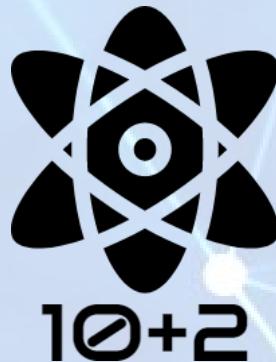


10+2 PCM NOTES

BY

JOYOSHISH SAHA

(PDF version handwritten notes of Maths, Physics and Chemistry
for 10+2 competitive exams like JEE Main, WBJEE, NEST, IISER
Entrance Exam, CUCET, AIPMT, JIPMER, EAMCET etc.)



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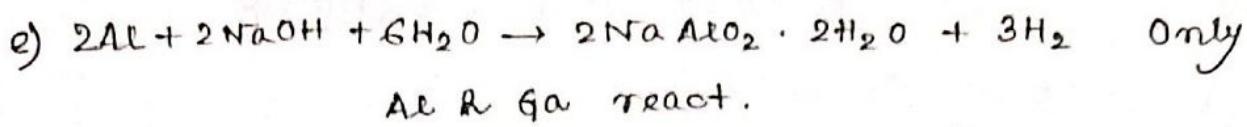
With best wishes from Joyoshish Saha

* Group 13 Elements:

- Physical Properties: a) atomic & ionic radii - Increase from B to Al then decrease from Al to Ga & then again increase. (For Ga, additional 10 d electrons)
 - b) ionisation enthalpy: Less than the corresponding members of alkaline earth metals and shows no regular trend - $B > Tl > Ga > Al > In$. (low screening effect of d & f electrons)
 - c) electronegativity decreases from B to Al & then increases. (discrepancy in atomic size)
 - d) Metallic or electropositive character increases from B to Al, then decreases.
 - e) density - increases down the group.
 - f) melting & boiling points - mp decreases sharply on moving down the group from B to Ga & then increase from Ga to Tl while bp decreases from B to Tl.
 - g) reducing character - $Al > Ga > In > Tl$.
 - h) physical state - Al, Ga, Tl, In are silvery white. Ga can exist in liquid state during summer (mp-303K). Boron is non-metallic, hard & black.
-
- Chemical Properties: a) $4M + 3O_2 \rightarrow 2M_2O_3$ All react at high temperature, Tl forms some Tl_2O as well. Boron trioxide is naturally acidic, Al & Ga oxides are amphoteric ; In, Tl oxides are basic.
 - b) $2Al + N_2 \rightarrow 2AlN$ Only Al reacts at high temperature.
 - c) $2M + 3X_2 \rightarrow 2MX_3$ All form trihalides. TlI_3 is unknown & $Tl^+[I_3]^-$ is formed.
 - d) $2M + 6HCl \rightarrow 2MCl_3 + 3H_2$ All react with dilute mineral acids except B. Al rendered passive by HNO_3 particularly when concentrated.

$13(III B)$
 ${}^5B(2s^22p^1)$
 ${}^{13}Al(3s^23p^1)$
 ${}^{31}Ga(4s^24p^1)$
 ${}^{49}In(5s^25p^1)$
 ${}^{81}Tl(6s^26p^1)$

$Al > Ga > In > Tl$.

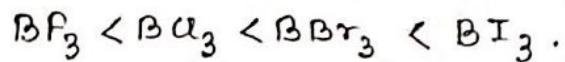


f) H + NH₃ → MNH₂ All form amides.

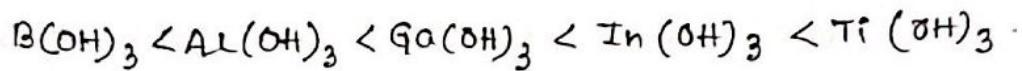
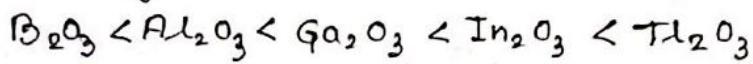
- Stability of +3 oxidation state $B^{3+} > Al^{3+} > Ga^{3+} > In^{3+} > Tl^{3+}$

- Stability of +1 oxidation state $B^+ < Al^+ < Ga^+ < In^+ < Tl^+$

- Lewis acid character - $BX_3 > AlX_3 > GaX_3 > InX_3$



- Basic Strength -



- Anomalous behaviour of Carbon & Boron:

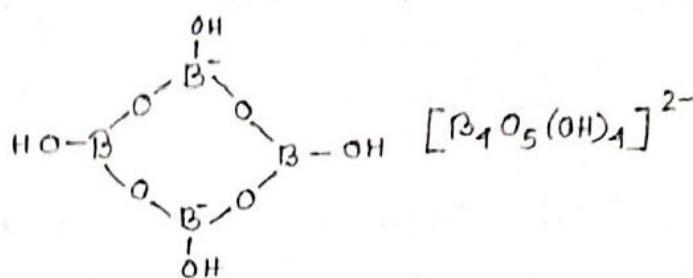
a) Boron shows anomalous behaviour due to its small size, high nuclear charge, high electronegativity & non-availability of d electrons.

b) Main differences - i) Boron is a typical non-metal whereas others are metals. ii) allotropy is exhibited alone by Boron. iii) It is a bad conductor of electricity whereas others are good conductors. iv) It forms only covalent compounds while others also form some ionic compounds. v) Hydroxides & oxides of boron are acidic in nature whereas those of others are amphoteric & basic. vi) Trihalides of boron exist as monomer whereas others exist as dimers. vii) Borates are more stable than aluminates. viii) It exhibits max. covalency of 4 while others exhibit a max covalency of 6. ix) It doesn't decompose steam while others do so. x) Concentrated HNO₃ oxidises boron to basic acid while others become passive specially Al & Ga.

* Some Important Compounds:

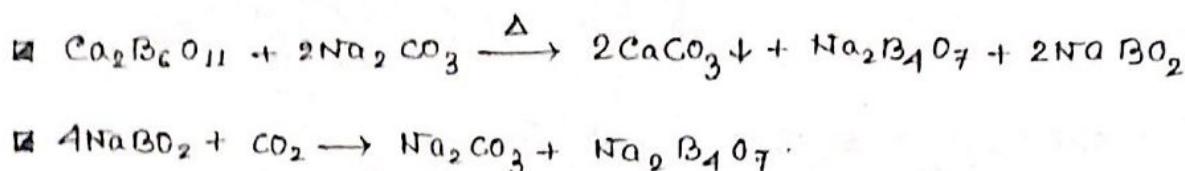
Compound-
Borax
 $(Na_2B_4O_7 \cdot 10H_2O)$

1. Structure: $Na_2B_4O_7(OH)_4 \cdot 8H_2O$

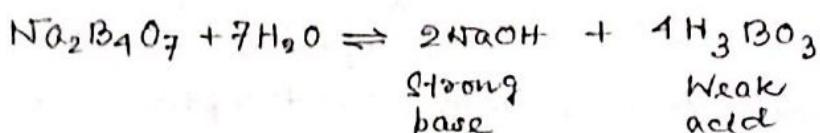


2. Preparation:

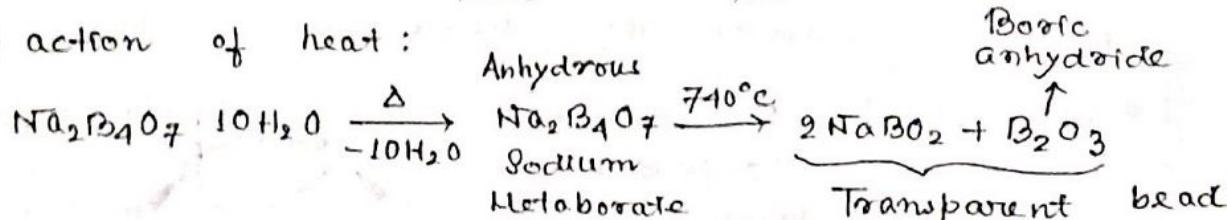
From Colemanite:



3. Properties: i) Its solution is basic in nature due to hydrolysis.



ii) action of heat:



4. Uses: i) as water softener & cleaning agent.
ii) for borax bead test.

● Compound- 1. Structure:

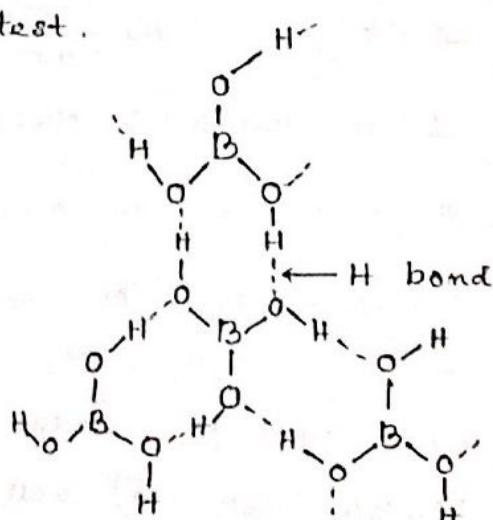
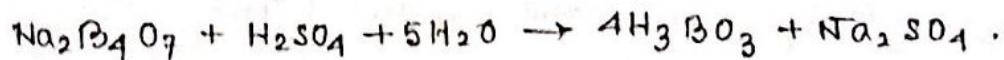
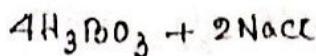
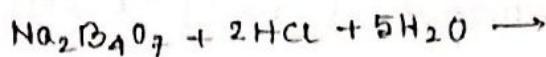
Boric acid/

Orthoboric acid

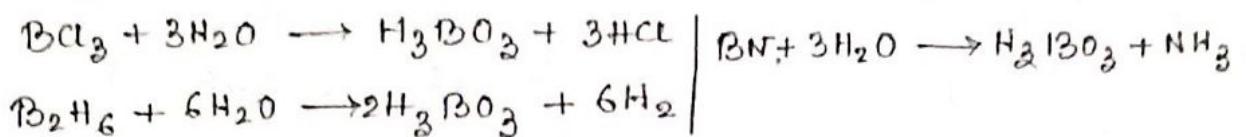
(H_3BO_3)

2. Preparation:

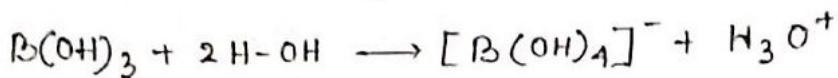
i) From Borax:



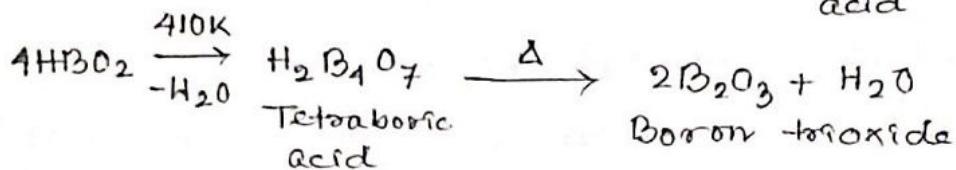
■ By hydrolysis of boron compounds:



3. Properties: i) It is a weak monobasic acid. It is not a protonic acid but acts as a Lewis acid.



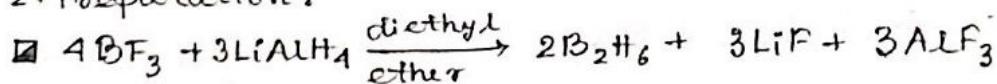
ii) Action of heat: $\text{H}_3\text{BO}_3 \xrightarrow{370\text{K}} \text{HBO}_2 + \text{H}_2\text{O}$
 Metaboric acid



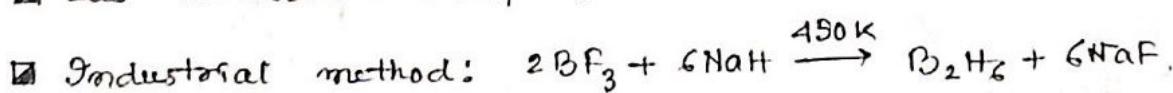
4. Uses: i) Used in the manufacture of heat resistant borosilicate glass. ii) aqueous solution of boric acid is used as a mild antiseptic especially as eye wash under the name boric lotion.

• Compound - Diborane (B_2H_6)	1. Structure: 4 2c-2e B-H terminal bonds		2 3c-2e B-H Bridge/Banana bonds.
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2. Preparation:

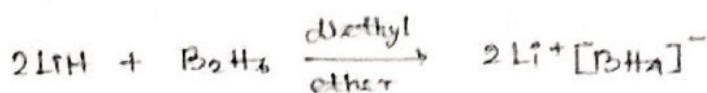
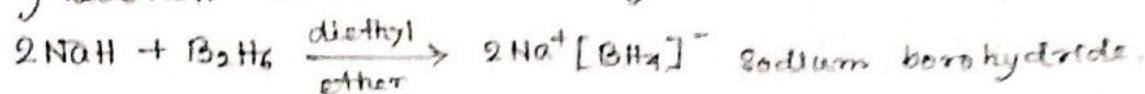


Lab method: $2\text{NaBH}_4 + \text{I}_2 \rightarrow \text{B}_2\text{H}_6 + 2\text{NaI} + \text{H}_2$

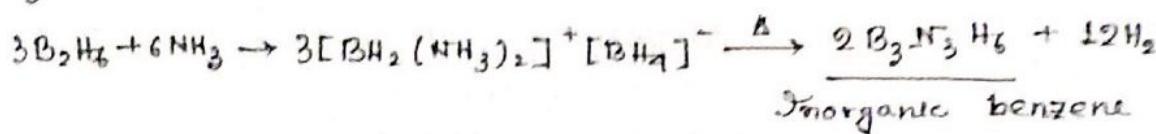


3. Properties: i) It catches fire spontaneously upon exposure to air. $\text{B}_2\text{H}_6 + 3\text{O}_2 \rightarrow \text{B}_2\text{O}_3 + 3\text{H}_2\text{O}$. ii) Boranes are readily hydrolysed by water to form boric acid. $\text{B}_2\text{H}_6 + 6\text{H}_2\text{O} \rightarrow 2\text{H}_3\text{BO}_3 + \text{CH}_4$. iii) With methanol, trimethyl borate is formed. $\text{B}_2\text{H}_6 + 6\text{CH}_3\text{OH} \rightarrow 2\text{B}(\text{OC}_2\text{H}_5)_3 + 6\text{H}_2$ iv) Diborane undergoes cleavage reactions with Lewis bases to give borane adducts. $\text{B}_2\text{H}_6 + 2\text{NMe}_3 \rightarrow 2\text{BH}_3 \cdot \text{NMe}_3$

v) Reaction with metal hydrides:



vi) Reaction with NH_3 :

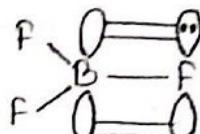


4. Uses: i) for preparing a number of borohydrides such as LiBH_4 , NaBH_4 etc. ii) As a reducing agent in organic reactions.

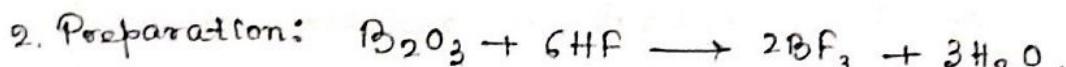
● Compound-



i. Structure:



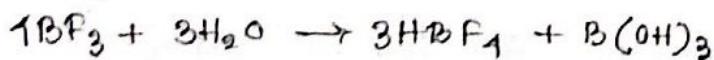
$\pi\text{-}\pi$ back bonding.



3. Properties: i) It undergoes rapid halide exchange reactions. $\text{BF}_3 + \text{Ba}_3 \rightarrow \text{BF}_2\text{Cl} + \text{BCl}_2\text{F}$.

ii) It is electron deficient, hence acts as Lewis acid that forms adducts with Lewis bases.

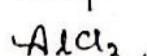
$\text{BF}_3 + (\text{C}_2\text{H}_5)_2\text{O} \rightarrow \text{BF}_3 \cdot \text{O}(\text{C}_2\text{H}_5)_2$ iii) It reacts with water to give boric acid and fluoroboric acid.



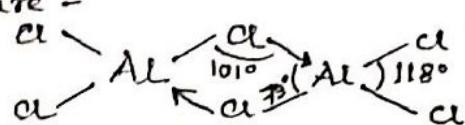
● 4. Uses: i) acts as a catalyst in organic reaction.

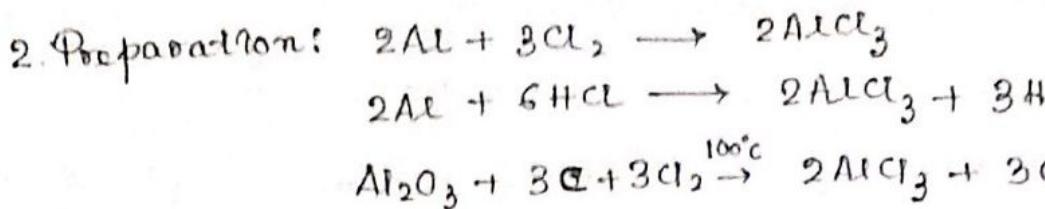
ii) used as an important reagent in organic chemistry as a Lewis acid.

● Compound-



i. Structure -





3. Properties: i) Anhydrous AlCl_3 fumes in moist air due to hydrolysis in the resulting solution & acidic. ii) $\text{AlCl}_3 + 3\text{H}_2\text{O} \rightarrow \text{Al}(\text{OH})_3 + 3\text{HCl}$

iii) $\text{AlCl}_3 + 3\text{NH}_4\text{OH} \rightarrow \text{Al}(\text{OH})_3 \downarrow + 3\text{NH}_4\text{Cl}$
 Gelatinous ppt.
 Insoluble in NH_4OH

Ex) $\text{AlCl}_3 + 3\text{NaOH} \rightarrow \text{Al(OH)}_3 \downarrow + 3\text{NaCl}$
 Soluble in excess NaOH

$$v) \text{AlCl}_3 + \text{NaOH} \rightarrow \text{NaAlO}_2 + 2\text{H}_2\text{O}.$$

Soluble metaaluminate.

1. Uses: Anhydrous AlCl_3 is used as a catalyst in Friedel-Crafts reaction & in cracking of petroleum.

- Alums: Alums are double sulphates of the type $\text{M}_2\text{SO}_4 \cdot \text{M}'_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ where M is a univalent cation like Na^+ , K^+ & NH_4^+ and M' is a trivalent cation like Al^{3+} , Fe^{3+} , Cr^{3+} .

Potash alum - $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$.

Sodium alum - $\text{Na}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$.

■ Uses: Potash alum is used for purification of water, as styptic, in fire extinguishers, as mordant for dyeing & for tanning of leather.

* Group 1A Elements:

- Physical Properties : a) atomic & ionic radii - covalent radii -

C < Si < Ge < Sn < Pb. b) ionisation energy -

C > Si > Ge > Sn > Pb. c) electronegativity -

C > Si = Ge ≈ Sn < Pb. d) oxidation state -

1A (JVB).

C ($2s^2 2p^2$)

Si ($3s^2 3p^2$)

Ge ($4s^2 4p^2$)

Sn ($5s^2 5p^2$)

Pb ($6s^2 6p^2$)

Stability of +1 oxidation state decreases down the group while that of +2 increases. e) Melting & boiling points - decrease from C to Pb. f) density - increases regularly from C to Pb. g) allotropy - all elements show allotropy.

- Chemical Properties :

Group 14 Elements	<u>Action of air</u> → HO, HO ₂
	<u>Reaction with H₂O</u> → SnO ₂ + H ₂
	<u>Reaction with acid</u> , GeHCl_3 (with hot HCl gas) SnCl_2 & H_2PbCl_4 (with conc. HCl)
	<u>Reaction with alkalies</u> → Na_2SiO_3 , Na_2SnO_3
	<u>Reaction with halogens</u> → MX_4 & MX_2

⇒ Pb does not decompose steam because of the protective layer of oxide.

⇒ PbBr_4 & PbI_4 do not exist due to the fact that Pb^{4+} is a strong oxidising agent while Br^- & I^- are strong reducing agents, hence Pb^{4+} can't survive in presence of Br^- & I^- ions.

⇒ Oxyanion tendency - C >> Si > Ge ≈ Sn >> Pb

⇒ Acidic strength - $\underbrace{\text{CO}_2 > \text{SiO}_2}_{\text{acidic}} > \underbrace{\text{GeO}_2}_{\text{less acidic}} > \underbrace{\text{SnO}_2 > \text{PbO}_2}_{\text{amphoteric}}$.

● Anomalous behaviour of Carbon: a) Carbon differs from rest of the members of group 14 because of its small size, high electronegativity, property of catenation & absence of d-orbitals. b) Main differences - i) The melting & boiling points, ionisation energy & electronegativity of C are very high as compared to the rest of the members. ii) It has max. tendency to show catenation as compared to other members of the family. iii) It has high tendency to form pC-pC multiple bonds while others form pC-dC bonds & that also to a lesser extent. iv) CO_2 is a gas while the oxides of other members are solids.

● Oxides of Carbon :

Oxide	Preparation	Properties & Uses
CO	1. $2\text{C(s)} + \text{O}_2(\text{g}) \xrightarrow{\Delta} 2\text{CO(g)}$ 2. $\text{HCOOH} \xrightarrow[\text{conc. H}_2\text{SO}_4]{373\text{K}} \text{H}_2\text{O} + \text{CO}$ 3. $\text{C(s)} + \text{H}_2\text{O(g)} \xrightarrow[173-1273\text{K}]{\text{Water gas}} \text{CO(g)} + \text{H}_2(\text{g})$ 4. $2\text{C(s)} + \text{O}_2(\text{g}) + 4\text{N}_2(\text{g}) \xrightarrow{1273\text{K}} 2\text{CO(g)} + 4\text{N}_2(\text{g})$ Producer gas. .	1. powerful reducing agent & reduces many metal oxides to the metal. 2. CO molecule acts as a donor & reacts with metals to form metal carbonyls. 3. It is an important fuel as it is a component of water gas, producer gas & coal gas. 4. It's toxic because it forms a complex with haemoglobin in the blood, and this complex is more stable than oxy-haemoglobin.
CO_2	1. $\text{C(s)} + \text{O}_2(\text{g}) \xrightarrow{\Delta} \text{CO}_2(\text{g})$ 2. $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \xrightarrow{\Delta} \text{CO}_2(\text{g}) + 2\text{H}_2\text{O(g)}$ 3. $\text{CaCO}_3(\text{s}) \xrightarrow{\Delta} \text{CaO(s)} + \text{CO}_2(\text{g})$ Limestone 4. $\text{CaCO}_3(\text{s}) + 2\text{HCl(aq)} \rightarrow \text{CaCl}_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O(l)}$	1. an acidic oxide, reacts with bases to form salts. 2. Solid CO_2 is called dry ice & is used to freeze foods & ice cream. 3. It's not poisonous but in excess may lead to increase in greenhouse effect.

* Some Important Compounds :

• Silicon dioxide / Silica (SiO_2) :

1. Structure : Has a 3D network structure in which each silicon is bonded to 4 O atoms which are tetrahedrally disposed around silicon.

2. Properties : i) Occurs in several crystallographic forms (Quartz, Cristobalite, Tridymite). ii) non-reactive because of very high Si-O bond enthalpy. iii) $\text{SiO}_2 + 2\text{NaOH} \rightarrow \text{Na}_2\text{SiO}_3 + \text{H}_2\text{O}$ iv) $\text{SiO}_2 + 4\text{HF} \rightarrow \text{SiF}_4 + 2\text{H}_2\text{O}$.

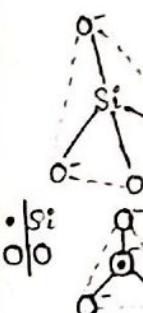
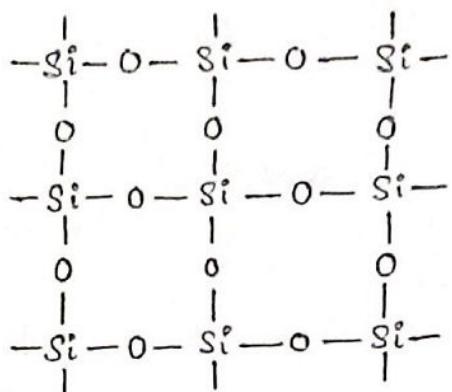
3. Uses : i) extensively used as piezoelectric material, made possible to develop extremely accurate clocks, modern radio & television. ii) Silica is used in the manufacture of glass & lenses for optical instruments. iii) Powdered quartz is used to manufacture silica bricks. iv) Silica gel ($\text{SiO}_2 \cdot x\text{H}_2\text{O}$) is used in chromatography & also for adsorbing moisture.

• Silicates : The basic building unit of all silicates is tetrahedral SiO_4^{4-} ion. Depending upon

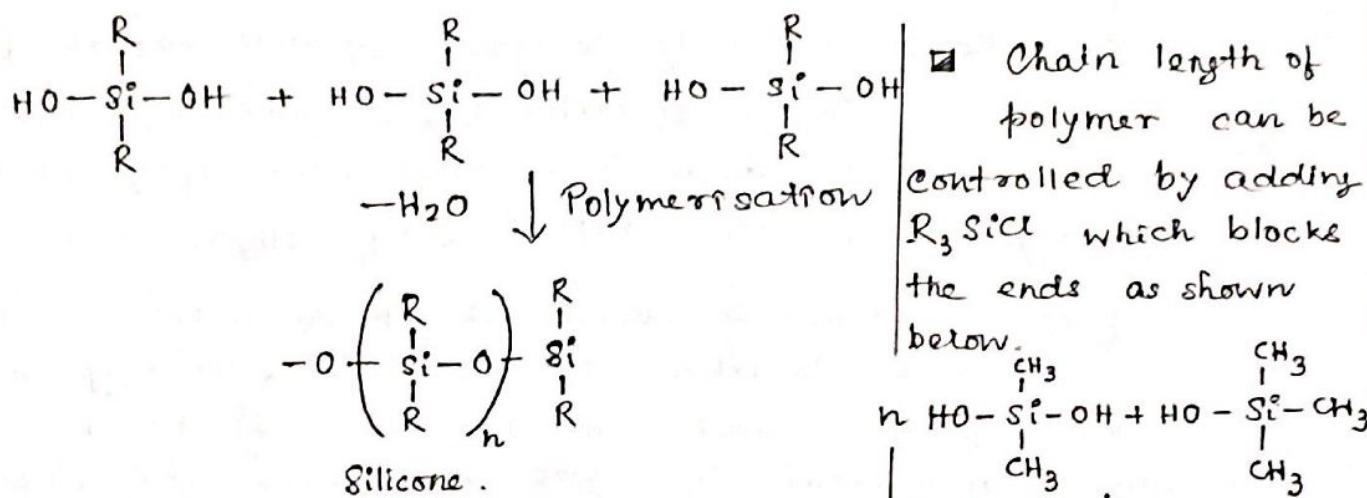
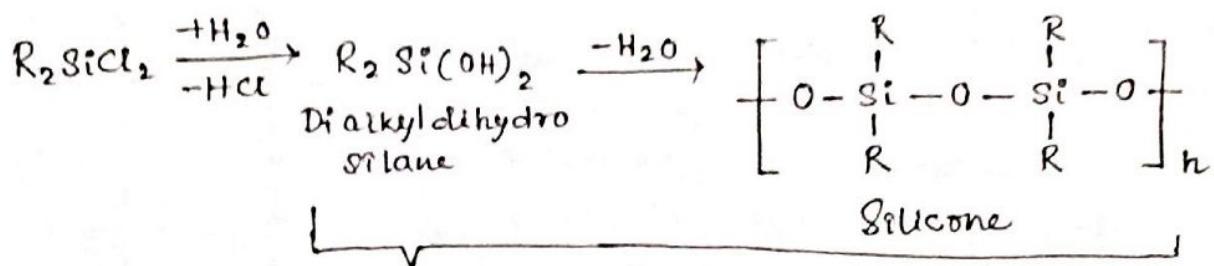
the linkages of SiO_4^{4-} . Depending upon the linkages of SiO_4^{4-} units, different types of structural arrangements are possible for silicates such as linear chains, cyclic chains, sheets etc.

• Zeolites : These are a class of 3D aluminosilicates. Their general formula is . . .

$M_{x/n} [\text{AlO}_2]_x [\text{SiO}_4]_y \cdot m\text{H}_2\text{O}$, where M = Na^+ , K^+ or Ca^{2+} , n = charge on the simple cation, m = no. of molecules of water of hydration.



- **Silicones:** Silicones are organo-silicon polymeric compounds containing $\text{Si}-\text{O}-\text{Si}$ linkages.



2. Properties: Being surrounded by non-polar alkyl groups, water repelling in nature. Have high thermal stability, high dielectric strength, resistance to oxidation & chemicals.

3. Uses: Used as sealant, greases, water proofing
fabrics, lubricants.

• Allotropes of Carbon: Carbon

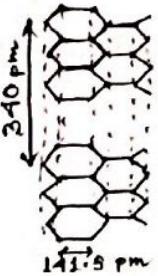
Natural Crystalline

Diamond
(sp³ hybridisation,
hardest substance)



Artificial Crystalline

Graphite
(sp² hybridized)
soft to touch



fullerenes, e.g. C_{60} also

known as bucky ball

has 52 five members &
by 20 six members -

mole & C is sp²
hybridised.

Amorphous

Wood charcoal.

sugar charcoal,
lamb black etc.

- * Group 15 Elements: Collectively called pnictogens.
- Occurrence: Molecular N_2 comprises 78% by volume of the atmosphere. In the Earth's crust, it occurs as sodium nitrate, $NaNO_3$ (Chile saltpetre) & KNO_3 (Indian Saltpetre). It is found in the form of proteins in plants & animals. P occurs in minerals of the apatite family, $Ca_x(PO_4)_6 \cdot CaX_2$ ($X = F, Cl$ or OH) (eg fluorapatite, $Ca_5(PO_4)_3 \cdot CaF_2$) which are the main components of phosphate rocks. P is present in bones as well as in living cells. Phosphoproteins are present in milk and eggs. As, Sb, Bi are found mainly as sulphide minerals.
- General Characteristics:
 - a) Electronic config - ns^2np^3 .
 - b) Physical state and metallic character - N_2 (unreactive gas), P_4 (solid non metal), As_4 & Sb_4 (solid metalloids), Bi (metal).
 - c) atomic radii - Increase down the group, smaller than that of group 14 elements due to increased nuclear charge.
 - d) Melting & boiling points - H.Pt. increases from N to As and then decreases whereas B.Pt. increases from N to Sb and decreases very slightly then.
 - e) Ionisation enthalpy - decreases regularly down the group due to increase in size.
 - f) electronegativity - decreases down the group.
 - g) Allotropy - Nitrogen (α & β nitrogen), phosphorus (white, red, scarlet, violet, α -black, β -black), arsenic (grey, yellow, black), antimony (metallic, yellow, explosive).

- Chemical Properties:
 - a) Stability of +3 oxidation state increases and that +9 decreases down the group due to inert pair effect.
 - b) Halides: All elements form dihalides of the type MX_2 & except nitrogen, all form pentahalides (MX_5).
 - b)i) stability: $NF_3 > NCl_3 > NBBr_3$
 - b)ii) Lewis acid strength - $PCl_3 > AsCl_3 > SbCl_3 \approx PF_3 > PBBr_3 > PI_3$.
 - b)iii) Lewis base strength - $NI_3 > NBBr_3 > NCl_3 > NF_3$.
 - b)iv) Bond angle - $PF_3 < PCl_3 < PBBr_3 < PI_3$ (increasing bp-bp repulsions).
 - c) Hydrides: All elements form hydrides of type MH_3 which are covalent & pyramidal in shape.

Ease of formation	stability	Basic character	Solubility	Bond angle	Strength of H-H bond	Dipole moment	Decomposition temperature
							Max

Max ←	BiH_3	SbH_3	AsH_3	PH_3	NH_3	Redecing Character
Rate of Combustion						

- d) Oxides: All form oxides (X_2O_3 , X_2O_4 , X_2O_5).

N_2O_3	P_2O_3	As_2O_3	Sb_2O_3	Bi_2O_3	↓	acidic nature increases
N_2O_4	P_2O_4	As_2O_4	Sb_2O_4	Bi_2O_4		
N_2O_5	P_2O_5	As_2O_5	Sb_2O_5	Bi_2O_5		

acidic nature decreases.

- Anomalous properties of nitrogen:
 - a) N_2 differs from the rest of the members due to small size, high electronegativity, high ionisation enthalpy & non-availability of d orbitals.
 - b) N_2 has unique ability to form p π -p π multiple bonds with itself and other elements having small size and high electronegativity.
 - c) N_2 bond enthalpy of $N \equiv N$ is very high.
 - d) Nitrogen cannot form d π -p π bond.

* Allotropes of Phosphorus:

■ White Phosphorus: A translucent, white waxy solid; non-porous, insoluble in water, soluble in carbon disulphide & glows in dark (chemiluminescence). It dissolves in boiling NaOH solution in an inert atmospheric giving $\text{PH}_3 \cdot \text{P}_4 + 3\text{NaOH} + 8\text{H}_2\text{O} \rightarrow \text{PH}_3 + \text{Na}_3\text{P}_4$. White phosphorus is less stable and therefore more reactive than the other solid phases under normal conditions because of angular strain under the effect of small angle, 60° , in the P_4 molecule. It readily catches fire in air to give dense white fumes of $\text{P}_4\text{O}_{10} \cdot \text{P}_4 + 5\text{O}_2 \rightarrow \text{P}_4\text{O}_{10}$.

■ Red Phosphorus: Obtained by heating white P at 573K in an inert atmosphere for several days. It is colourless, non-porous and insoluble in water as well as in carbon disulphide. Chemically less reactive than white phosphorus. It is polymeric, consisting of chains of P_4 .



■ Black Phosphorus: Has two forms α -black, β -black.

α -black P is formed when red P is heated in a sealed tube at 803K. It can be sublimed in air, has opaque monoclinic or rhombohedral crystals. β -black P is formed by heating white P at 473K under high pressure.

* Some Important Compounds:

Cmpd	Preparation	Properties	Uses
N_2 $\text{N} \equiv \text{N}$ Isotopes ^{14}N , ^{15}N , ^{17}N	$\text{NH}_4\text{Cl} + \text{NaNO}_2 \rightarrow \text{N}_2 \uparrow + 2\text{H}_2\text{O} + \text{NaCl}$ $(\text{NH}_4)_2\text{Cr}_2\text{O}_7 \xrightarrow{\Delta} \text{N}_2 \uparrow + 4\text{H}_2\text{O} + \text{Cr}_2\text{O}_3$ $\text{Ba}(\text{N}_3)_2 \xrightarrow{\Delta} \text{Ba} + 3\text{N}_2 \uparrow$	N_2 reacts with H to form NH_3 (Haber's process) N_2 reacts with O_2 at 2000K to form NO N_2 reacts with B to form BN N_2 reacts with Si to form Si_3N_4 N_2 reacts with CaC_2 to form $\text{CaCN}_2 + \text{C}$ N_2 reacts with $\text{Al}_2\text{O}_3 + \text{C}$ to form $\text{AlN} + \text{CO}$	Used in manufacture of HNO_3 , NH_3 , $\text{Ca}(\text{CN})_2$.

● Oxides of Nitrogen:

Oxide	Physical appearance & chemical nature	Structure.
Nitrous oxide (N_2O)	colourless gas, neutral.	$\ddot{\text{N}}=\text{N}=\ddot{\text{O}} \leftrightarrow :\text{N}=\text{N}-\ddot{\text{O}}:$
Nitric oxide (NO)	colourless gas, neutral.	$:\text{N}=\ddot{\text{O}}: \leftrightarrow :\dot{\text{N}}=\ddot{\text{O}}:$
Dinitrogen trioxide (N_2O_3)	blue solid, acidic	$\begin{matrix} \ddot{\text{O}} & & \ddot{\text{O}} \\ & \text{N} - \text{N} = & \\ & \backslash & / \\ \ddot{\text{O}} & & \ddot{\text{O}} \end{matrix} \leftrightarrow \begin{matrix} \ddot{\text{O}} & & \ddot{\text{O}} \\ & \text{N} - \text{N} = & \\ & / & \backslash \\ \ddot{\text{O}} & & \ddot{\text{O}} \end{matrix}$
Dinitrogen tetroxide (N_2O_4)	colourless solid, or liquid, acidic	$\begin{matrix} \ddot{\text{O}} & & \ddot{\text{O}} \\ & \text{N} - \text{N} = & \\ & \backslash & / \\ \ddot{\text{O}} & & \ddot{\text{O}} \end{matrix} \leftrightarrow \begin{matrix} \ddot{\text{O}} & & \ddot{\text{O}} \\ & \text{N} - \text{N} = & \\ & / & \backslash \\ \ddot{\text{O}} & & \ddot{\text{O}} \end{matrix}$
Nitrogen dioxide (NO_2)	brown gas, acidic	$\begin{matrix} \ddot{\text{O}} & & \ddot{\text{O}} \\ & \text{N} = & \\ & \backslash & / \\ \ddot{\text{O}} & & \ddot{\text{O}} \end{matrix} \leftrightarrow \begin{matrix} \ddot{\text{O}} & & \ddot{\text{O}} \\ & \text{N} = & \\ & / & \backslash \\ \ddot{\text{O}} & & \ddot{\text{O}} \end{matrix}$
Dinitrogen pentoxide (N_2O_5)	colourless solid, acidic	$\begin{matrix} \ddot{\text{O}} & & \ddot{\text{O}} & & \ddot{\text{O}} \\ & \text{N} = & \text{N} = & \text{N} = & \text{O} \\ & \backslash & / & \backslash & / \\ \ddot{\text{O}} & & \ddot{\text{O}} & & \ddot{\text{O}} \end{matrix} \leftrightarrow \begin{matrix} \ddot{\text{O}} & & \ddot{\text{O}} & & \ddot{\text{O}} \\ & \text{N} = & \text{N} = & \text{N} = & \text{O} \\ & / & \backslash & \backslash & / \\ \ddot{\text{O}} & & \ddot{\text{O}} & & \ddot{\text{O}} \end{matrix}$

● Oxoacids of nitrogen & phosphorus:

Oxoacid	Properties	Structure.
Hyponitrous acid ($\text{H}_2\text{N}_2\text{O}_2$)	Weak acid	$\text{HO}-\ddot{\text{N}}=\text{N}^+/\text{OH}$
Nitrous acid (HNO_2)	Weak, unstable acid	$\text{H}-\text{O}-\ddot{\text{N}}=\text{O}$
Nitric acid (HNO_3)	Strong, stable acid	$\text{H}-\text{O}-\text{N}=\text{O}$
Pernitric acid (HNO_4) Pernitric acid	unstable, explosive	$\text{HO}-\text{O}-\text{N}=\text{O}$
Phosphoric acid, H_3PO_4 Hypophosphorous acid	monobasic, strong, reducing agent	$\begin{matrix} \text{H} & & \text{H} \\ \text{HO} & / & \backslash \\ & \text{P} & \\ & \backslash & / \\ & \text{H} & \end{matrix}$ Basicity = 1 Oxidation state of P = +1
Phosphonic acid (Orthophosphorous acid) H_3PO_3	dibasic, reducing agent	$\begin{matrix} \text{O} & & \text{H} \\ \text{HO} & / & \backslash \\ & \text{P} & \\ & \backslash & / \\ & \text{H} & \end{matrix}$ Basicity = 2 OS of P = +3
Phosphoric acid, H_3PO_4 Orthophosphoric acid	non-reducing, tribasic	$\begin{matrix} \text{O} & & \text{H} \\ \text{HO} & / & \backslash \\ & \text{P} & \\ & \backslash & / \\ & \text{OH} & \end{matrix}$ Basicity = 3 OS of P = +5
Metaphosphoric acid (glacial phosphoric acid) $(\text{HPO}_3)_n$	monobasic	$\left(\begin{matrix} \text{O} & & \text{H} \\ \text{O} & / & \backslash \\ & \text{P} & \\ & \backslash & / \\ & \text{OH} & \end{matrix} \right)_n$ Basicity = 1 OS of P = +5
Pyrophosphorous acid $\text{H}_4\text{P}_2\text{O}_5$	dibasic	$\begin{matrix} \text{O} & & \text{O} \\ \text{H} & \text{P} & \text{O} & \text{P} & \text{H} \\ & \parallel & & \parallel & \\ \text{HO} & & \text{O} & & \text{OH} \\ & & \backslash & / & \\ & & \text{H} & \text{O} & \end{matrix}$ Basicity = 2 OS of P = +3.
Pyrophosphoric acid $\text{H}_4\text{P}_2\text{O}_7$	Tetrabasic	$\begin{matrix} \text{O} & & \text{O} \\ \text{H} & \text{P} & \text{O} & \text{P} & \text{O} & \text{H} \\ & \parallel & & \parallel & & \\ \text{HO} & & \text{O} & & \text{O} & & \text{H} \\ & & \backslash & / & & / & \\ & & \text{H} & \text{O} & & \text{OH} & \end{matrix}$ Basicity = 4 OS of P = +5
Hypophosphorous acid, $\text{H}_4\text{P}_2\text{O}_6$	Tetraabasic	$\begin{matrix} \text{O} & & \text{O} \\ \text{H} & \text{P} & \text{P} & \text{O} & \text{H} \\ & \parallel & & \parallel & \\ \text{HO} & & \text{O} & & \text{OH} \\ & & \backslash & / & \\ & & \text{H} & \text{O} & \end{matrix}$ Basicity = 4 OS of P = +4

- Nitrogen may show +5 oxidation state but it is never pentavalent.
- ⇒ Quicklime is used for drying NH_3 as it reacts with other dehydrating agents.
- ⇒ In liquid or solid state, NO forms a loose dimer (N_2O_2) which is diamagnetic in nature.
- ⇒ Phosphine in combination with acetylene is used in preparing Holme's signals used in preparing soft drinks.
- ⇒ Al_3PO_4 is used in the soft drinks.
- ⇒ N_2O_5 & P_2O_5 are covalent in vapor state, butionic in solid state.

* Group 16 Elements : Group of chalcogens.

- General Properties : a) Physical state & metallic character : O_2 (gas), S_8 (solid non-metal), Se & Te (solid metalloid), Po (radioactive).
- b) atomic radii - increase down the group.
- c) Ionisation enthalpy - decrease down the group.
- d) Electronegativity - decrease down the group.
- e) Electron gain enthalpy - Increases from oxygen to sulphur & then decreases.
- f) melting & boiling points - Increase down the group upto Te & then decrease.
- g) allotropy - all show.

• Allotropes of Sulphur : Yellow rhombic (α -sulphur) & monoclinic (β -sulphur)

The stable form at room temp is rhombic sulphur, which transforms to β -sulphur, when heated above 369K. At 369K, both forms are stable; this temp. is called transition temp.

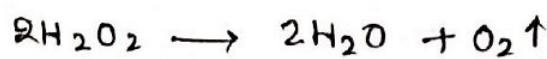
16 (VIB)
 $\text{O}(2s^2 2p^4)$
 $\text{S}(3s^2 3p^4)$
 $\text{Se}(4s^2 4p^4)$
 $\text{Te}(5s^2 5p^4)$
 $\text{Po}(6s^2 6p^4)$

● Chemical Properties:

a) Stability of -2 oxidation state decreases down the group, & of +1 os increases & of +6 os decreases down the group, due to inert pair effect. b) hydrides - all elements form stable hydrides of the type H_2N . c) general trend of hydrides - Bo.pt. $H_2O > H_2Te > H_2Se > H_2S$; Volatility. $H_2S > H_2Se > H_2Te > H_2O$; bond angle - $H_2O > H_2S > H_2Se > H_2Te$; acidic character - $H_2O < H_2S < H_2Se < H_2Te$; reducing power - $H_2Te > H_2Se > H_2S > H_2O$.

d) Halides: All elements form halides of the type EX_6 , EX_4 , EX_2 . e) Simple oxide - MgO , Al_2O_3 ; Mixed oxide - Pb_3O_4 , Fe_3O_4 ; Acidic oxide - SO_2 , Cl_2O_7 , CO_2 , N_2O_5 ; Basic oxide - Na_2O , CaO , BaO ; Amphoteric oxide - Al_2O_3 ; Neutral oxide - CO , NO , N_2O . f) anomalous behaviour of oxygen - strong hydrogen bond is present in H_2O , not in H_2S , due to small size & high electronegativity.

● Dioxygen: □ Preparation: $2KClO_3 \xrightarrow[\text{MnO}_2]{\Delta} 2KCl + 3O_2$



□ Properties: $O_2 + 2Mg = 2MgO$