radius because of poor shielding of d \& f orbital}}$$

* Ionization Energy.

$IE \propto \frac{1}{size}$

$C > Si > Ge > Sn < Pb$

↳ Increase in IE because of very poor shielding of F block

* Electronegativity

$C > Si = Ge = Sn = Pb$

↑

less size
more attraction
more Electronegativity

* Chemical properties

$C_6 \rightarrow 1s^2 \quad 2s^2 \quad 2p^2$

$\boxed{\uparrow\downarrow} \quad \boxed{\uparrow\ |\ \uparrow\ |\ \ }$

$C^* \rightarrow \boxed{\uparrow} \quad \boxed{\uparrow\ |\ \uparrow\ |\ \uparrow}$) 4 covalent bond (maximum)

Carbon can't exceed its covalence more than four.

Other elements (Si, Ge, Sn, Pb) → due to presence of vacant d orbital it forms more than 4 bond

SiF_6^{-2}, $GeCl_6^{-2}$, $[Sn(OH)_6]^{-2}$

* Hydrolysis of carbon Halide.

$CCl_4 + H_2O \longrightarrow$ no Rxn (due to absence of vacant orbital)

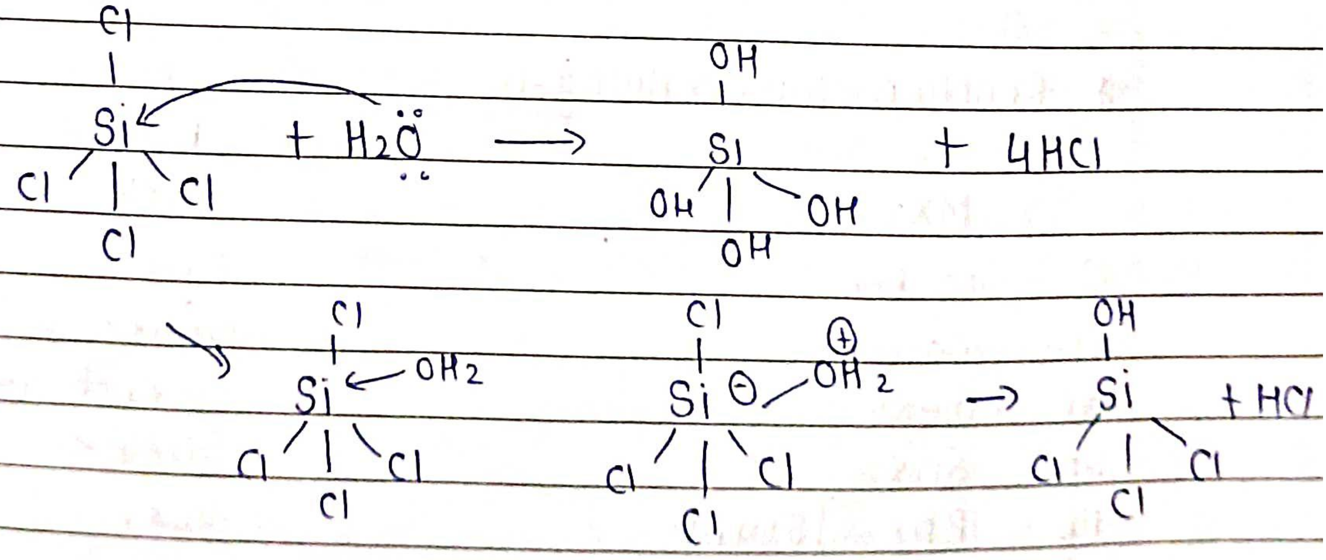
$H_4SiO_4 \rightarrow$ Silicic Acid

$SiCl_4 + H_2O \longrightarrow \boxed{Si(OH)_4} + 4HCl$

$GeCl_4 + H_2O \longrightarrow Ge(OH)_4 + 4HCl$

$SnCl_4 + H_2O \longrightarrow Sn(OH)_4 + 4HCl$

$PbCl_2 + H_2O \rightarrow \underset{\substack{\downarrow \\ PbO}}{Pb(OH)_2} + 2HCl$



* Reaction with Oxygen

Carbon family reacts with oxygen and form oxide

(+2)		(+4)	
MO		MO_2	acidic
CO	→ neutral	CO_2	
SiO	→ it exists only at high temp	SiO_2	
GeO	→ acidic	GeO_2	
SnO	Amphoteric	SnO_2	Amphoteri
PbO		PbO_2	

NO, CO, N_2O, H_2O ⟶ 4 oxides are neutral.

Amphoteric oxide → Sn, Pb, Zn, Al

* Reaction with H_2O

C, Si, Ge + H_2O ⟶ no reaction

$Sn + H_2O\,(hot) \longrightarrow \overset{+4}{Sn}O_2$

$Pb + H_2O \longrightarrow PbO$ (becomes passive due to formn of oxide on it)

* Reaction with Halogen

	+2 MX_2	+4 MX_4	
C	no Rxn	CX_4	
Si	no rxn	SiX_4	
Ge	GeX_2	GeX_4	stable
Sn	SnX_2	SnX_4	
Pb	PbX_2 stable	PbX_4	

SnF_4 and PbI_4 → ionic (due to Fajan's Rule)
Small cation Large anion → covalent nature
Large cation Small anion → ionic nature

PbI_4 doesn't exist ; Pb-I bond do not provide sufficient energy to make Pb^{+4} (can't excite 6 s electron and hence can't form 4 unpaired e^-)

* Anomalous behaviour of carbon.

→ Small size, High electronegativity, high I.E, unavailability of d orbital.

→ Carbon forms pπ-pπ multiple bond C=C, C≡C, C≡N, C=O, C=S.

→ Heavier element forms dπ-pπ, dπ-dπ

→ Catenation- ability to link with one-another through covalent bond to form long chain is called catenation

$\boxed{\text{Catenation} \propto \text{strength of single bond}}$

→ Catenation order - C-C > Si-Si > Ge-Ge > Sn-Sn

→ Pb do not show catenation

→ Bond energy order C-C > Si-Si > Ge-Ge > Sn-Sn

due to pπ-pπ bond & catenation it shows allotropic forms

Allotropes

1) Crystalline
→ Diamond
→ Graphite
→ Fullerene

2) Amorphous
→ carbon black ← burning hydrocarbon in limited supply of air
coke, charcoal ← Heating wood or coal respectively at high temp. in absence of air
} Impure form of graphite & Fullerene

* Diamond
→ crystalline lattice
→ each carbon → sp^3 (each carbon form 4 σ bond)
→ C-C is 1.54 A° or 154 pm.
→ rigid 3D network.
→ It is the hardest substance
→ used as abrasive for sharpening of hard tools

* Graphite
→ Thermodynamically it is most stable allotrope.
→ Layered structure.
→ Layers are held by vanderwall force of attraction
→ distance between layers → 340 pm
→ each layer has planar hexagonal rings of carbon atom
→ C-C bond length is 141.5 pm.
→ Each carbon makes 3 σ bond & hence sp^2 hybridizati
→ 4th electron forms π bond
→ 4th e^- is mobile & delocalized over layer of graphite and conducts electricity.
→ due to weak vanderwall force betn layers,
• Graphite is soft & slippery
→ It is used as dry lubricant in machines (at high tem
because oil & greece catches fire at high temp.

* Fullerene
→ when Graphite is heated in electric arc in presence of inert gas (He / Ar)
→ Purest form of carbon.
→ because they have smooth closed str. without dangling bon
dangling bond → In diamond / graphite some surface carbon have free valency these are carbon atom form new bond with impurity. These bonds are called dangling bond

→ cage like molecule
→ C_{60} → soccer ball
  → Buckminister Fullerene
  → Bucky Ball.
  → 20 → 6 member Ring } → 60 vertex occupied by
  12 → 5 member ring } carbon

→ 6 member ~~is~~ ring is fused with 6 or 5 member ring but 5 member ring is fused with only 6 member ring
→ all carbon → sp^2 (3 σ bond)
→ Remaining e^- is delocalised & gives aromatic character to molecule
→ It contains C=C & C−C
138·3 pm 143-5 pm

* Compounds of carbon

1) Carbon monoxide [CO]
→ Oxidation of carbon in limited supply of air

$$\underset{}{2\,C(s)} + \underset{\text{(limited)}}{O_2(g)} \longrightarrow 2\,CO(g)$$

→ Pure CO is obtained by dehydration of formic acid

$$\underset{\text{Formic acid}}{HCOOH} \xrightarrow{-H_2O} \underset{\text{(Pure)}}{CO} + H_2O \quad \text{with } \underset{\text{(dehydrating agent)}}{\text{conc. } H_2SO_4}$$

→ commercially

$$\underset{\text{(Hot coke)}}{C(s)} + \underset{\text{(steam)}}{H_2O(g)} \xrightarrow{\overset{473k}{\cancel{48k} - 1273k}} \underbrace{CO + H_2}_{\text{water gas or syn gas}}$$

If air is passed in place of steam.

$$2\,C(s) + O_2(g) + 4\,N_2(g) \xrightarrow{1273\,K} \underbrace{2\,CO(g) + 4\,N_2(g)}_{\text{Producer gas}}$$

* Water gas and producer gas are very important industrial fuel.

→ colourless, odourless, water insoluble
→ 'CO' is a powerful Reducing agent.
→ Used in extraction of metal from metal oxide

$$Fe_2O_3 + CO \longrightarrow Fe + CO_2$$
$$ZnO + CO \longrightarrow Zn + CO_2$$

$$\cdot C \overset{\longleftarrow}{\equiv} \ddot{O}$$

$$\overset{\ominus}{:C} \equiv \overset{\oplus}{O}: \quad 1\sigma \text{ bond}, \; 2\pi \text{ bond}$$

$C \overset{\leftarrow}{\equiv} O:$ ↳ due to this lone pair it reacts with metal & form metal carbonyl

→ CO is poisonous in nature.
→ It forms Carboxyhaemoglobin which is 300 times more stable than Oxyhaemoglobin (leads to death)

2) Carbondioxide CO_2

Complete combustion of carbon & carbon containing compound in excess of air.

$$C(s) + O_2(g) \longrightarrow CO_2(g)$$
$$CH_4(s) + O_2(g) \longrightarrow H_2O(g) + CO_2(g)$$

Laboratory preparation

$$\underset{\text{(limestone)}}{CaCO_3} + HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

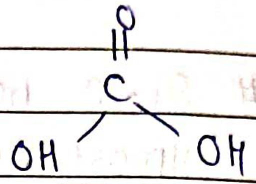
→ colourless & odourless

→ Reaction with water

$CO_2 (g) + H_2O (g) \longrightarrow H_2CO_3$

$\boxed{\text{carbonic acid}}$

$$\boxed{\begin{array}{l} H_2CO_3 + H_2O \rightleftharpoons HCO_3^- + H_3O^+ \\ HCO_3^- + H_2O \rightleftharpoons CO_3^{-2} + H_3O^+ \end{array}}$$



$\boxed{\text{dibasic acid}}$

H_2CO_3 / HCO_3^- buffer system, it helps to maintain maximum Ph of blood 7.26 to 7.42

→ CO_2 is used in photosynthesis (Green plants convert atmospheric CO_2 into carbohydrate such as glucose)

→ $CO_2 + H_2O \xrightarrow[\text{Chlorophyll}]{h\nu} \underset{\text{glucose}}{C_6H_{12}O_6} + O_2 + H_2O$

→ CO_2 is non poisonous

→ If CO_2 in atmosphere increases, this is called green house effect (Temp. of atmosphere ↑)

→ CO_2 is obtained in solid form as dry ice.

→ dry ice is used as refrigrant

→ $\underset{\xleftarrow{\ \mu\ }}{O=C}\underset{\xrightarrow{\ \mu\ }}{=O}$ 2σ & 2π bond

sp hybridization Linear

pπ - pπ bond

$\mu = 0$; non polar (zero dipole)

$$\ddot{O}=C=\ddot{O} \longleftrightarrow {}^{\ominus}:\ddot{O}-C\equiv\overset{\oplus}{O}:$$

$$:\overset{+}{O}\equiv C-\ddot{O}:^{-}$$

* Silicon dioxide / SiO_2 / silica → used as pizeoelectric material

→ 3 crystalline forms of Si
- → Quartz
- → Cristobalite
- → Tridymite

→ These crystalline forms are interconvertible

→ covalent 3D Network, each 'Si' is covalently bonded in a tetrahedral manner to 4 oxygen atom
→ 8 membered ring with alternate Si & O atom.

Si-O bond enthalpy is very high. So SiO_2 is almost non-reactive
SiO_2 reacts with HF and NaOH.

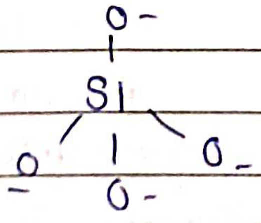
$$SiO_2 + HF \longrightarrow SiF_4 + 2H_2O$$
$$SiO_2 + NaOH \longrightarrow Na_2SiO_3 + H_2O$$

Silica gel is used as dry agent

* Silicones
→ Organo silicon polymer having 'R_2SiO' as repeating unit are called silicones represented as $\boxed{R_nSiCl_{4-n}}$

$$2\,CH_3-Cl + Si \xrightarrow[570K]{Cu\ Powder} (CH_3)_2SiCl_2$$
$$\downarrow +H_2O,\ -HCl$$
$$(CH_3)_2Si(OH)_2$$

* Silicates
→ Derivative of Silicic acid (H_4SiO_4) ($Si(OH)_4$)
→ Basic unit → SiO_4^{-4}
→



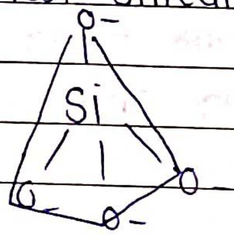
→ 4 σ bond
→ sp^3 hybridization
→ Tetrahedral

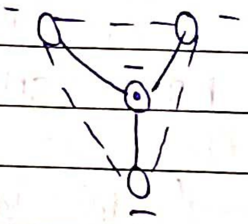
Types of silicates

1) ortho silicate
2) Pyro ‶
3) Cyclic
4) Single chain ‶
5) Double chain
6) Sheet ‶
7) 3D silicate ‶

1) ortho silicate

→ Simplest silicate which contains SiO_4^{-4} tetrahedral unit



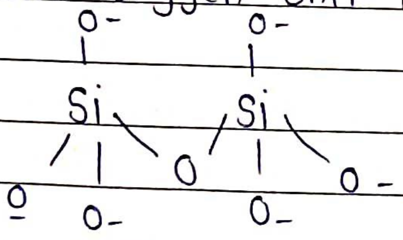


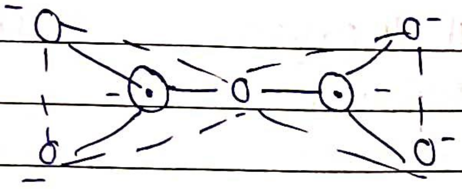
Side view   Top view

Formula - SiO_4^{-4}

2) Pyro silicate

One oxygen unit is shared between two SiO_4^{-4} basic unit





Formula ($Si_2O_7^{-6}$)

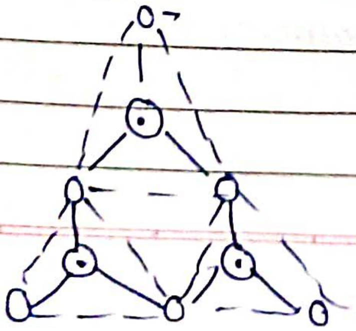
3) Cyclic Silicate

Two oxygen atom of single tetrahedral unit SiO_4^{-4} is shared

$Si_3O_9^{-8}$

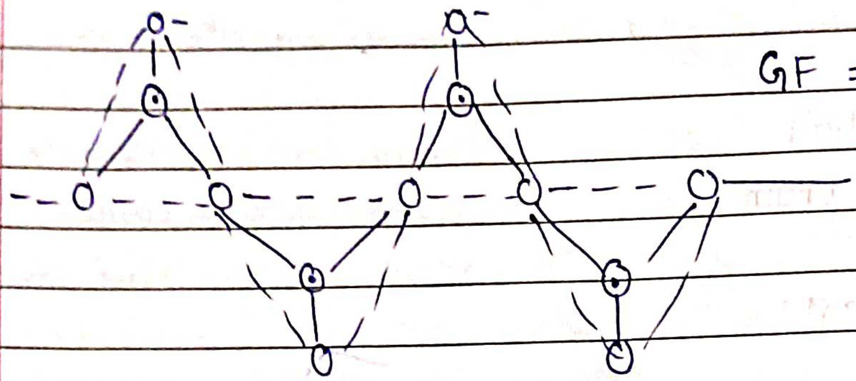
General Formula

$= (SiO_3)_n^{-2n}$



4) Single chain silicate.

each unit shares 2 oxygen atom



GF = $(SiO_3)_n^{-2n}$

5) Double chain.

2 and 3 oxygen atom share

↳ some basic silicate units share 3 atom

↳ some basic silicate units share 2 atom

GF = $(Si_4O_{11})_n^{-6n}$

6) Sheet silicate

3 oxygen atom share

GF = $(Si_2O_5)_n^{-2n}$

3D silicate

all 4 oxygen shared

SiO_2