CHEMISTRY

CLASS NOTES FOR CBSE

Chapter 10. S-Block Elements

01. Physical Properties

(i) **Atomic Size**

Atomic Number	Atomic Radil	Element	Metalic Character
5	85 pm	B	Non-metal
13	143 pm	Al	Metal
31	135 pm	Ga	Metal
49	167 pm	In	Metal
81	170 pm	Tl	Metal

(ii) **Electronegativity**

Atoms	B	Al	Ga	In	Tl
Electronegativity	2	1.5	1.6	1.7	1.8

Due to poor shielding of 3*d* and 4*d* and lanthanoid contraction.

(iii) **Ionization Energy**

B > Tl > Ga > Al > In

(iv) **Oxidation States**

Stability of +3 oxidation state decreases down the group due to inert pair effect, as well stability of +1 oxidation state increases.

(v) **Melting Point**

B > Al > Tl > In > Ga

Ga has on unused structure. It congests if only Ga_2 molecules it has, thus low melting point.

(vi) **Boiling Point**

B > Al > Ga > In > Tl

NOTE ☞ *Indium in +1 oxidation state is reducing agent.*

(i) **Reactivity towards air**

B_2O_3 — Acidic Oxide
AlO_3 — Amphoteric Oxide
Ga_2O_3 — Amphoteric Oxide
In_2O_3 — Basic Oxide
Tl_2O_3 — Basic Oxide

$$4E(s) + 3O_2\ (g) \xrightarrow{\triangle} 2E_2O_3(s)$$

$2E(s) + N_2(g) \xrightarrow{\triangle} 2EN(s)$ (Where E = B, Al, Ga, In, Tl)

B_2O_3 is called boric anhydride as it is anhydride of boric acid

(ii) **Reactivity towards acids**

Boron is not affected by acids agents like HCl and dil. H_2SO_4 while all other elements react with conc. H_2SO_4 and HNO_3 Ga and Al develop protective layer of oxide with conc. HNO_3.

$2\ Al(s) + 6HCl(aq) \rightarrow 2Al^{3+}(aq)\ 6Cl^{-}(aq) + 3H_2(g)$

$2\ B(s) + 3H_2SO_4(aq) \rightarrow 2H_3BO_3 + 3SO_2(g)$

$B(s) + 3HNO_3(aq) \rightarrow 3H^{+}(aq) + BO_3^{-3}(aq) + 3NO_2(g)$

(iii) **Reactivity towards alkalies**

Except indium and thallium all other elements react with alkali solutions

$2M(s) + 2NaOH(aq) + 2H_2O \rightarrow 2NaMO_2(s) + 3H_2(g)$ (M = Al or Ga)

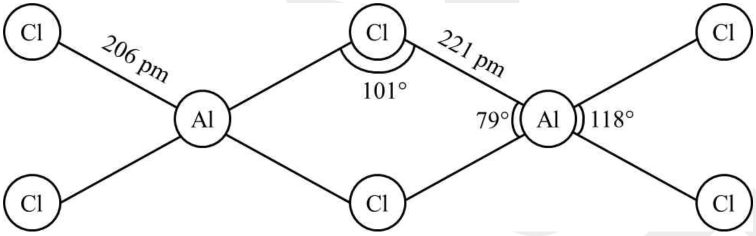
Example, Al also reacts with aq. Alkali and liberates dihydrogen.

$$2Al(s) + 2NaOH(aq) + 6H_2O(l) \rightarrow \underset{\text{Sodium terahydroxoaluminate (III)}}{2Na^{+}[Al(OH)_4]^{-}(aq)} + 3H_2(g)$$

(iv) **Reactivity towards halogens**

Trihalides are formed when these elements react with halogens. All these halides exist as discrets molecular species which are sp^2 hybridised and covalently bonded. TlI_3 is unstable.

$AlCl_3$ achieves stability by forming a dimer.



Acidic strength is inversely proportional to back-bonding, as back-bonding decreases from BF_3 to BI_3 as given below

$BF_3 > BCl_3 > BBr_3 > BI_3$

Hence, Lewis acidic strength will increase as under

$BF_3 > BCl_3 > BBr_3 > BI_3$

$p\pi$-$p\pi$ back-bonding is strongest in BF_3 because both B and F involve $2p$ orbital in back-bonding. Stability of halides in +3 oxidation state decreases down the group.

Anomalous Behaviour of Boron

(i) Boron has very small atomic radii, hence greater nuclear attraction on the outermost electrons. it has very high ionisation energy. This gives boron distinctly non-metallic character while the rest are metals.

(ii) Boron has maximum covalency of four due to non-availability of *d*-orbitals while the rest have maximum covalency of six.

(iii) Boron alone exhibits allotropy.

(iv) Boron shows +3 oxidation state while other can show +1 and +3 oxidation states.

Comparison of Boron and Aluminium

(i) Same Electronic Configuration

(ii) Same Valency

(iii) Same Oxidation State

(iv) **Action of alkalies**

$$2B + 6NaOH \longrightarrow \underset{\text{Sodium borate}}{2Na_3BO_3} + 3H_2$$

$$2Al + 2NaOH + 2H_2O \longrightarrow \underset{\substack{\text{Sodium meta}\\\text{aluminate}}}{2NaAlO_2} + 3H_2$$

(v) **Formation of oxides**

$$4B + 3O_2 \xrightarrow{700°C} 2B_2O_3 \text{ (Boron oxide or alumina)}$$

$$4Al + 3O_2 \xrightarrow{800°C} 2Al_2O_3 \text{ (Alumina oxide or alumina)}$$

Dissimilarities between Boron and Aluminium

Boron and aluminium show dismilarities in properties due to difference in their electronic configuration, size and ionisation potential. Main points of difference are given in the table.

Boron	Aluminium
(i) Boron is a non-metal	Aluminium is a metal.
(ii) It is a bad conductor of heat and electricity.	It is a good conductor of heat and electricity.
(iii) It has high melting point (m.pt. 2300°C).	It has lowe melting point (m. pt. 660°C).
(iv) Boron shows allotropy. The allotropic forms are crystalline boron and amorphous boron.	Aluminium does not show allotropy.
(v) Borates are very stable.	Aluminates are less stable.

Diagonal Relationship of Boron and Silicon

(i) Both boron and silicon are non-metals. Both have high melting points [B = 2300°C; Si = 1410°C], high ionisation energies (B = 8.3 eV, Si = 8.20 eV) and are bad conductors of electricity at normal temperature. However, the conductance improves as the temperature increases. Hence, both are semiconductors.

(ii) Both have nearly equal densities, electronegativities [Density B = 3.30 g mL^{-1}; Si = 3.52 g mL^{-1}; Electronegativity B = 2.0; Al = 1.8]

(iii) Both boron and silicon show allotropy.

(iv) Both Boron and silicon do not form cations as their ionisation energy is very high.

(v) Most of the compounds of boron and silicon are covalent.

(vi) Halides of boron and silicon are hydrolysed.

$$BCl_3 + 3H_2O \rightarrow H_3BO_3 + 3HCl$$

$$SiCl_4 + 4H_2O \rightarrow H_4SiO_4 + 4HCl$$

(vii) Both react with fused alkalies and evolves hydrogen.

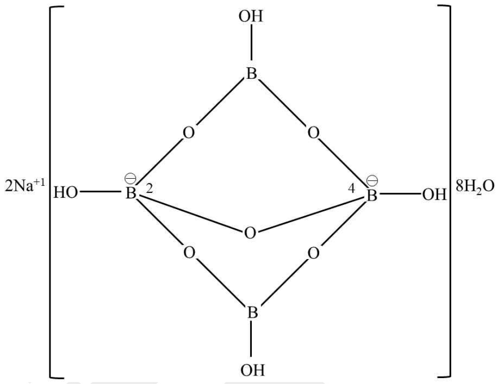
$$2B + 6NaOH \rightarrow 2Na_3BO_3 + 3H_2\uparrow$$

$$Si + 2NaOH + H_2O \rightarrow Na_2SiO_3 + 3H_2\uparrow$$

Some Important Compounds of Boron

(viii) **Borax**

$Na_2B_4O_710\ H_2O$ / $Na_2\ [B_4O_5\ (OH)_4]\ 8\ H_2O$



Number of B in sp^3 hybridisation = 2 (1, 3)

Number o B in sp^3 hybridisation = 2 (2,4)

Oxidation state of all boron present = +3 state

n-factor = 2

Number of B—O—B bonds = 5

Number of B—O bonds = 14

Number of bridging oxygen between two boron = 5

Number of bridging oxygen between two boron = 5

It furnishes two OH^- from 2nd and 4th, then octet of B cannot be completed. After cleavage it will be highly unstable structure.

On heating borax first looses water molecuels and swells up and gives sodium metaborate which on further heating turns into a transparent liquid whichsolidifies into glassy bead.

$$Na_2B_4O_7.10H_2O \xrightarrow[\text{loop}]{\text{Pt}} \underset{\text{Anhydrous borax}}{Na_2B_4O_7} + 10H_2O \quad \underbrace{NaBO_2 + B_2O_3}_{\text{Glassy bead}}$$

$$\Delta$$

This glassy bead reacts with CuO or CoO to give blue bead and reacts with TiO to give yellow bead.

$$\text{Glassy bead} + CuO \longrightarrow \underset{\text{Blue bead}}{Cu(BO_2)_2}$$

$$\text{Glassy bead} + CoO \longrightarrow \underset{\text{Blue bead}}{Cu(BO_2)_2}$$

$$\text{Glassy bead} + TiO \longrightarrow \underset{\text{Yellow bead}}{Cu(BO_2)_2}$$