

BASARA SARASWATHI BHAVAN_MDP N-120

SECTION:SR

13_GROUP

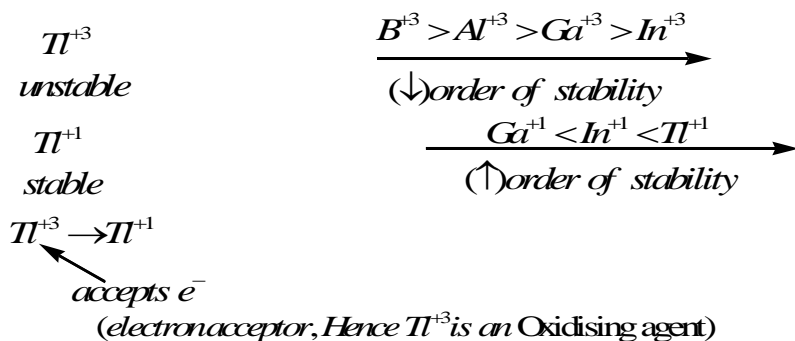
Prepared by Dr. APR

B Al Ga In Tl
General electronic configuration ns^2np^1

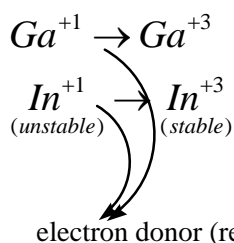
Oxidation states:- +1,+3

The possible oxidation states are +1(due to involvement of only p electron)

+3(due to involvement of both s and p electrons). Down the group the stability of +3 oxidation state decreases that of +1 O.S increases due to increasing inertness of the electrons. Thallium(*Tl*) can exhibit stable +1 cannot exhibit stable +3 due to inert pair effect. Thallium resembles group 1 elements due to its +1 oxidation state.



Compounds of Tl^{+3} are unstable, changes to more stable Tl^{+1} by accepting the electrons, compounds of Tl^{+3} act as oxidising agents



electron donor (reducing agents)

Ga^{+1}, In^{+1} changes to more stable Ga^{+3}, In^{+3} by donating electrons and they act as reducing agents.

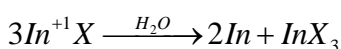
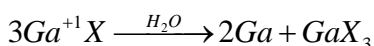
Ga^{+1} is more reducing than In^{+1} ($Ga^{+1} < In^{+1}$) \rightarrow lesser the stability, greater the reducing character.

character.

\rightarrow The oxidation state of *Ga* in GaX_2 appears to be +2. But, it is not +2, it is a compound with Ga^{+1} and Ga^{+3}



$\rightarrow GaX$ or Ga^{+1} and InX or In^{+1} are unstable and undergoes disproportionation in aqueous solution.

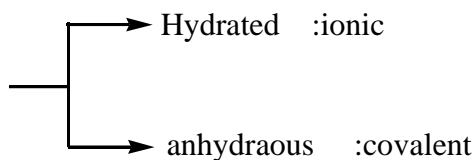


Nature of compounds :

\rightarrow boron always forms covalent compounds due to high ionisation energy.

$\rightarrow B^{+3}$ in aqueous solution cannot exist.

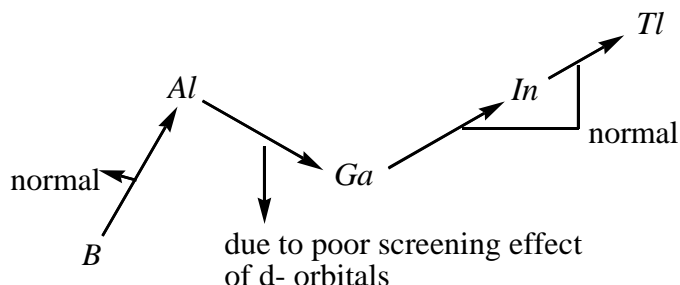
Compounds of *Al* :



The hydration energy of Al^{+3} is greater than $IE_1 + IE_2 + IE_3$ of Al , therefore hydrated compounds are ionic in nature.

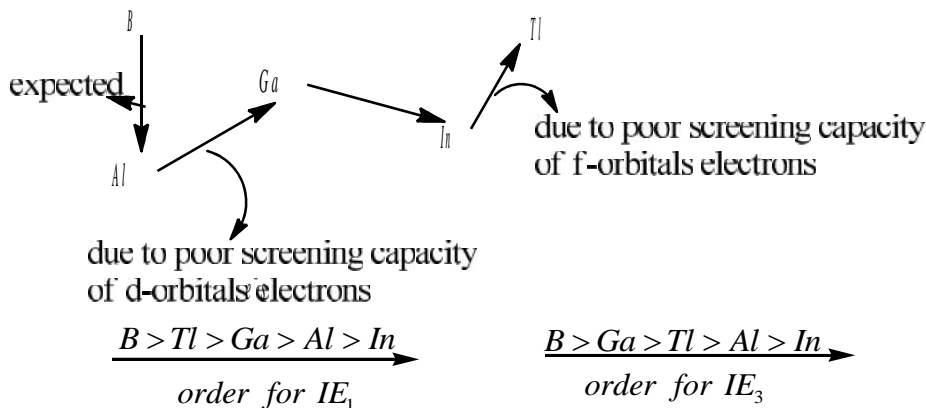
Atomic radii:

<i>B</i>	<i>Al</i>	<i>Ga</i>	<i>In</i>	<i>Tl</i>
$(0.88A^\circ)$	$(1.43A^\circ)$	$(1.35A^\circ)$	$(1.67A^\circ)$	$(1.70A^\circ)$



Sudden jump in atomic radii from B to Al is due to difference in number of electrons in penultimate shell.

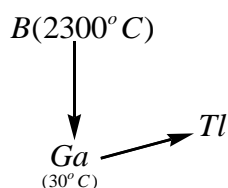
Ionisation energies :



Melting point:

→ ' B ' is giant covalent polymer with large number of strong covalent bonds. Hence, it has high melting point.

→ Gallium exists as Ga_2 molecule. There exists weak attractive forces between molecules.



$$B > Al > Tl > In > Ga \quad \text{order of M.P}$$

→ regular decrease in B.Ps is observed.

→ Ga have high liquid range. ∴ used in high temperature thermometers as thermometric liquid.

Density:

→ regular increase is observed $B \text{ (2.35 g/cc)} \text{ --- } Tl \text{ (11.85 g/cc)}$

Chemical reactivity towards air:

→ Crystalline boron is unreactive.

→ Aluminium is unreactive towards air due to layer of Al_2O_3 .

→ Amorphous boron and Al on heating in air forms corresponding oxides (B_2O_3, Al_2O_3).

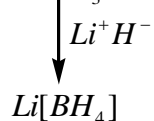
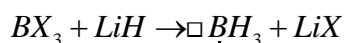
→ On heating to high temperature, forms corresponding nitrides. (BN, AlN)

Hydrides:

→ Group 3 elements are expected to form MH_3 type of simple hydrides but no element forms simple MH_3 type hydrides but forms complex hydride of the type .

type : $Li[BH_4]$, $Li[AlH_4]$

→ Due to availability of vacant P orbital, they form complex hydrides.



(↑) order of stability

BH_4^- is a larger anion, more stabilised by larger cation

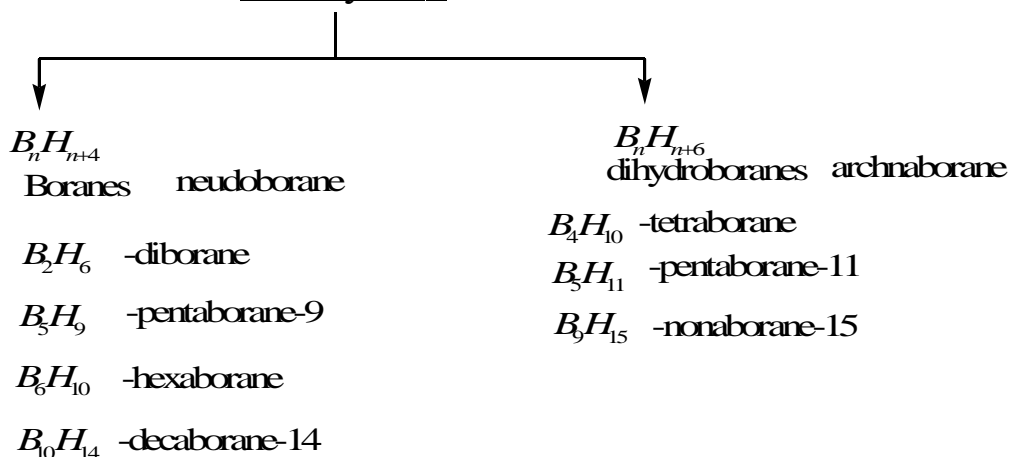
→ Complex hydrides are good selective reducing agents

→ lesser the stability of complex hydride , greater the reducing character



(↓) order of reducing character

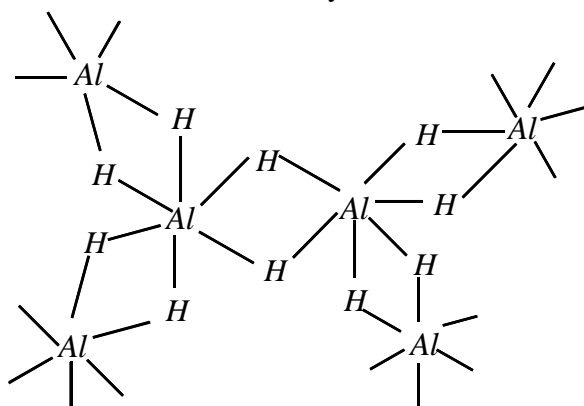
Boron hydrides:



Hydrides of other elements are polymeric.

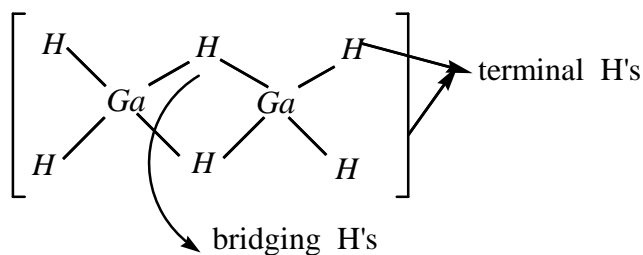
'Al' hydrides are called allanes (AlH_3)_n

Each 'Al' is surrounded by 6 'H' atoms



All bridging 'H' bonds are $2e^- 3C$ bonds

→ (GaH_3)₂ is dimeric in vapour state

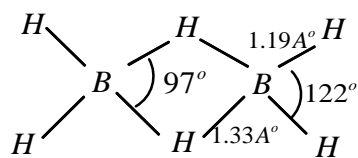


→ $(GaH_3)_2$ is polymeric in solid state

→ $(InH_3)_n$ exists as polymer in both vapour and solid state.

B_2H_6 (diborane):

Well established structure of diborane



No. Of terminal hydrogens is 4 ; No of bridging hydrogens is 2

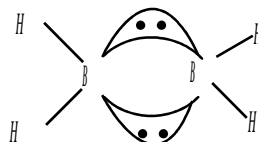
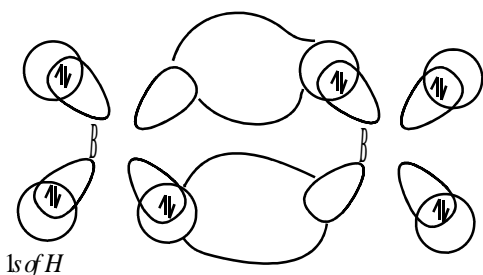
The specific heat data indicates there is no B-B rotation

→ The electron diffraction studies indicate BH_2 groups and bridging H's are in different plane.

→ proton nuclear magnetic resonance (NMR) indicates different types of hydrogens in the compound.

Orbital structure of diborane

Hybridisation of boron is sp^3



→ The no. Of 2e 2c bonds are 4

→ $sp^3 - s$ \uparrow bonds = 4

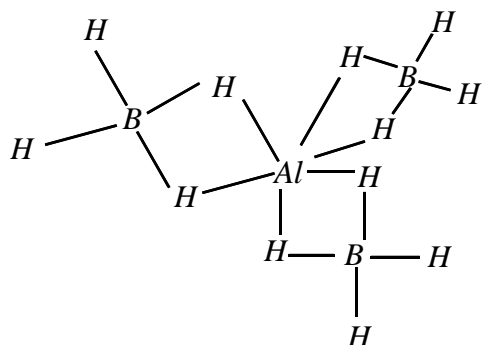
→ The no. of 2e 3c bonds are 2. These bonds are called banana bonds or tau bonds.

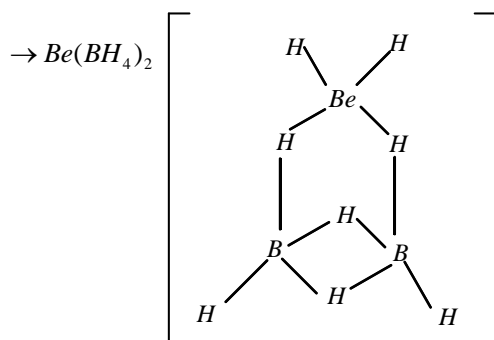
→ $sp^3 - s - sp^3$ bonds are 2

→ terminal B-H bond order : 1

→ bridging B-H bond order : 0.5

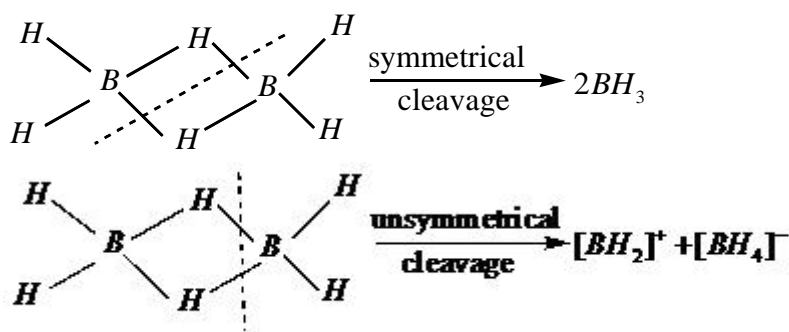
→ other compounds containing 2e 3c bonds are $Al(BH_4)_3$ (aluminium tetrahydro borate)





→ Diborane have less no. of electrons (12) than required for bond formation (16) ∴ classified as electron deficient compound (Lewis acid).

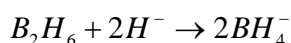
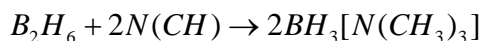
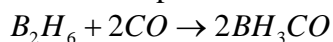
Cleavage of B_2H_6 :-



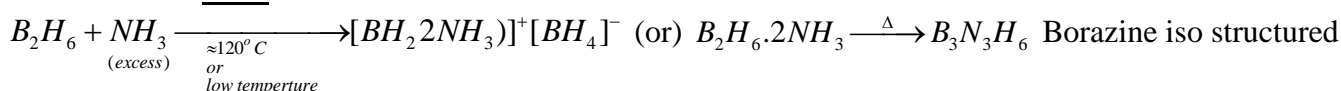
→ symmetrical cleavage takes place in presence of bulky soft bases with S,P donor atoms or $(CH_3)_3N$ or CO or Et_2O , THF each bulky group is attached to each boron.

→ unsymmetrical cleavage takes place in presence compact hard bases like H^- , NH_3 , CH_3NH_2 , $(CH_3)_2NH$.

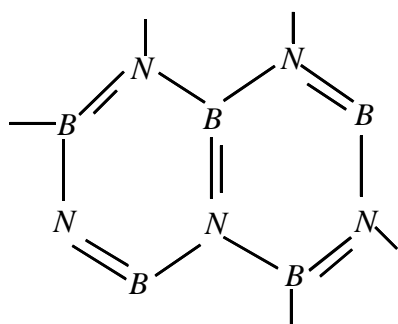
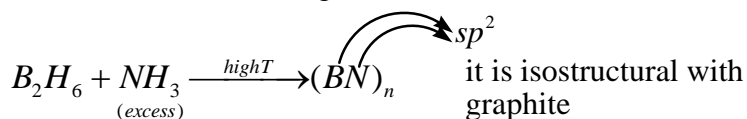
→ two compact hard bases are attached to one boron atom



Reaction with NH_3 :-



with benzene called as inorganic benzene



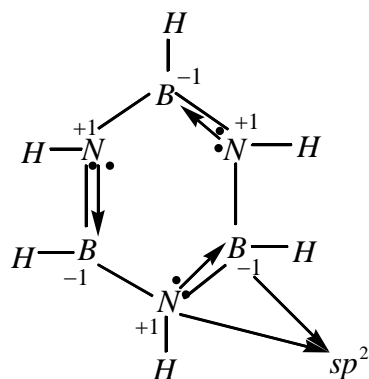
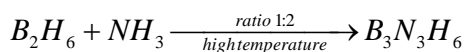
3.34 \AA

B-N (similar to graphite) bond order is 1.33 bond order

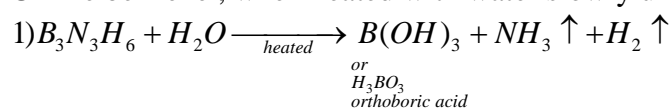
$$= 1 + \frac{\text{no. of } \pi \text{ bonds / dative bonds}}{\text{no. of elements sharing}} = 1 + \frac{2}{6} = 1 + \frac{1}{3} = 1.33 \text{ \AA}$$

Boron of 2nd layer is placed over nitrogen of the 1st layer . crystalline forms of *BN* is harder than diamond .

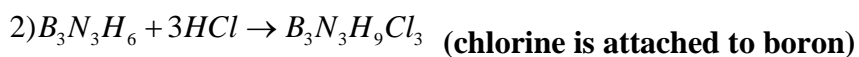
$MP = 3000^{\circ}C$



Compared to benzene it's chemical properties are different .it has delocalisation of π electrons, aromatic
Unlike benzene , when heated with water slowly undergoes hydrolysis



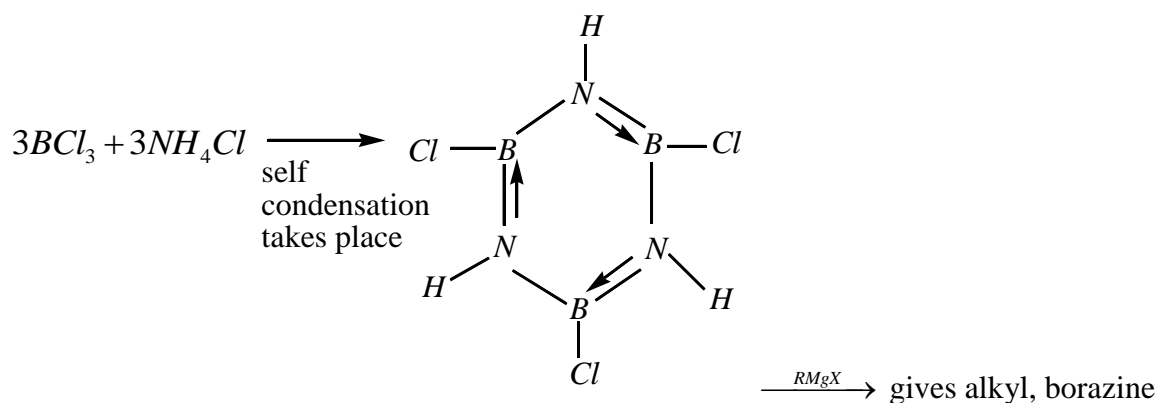
Addition with *HCl*



Number of isomers in disubstituted borazine :4

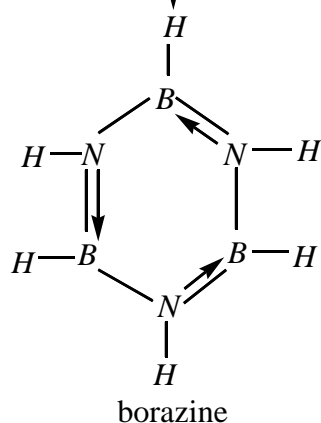
Preparation of borazine:

Prepared by condensation of equimolar quantities of BCl_3 and NH_4Cl



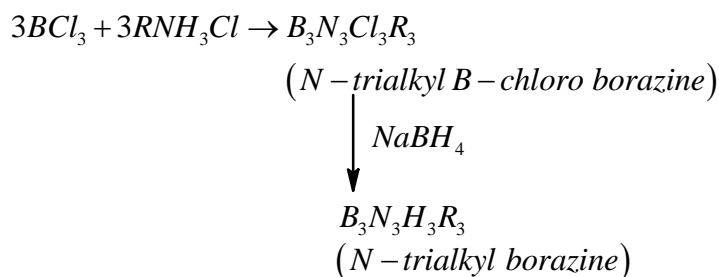
B-trichloro borazine

$\xrightarrow{\text{reduce with } NaBH_4}$



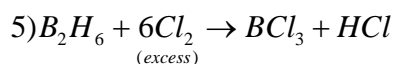
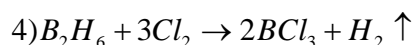
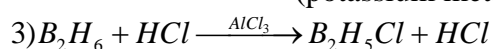
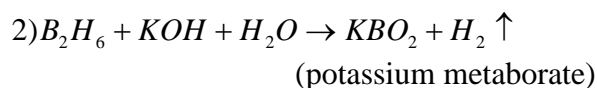
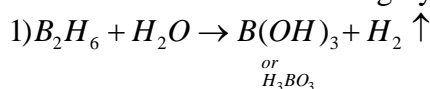
Preparation of N-trialkyl borazine:

Prepared by condensation of equimolar quantities of BCl_3 and alkylammonium chloride followed by reduction with $NaBH_4$



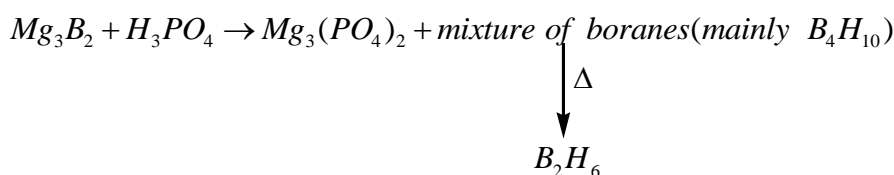
Properties of B_2H_6 :

- B_2H_6 is a gas at low temperature, high thermal stability
- easily undergoes hydrolysis and alkaline hydrolysis.
- it burns with O which is highly exothermic

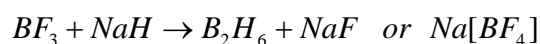


Preparation of B_2H_6 :

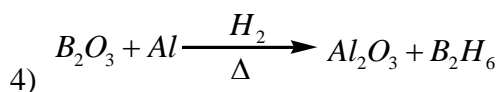
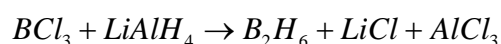
1) Reaction of phosphoric acid with magnesium boride:-



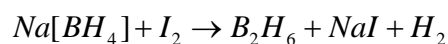
2) **Industrial method**: by reduction of BF_3 with sodiumhydride at 450K:-



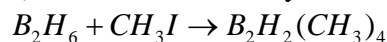
3) Laboratory method: reduction of BCl_3 with $LiAlH_4$:



5) oxidation of $NaBH_4$ with iodine:



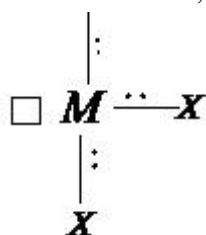
6) Reaction with methyl iodide:-



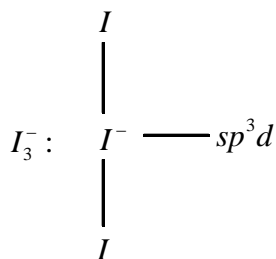
Formation of tetramethyldiborane indicates the presence of four terminal hydrogens.

Halides: (MX_3)

Fluorides of *Al, Ga, In* are ionic, rest of the trihalides are covalent (Cl^- , Br^- , F^- , I^-)



In all these trihalides, central atom has incomplete octet, and thus are classified as electron deficient compounds



TlF_3 -not exists (cannot exist as 'F' does not contain d- orbitals)

TlI_3 exists (which contains I_3^-)

The central atom of trihalides have a tendency to accept pair of electrons to complete the octet \therefore acts as lewis acids.

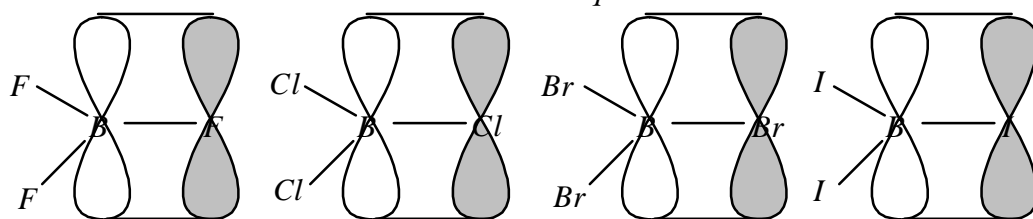
Lewis acidic character : $\xrightarrow{BX_3 \quad AlX_3 \quad GaX_3 \quad InX_3}$
 (\downarrow) decreasing order of Lewis acidic character

The above order is applicable to compact hard bases

$\xrightarrow{BX_3 \quad AlX_3 \quad GaX_3 \quad InX_3}$
 (\uparrow) order of Lewis acidic character

Above order is applicable to soft bases.

Lewis acidic character of boron trihalides : $BF_3 < BCl_3 < BBr_3 < BI_3$ the order of acidic character can be explained by strength of back bonding (BF_3, BCl_3, BBr_3, BI_3)
gas gas liquid solid



Stronger the back bond lesser the lewis acidic character. The strength of the bond (\downarrow) from BF_3 to BI_3 lewis acidic character of trihalides increases

Hydrolysis : BF_3 undergoes incomplete hydrolysis. Where as other halides are completely hydrolyzed.

$BX_3 + 3H_2O \longrightarrow H_3BO_3 + 3HX$ ($X = Cl, Br, I$). BF_3 incomplete hydrolysis is due to formation of BF_4^-

$BF_3 + 3H_2O \longrightarrow H_3BO_3 + 3HF$, $BF_3 + HF \longrightarrow HBF_4$

Complex Halides :

Maximum coordination number of B is 4 and maximum coordination number Al is 6, satisfied by only 'F'

BF_4^- , AlF_6^{3-} ,

$[GaX_6]^{3-}$, $[InX_6]^{3-}$ $X = F, Cl$

Halides:

\rightarrow Boron trihalides are monomers as the e^- deficient character is satisfied by back bonding.

In case of $AlCl_3$, Al cannot form f -bond with the Cl : satisfies its e^- deficient character by formation of dimer.

Alternates:

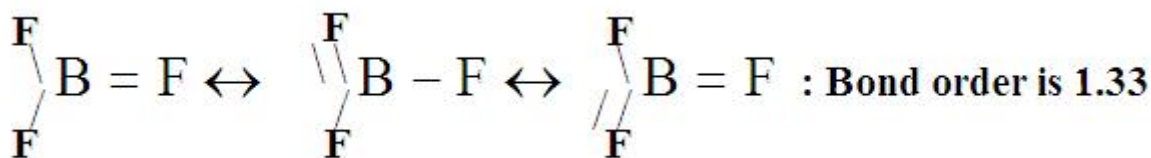
'B' atom is too small to accommodate with 4 larger halides Cl^- , Br^- & I^-

\therefore cannot exist as dimer. Fluorine is smaller than other halides. BF_3 is expected to form dimer but actually it is not so.

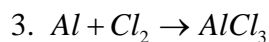
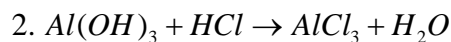
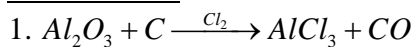
Reason: In BF_3 , $B-F$ f bond ($P_f - P_f$) is stronger, more energy is required to break it. This much energy is not released when it forms a bridged structure. it remains as a monomer.

B-F bond length in BF_3 is shorter than B-F single bond length. B-F B.E greater in BF_3 than B-F than single bond due to back bonding

All B-F bond lengths are equal due to resonance.



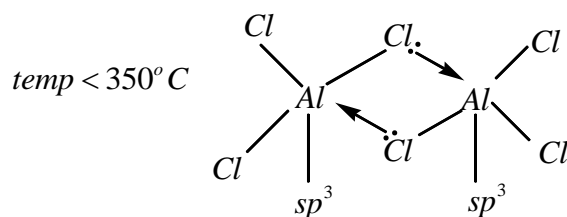
Preparation of BF_3 prepared by reaction of Boric acid with Hydrogen fluoride $\text{H}_3\text{BO}_3 + 3\text{HF} \rightarrow \text{BF}_3 + 3\text{H}_2\text{O}$
 $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$:



1 and 3 are used for preparation of anhydrous and method 2 is used for preparation of hydrated AlCl_3

Structure of AlCl_3 :

In fused state vapour state dissolved in organic solvents exists as a dimer

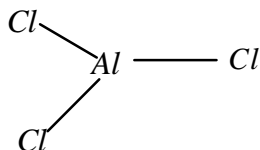


no. of terminal chlorides=4, no. of bridging chlorides=2 all are $2e^- 2C$ bonds

$t < 350^\circ \text{C}$ dimer, $t > 350^\circ \text{C}$ monomer

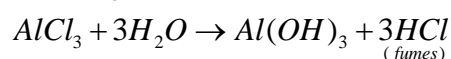
in solid state C.No. of Al^{+3} is 6

in vapour state, $> 350^\circ \text{C}$, it exists as a monimer

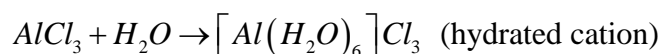


hydrated AlCl_3 cannot be converted to anhydrous by heating but can be converted by (using heating in presence of SOCl_2), $\text{SOCl}_2 \Rightarrow$ "thionylchloride", $\text{SOCl}_2 + \text{H}_2\text{O} \rightarrow \text{SO}_2 + 2\text{HCl}$

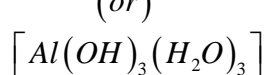
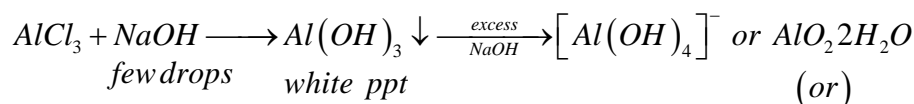
$\rightarrow \text{AlCl}_3$ when exposed to moist air gives fumes



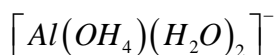
$\rightarrow \text{AlCl}_3$ when dissolved in water gives hydrated cation



\Rightarrow **Reaction with NaOH :**

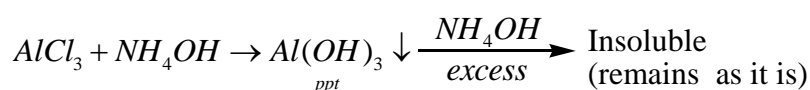


hydrated aluminium hydroxide ppt



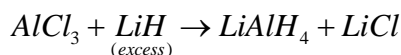
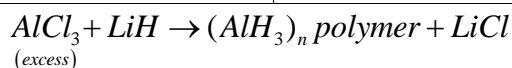
hydrated tetrahydroxo aluminate

\Rightarrow **Reaction with NH_4OH :**



State	AlF_3	AlCl_3	AlBr_3	AlI_3
Solid state	C.No=6	C.No=6	C.No=4 Molecular dimer	C.NO=4 Molecular dimer
At M.P/fused state	-	C.No=4	"	"

		Molecular dimer		
Vapour state	monomer	Dimer C.No=4 At $< 350^{\circ}C$ $> 350^{\circ}C$ (monomer)	"	"



Oxyacids of Boron:

Fluorine is the only non-metallic element which cannot form stable oxy acid due to its more electronegativity than 'O' and lack of vacant d- orbitals .

i) H_3BO_3 Orthoboric acid

ii) HBO_2 metaboric acid

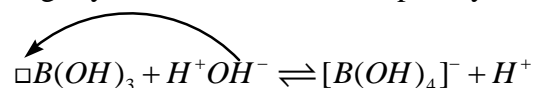
iii) $H_2B_4O_7$ tetraboric acid

iv) $H_6B_4O_9$ pyroboric acid

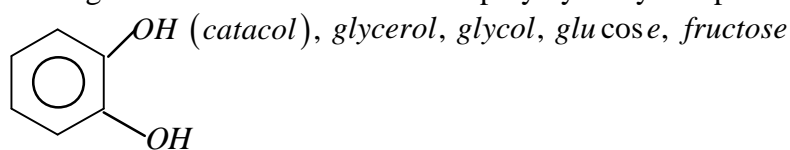
i) H_3BO_3 (Orthoboric acid): $B(OH)_3$

White crystalline slippery solid.

Slightly soluble in cold water, plenty soluble in hot water

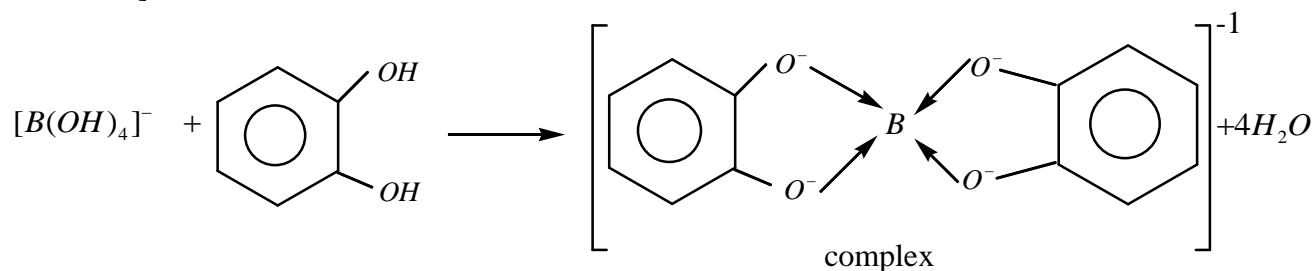


It is a weak monobasic Lewis acid. To increase the acidic character of H_3BO_3 or shift the equilibrium towards right hand side Cis di-ol or Cis-poly hydroxy compounds are used



Eg:

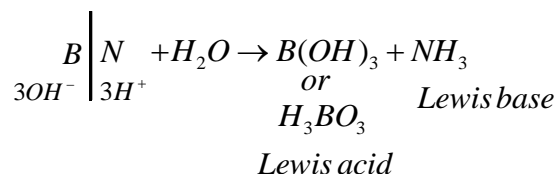
Cis di-ol eliminates $[B(OH)_4]^-$ from equilibrium state in the form of complex [max.coordination number Boron is 4]



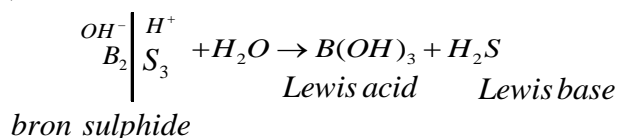
To get the exact end point during the titration of H_3BO_3 with standard $NaOH$, cisdiol are added , phenolphthalein indicator is used .

Preparation of H_3BO_3 :

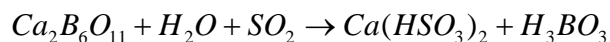
1)



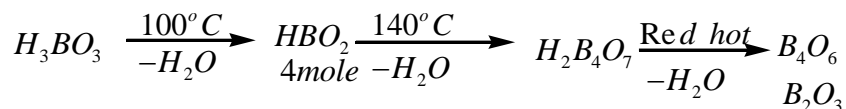
2)



3) From colemanite ($Ca_2B_6O_{11}$) by passing SO_2



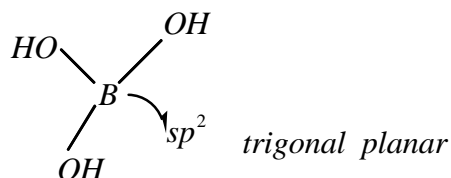
Effect of heat:



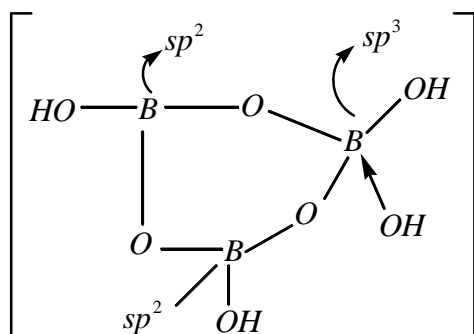
B_2O_3 is anhydride of H_3BO_3

Structure :

In dilute solution, it exists as a monomer



In concentrated solution, it exists as a trimer

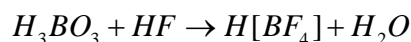


B-O-B bonds:3

; -OH groups attached to B=4

In solid state, it has 2 dimensional sheet structure with H- bonding

It dissolves in HF acid



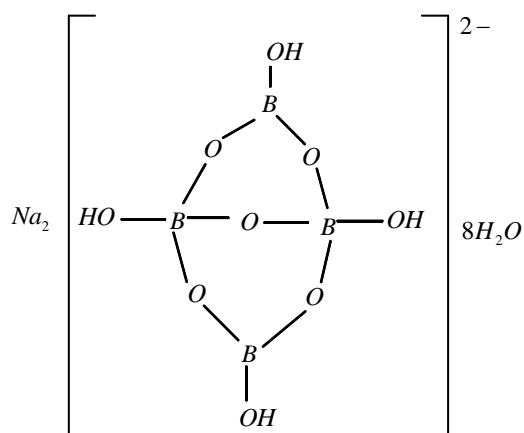
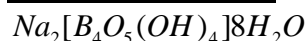
Hydrogen tetrafluoro borate is stronger acid than H_3BO_3

Borax: ($Na_2B_4O_7 \cdot 10H_2O$) prismatic borate / common form of borax.

$Na_2B_4O_7 \cdot 5H_2O$ octa hedral borax/ jewellery

$Na_2B_4O_7$ Borax glass – glassy transparent material . fairly soluble in cold water , freely soluble in hot water

Structure of Borax:



no of sp^3 or tetrahedral boron atoms are 2

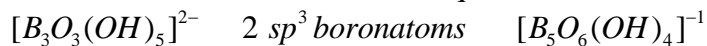
sp^2 or trigonal planar boron atoms are 2

No. Of water molecules attached to the metal ion is 8

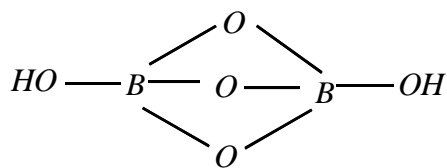
No. of B-O-B bonds is 5

No. of sp^3 boron atoms is equal to the no of -Ve charges

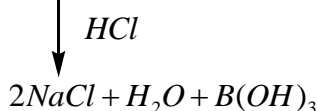
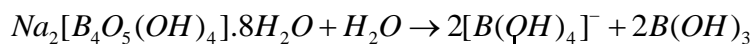
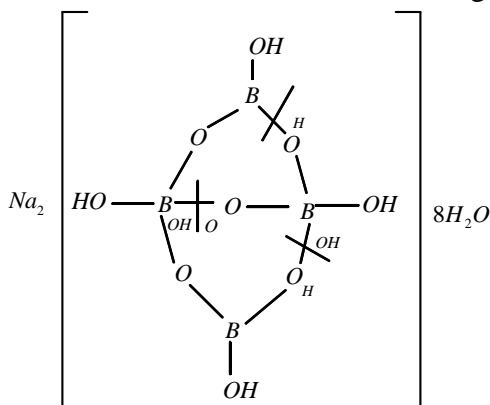
No. of 'O' atoms around boron is equal to the no. of B-O-B bonds



3 B-O-B bonds



When borax is dissolved in water ring is broken



Aqueous solution of Borax completely reacts with 2 moles of (HCl) acid

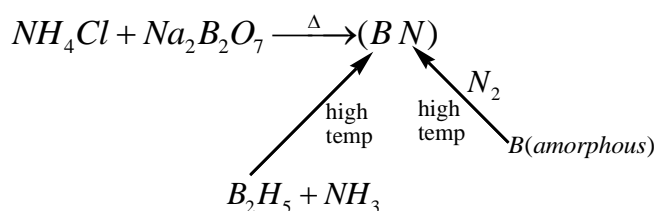
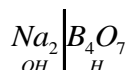
Borax is a metaborate.



→ Aqueous solution of Borax acts as a buffer

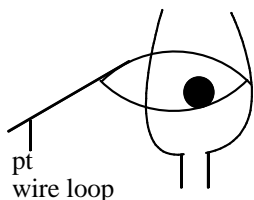
→ Acidic hydrolysis of Borax gives $B(OH)_3$

→ Aqueous solution of Borax is (basic) alkaline in nature



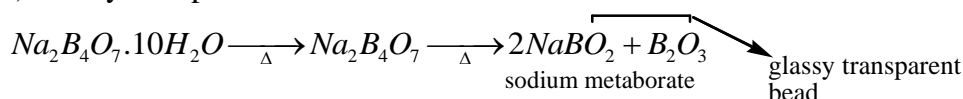
Borax bead test:

→ used for identification of metal salts

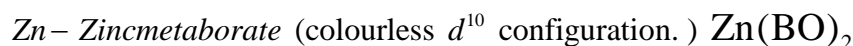
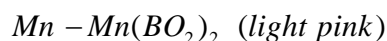
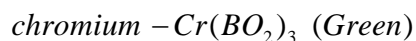
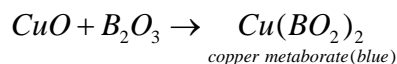
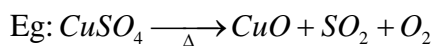


1) Borax is taken and heated on a platinum wire loop and heated in the flame .

2) Glassy transparent bead is formed



3) Glassy transparent bead is dipped into given metal solution and heated in the flame . Based on the colour of the bead , metal ion is identified .



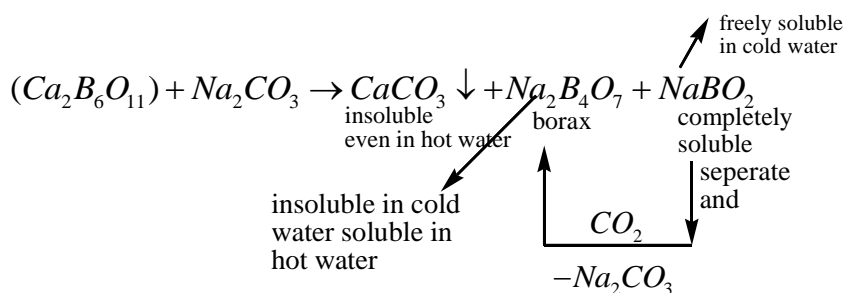
→ colour in the borax bead test is due to the formation of metalmetaborates.

→ Metals which can form coloured metaborates are identified by this test.

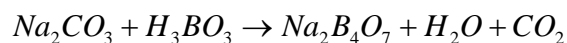
→ B_2O_3 is the intermediate compound.

Method of preparation of Borax:

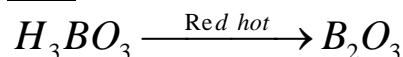
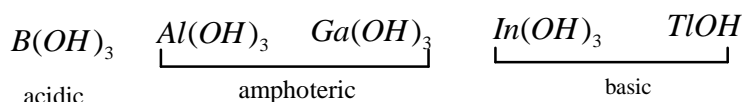
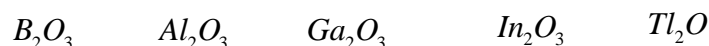
1) From colemanite ($\text{Ca}_2\text{B}_6\text{O}_{11}$) from reaction with Na_2CO_3



2) From orthoboric acid by reaction with Na_2CO_3

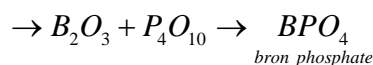
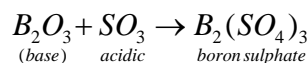


Oxides:- (M_2O_3)



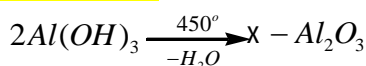
→ B_2O_3 is anhydride of orthoboric acid

→ In presence of strong acidic oxides like SO_3 , P_4O_{10} , B_2O_3 acts as a base.

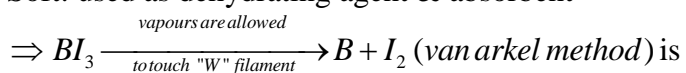


Al_2O_3 :-

$\gamma - \text{Al}_2\text{O}_3$



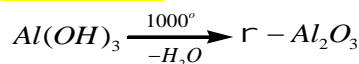
Soft: used as dehydrating agent & absorbent



colourless but can be coloured with Fe_2O_3 or Cr_2O_3

⇒ synthetic rubies are prepared by heating with Cr_2O_3 which are used in jewellery

$\alpha - \text{Al}_2\text{O}_3$



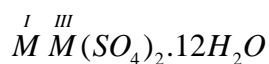
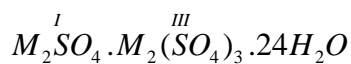
Very hard : known as corundum

⇒ Al_2O_3 is used as refractory material. The material is chemically inert with high M.P

Mixture of Al_2O_3 with SiO_2 and FeO is called emray which is used in sand paper.

Alums:

Double sulphates of mono positive and tri positive cations with $24\text{H}_2\text{O}$ molecules



Each metal is surrounded by $6H_2O$ molecules

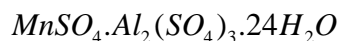
$Na^+, K^+, Rb^+, NH_4^+, Tl^+$ all these mono positive cations can form alums except Lithium

Lithium cannot form Alum as it is too small to accommodate $6H_2O$ molecules

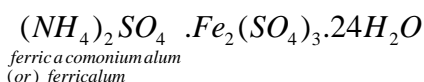
$Al^{+3}, Ga^{+3}, In^{+3}, Fe^{+3}, Co^{+3}, Cr^{+3}, Mn^{+3}, Ti^{+3}, V^{+3}, Rh^{+3}, Ir^{+3}$ all these tri positive cations can form Alums

Pseudo Alums:

Double sulphates of di positive and tri positive cations with $24H_2O$ are called pseudo Alums.



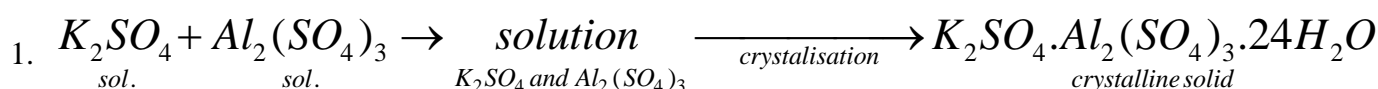
Potash Alum / common Alum:-



→ Aqueous solution of potash Alum is acidic in nature.

Preparation of potash Alum:

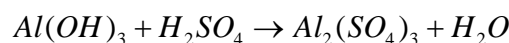
$K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$ - potash alum/ common alum



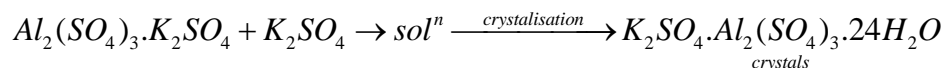
2.From Alum stone (alunite):-



Step-1: Alunite is dissolved in H_2SO_4 . Entire $Al(OH)_3$ is converted into $Al_2(SO_4)_3$



Step-2: Calculated quantity K_2SO_4 is added resulting solution and evaporated and crystallised to get common alum



→ Alums swell on heating due to loss of water

Uses of Alums:

- 1) Used for purification of drinking water
- 2) A antiseptic
- 3) As mordant → fixing agent in dye industry
- 4) Alums form Aluminium hydroxide on the cloth . The dye sticks to the $Al(OH)_3$

Extraction of Boron:

Ores: 1) Borax (tincal) - impure / crude borax

2) kernite (rasorite) $Na_2B_2O_7 \cdot 4H_2O$

3) colemanite $(Ca_2B_6O_{11} \cdot 5H_2O)$

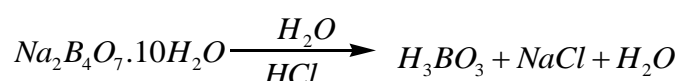
4) pandernite $(Ca_2B_6O_{11} \cdot 3H_2O)$

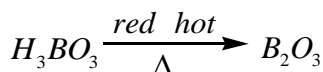
Extraction of Boron involves 2 steps :

Step-I: conversion of Ore to B_2O_3

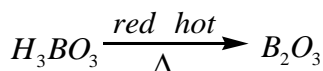
Step-II: Reduction of B_2O_3 - Boron

Step-I: a) B_2O_3 from borax.

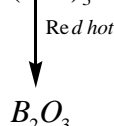
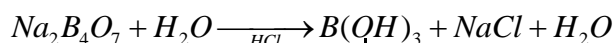
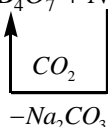




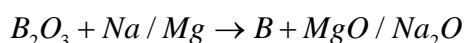
b) (i) B_2O_3 from $Ca_2B_6O_{11} \cdot 5H_2O$



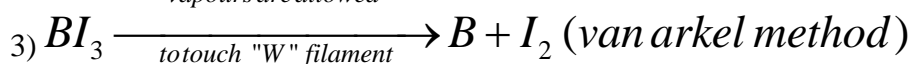
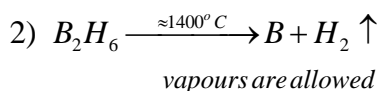
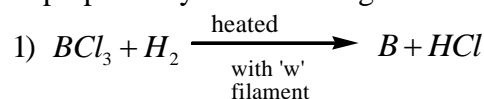
b) (ii) B_2O_3 from $Ca_2B_6O_{11} \cdot 5H_2O$



Step-2: Reduction of B_2O_3 to boron. Na / Mg can be used



Boron prepared by the above method is impure called Moissan boron small amount of crystalline boron can be prepared by the following methods:

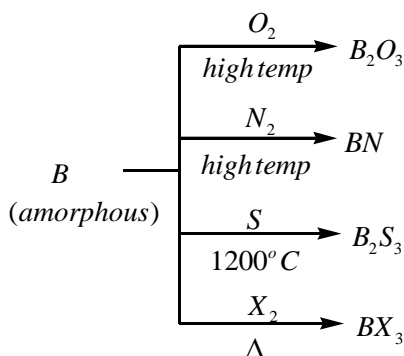


Properties of Boron:

- 1) Among the 13th group elements, only 'B' is polymorphic (allotropic modifications)
- 2) It has high M.P due to unusual crystal structure.

Reason: Boron exhibits 4 allotropic modifications due to its e^- deficient character. All the allotropic modifications contain icosahedral units. They differ in arrangement of these units. Among the modifications α -rhombohedral is thermodynamically more stable. In icosahedral units each 'B' is attached to 5 other 'B' atoms on 12 corners.

Chemical properties :



Uses of Boron:

- 1) Used in nuclear reactors as control rods.
- 2) Boron nitride (BN) threads are used in bullet proof cloth.

Comparison between 'B' and 'Al':-

Reagent	B	Al
Air	Crystalline boron is unreactive . $\begin{array}{c} B + O_2 \xrightarrow{\text{high temp}} B_2O_3 \\ \downarrow \\ \text{(amorphous)} \\ B + N_2 \xrightarrow{\text{high temp}} BN \end{array}$	Readily reacts with air and forms oxide layer $Al + O_2 \xrightarrow[\text{temp}]{\text{room}} Al_2O_3$ Prevents the metal to further react . $Al + N_2 \xrightarrow[\text{temp}]{\text{high}} AlN$
Water	No reaction with water at room temp only red hot boron can decompose water $B + H_2O \rightarrow B_2O_3 + H_2 \uparrow$	Stable towards water due to formation of oxide layer (Al_2O_3) however it liberates H_2 with steam after removal of oxide layer $Al + H_2O \rightarrow Al_2O_3 + H_2 \uparrow$ In industry purposefully Al_2O_3 layer is created by electrolysis of <i>dil.</i> H_2SO_4 using 'Al' sheet as anode The process is called anodising $H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$ $H_2O \rightleftharpoons H^+ + OH^-$ (-)cathode: $2H^+ + 2e^- \rightarrow H_2$ (+)anode: $OH^- \rightarrow 2H_2O + O_2 \uparrow$ <div style="text-align: center;"> \downarrow combines with Al sheet and forms uniform Al_2O_3 layer </div>
Reaction with acids (non-oxidising acids <i>HCl, dil.H₂SO₄, dil.HNO₃</i>)	Not attacked by non-oxidising acids like (<i>HCl, dil.H₂SO₄, dil.HNO₃</i>) Attacked by oxidising acids like <i>conc.HNO₃, conc.H₂SO₄</i> $B + HNO_3 \rightarrow H_3BO_3 + NO_2 + H_2O$ $B + H_2SO_4 \rightarrow H_3BO_3 + SO_2 + H_2O$ Boron dissolves only in fused <i>NaOH</i>	<i>conc.HNO₃</i> makes <i>Al</i> passive due to formation of Al_2O_3 protective layer. (also with <i>HClO₄, H₂CrO₄</i>). Dissolves both in <i>conc. & dil.HCl</i> $Al + \text{conc or dil } HCl \rightarrow AlCl_3 + H_2 \uparrow$ No reaction with cold <i>dil.H₂SO₄</i> , reacts with hot <i>conc H₂SO₄</i> $Al + \text{dil.H}_2\text{SO}_4 \xrightarrow{\Delta} H_2 + Al_2(SO_4)_3$ Dissolves in aq.soln of <i>NaOH</i>

Anomalous properties of Boron:

- 1) Boron always forms covalent compounds other elements can form ionic and covalent compounds.
- 2) Only Boron exhibits allotropy others cannot exhibit allotropy .
- 3) B_2O_3 is acidic . Ga_2O_3, Al_2O_3 -amphoteric.
- 4) Boron is not attacked by non-oxidising acids. Other elements are attacked.
- 5) Maximum coordination no. Of 'B' is 4. Other elements is 6
- 6) B^{+3} is not existing in aqueous solution , other can form their tripositive cations in aqueous solutions.