Chemistry Study Materials for Class 11

(NCERT Quick Revision Notes of Chapter- 11)

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The p- Block Element

These are elements in which the last electron enters in the outer most p-sub shell. They include elements of groups 13 to 18. Their general outer electronic configuration is ns^2np^{1-6} (except for He). They include metals, non-metals and metalloids.

Their maximum oxidation state = the total no. of valence electrons (i.e., the sum of the s- and p- electrons). But their common oxidation state may differ from the maximum oxidation state or group oxidation state. Generally, in the p-block elements, down the group, the common oxidation state is 2 less than the maximum oxidation state. This is due to the **inert pair effect.** *It is the reluctance of s-electrons to participate in chemical bonding.* It is commonly seen in the elements of groups 13, 14 & 15. [Down the group, due to the poor shielding effect of inner d and f orbitals, the effective nuclear charge is greater, which holds the s-electrons tightly. So they cannot participate in bonding].

Due to the above reason, TlCl is more stable than $TlCl_3$. Similarly lead mainly form $PbCl_2$ than $PbCl_4$.

Or, Tl^+ is stabler than Tl^{3+} and Pb^{2+} is stabler than Pb^{4+}).

Group 13 Elements (Boron Family)

Group 13 include Boron (B(, Aluminium (Al), Gallium (Ga), Indium (In), Thalium (Tl) and Nihonium (Nh). Among these elements, Boron is a typical non-metal and the other elements are metals.

Atomic radii: Down the group, atomic radius increases. But atomic radius of gallium is less than that of aluminium. This is due to the presence of completely filled d-orbitals in Ga (Ga - [Ar] $3d^{10}\,4s^2\,4p^1$). The presence of 10 d-electrons offer only poor shielding effect for the outer electrons, from the increased nuclear charge.

Ionisation Enthalpy: The ionisation enthalpy values do not decrease smoothly down the group. This is due to the poor shielding effect of the completely filled inner d and f electrons.

Oxidation state: The common oxidation state of 13th group elements is +3. Due to high ionisation enthalpy, boron does not form +3 ions and it only forms covalent compounds. The stability of +3 oxidation state decreases and that of +1 oxidation state increases down the group. This is due to inert pair effect.

The trivalent compounds formed by 13th group elements are called electron deficient compounds. In these compounds, the number of electrons around the central atom of the molecule is only 6. In order to attain stable octet configuration, they accept a pair of electrons and so they behave as Lewis acids. e.g. BF_3, BCl_3, $AlCl_3$, B_2H_6 etc.

Chemical properties

Reactivity towards air: Boron is unreactive in crystalline form. Due to the presence of an oxide layer on the surface, Al does not react with air at normal temperature. But at high temperatures, they form oxide and nitride.

$$2E + 3O_2 \longrightarrow 2\,E_2O_3$$

$$2E + N_2 \longrightarrow 2\,EN \quad [E = \text{Any } 13^{th} \text{ group element}]$$

The oxide of boron (B_2O_3) is acidic, the oxides of Aluminium and Gallium are amphoteric and that of Indium and Thalium are basic.

Reactivity towards acids and alkalies: Boron does not react with acids and alkalies even at moderate temperatures. But aluminium dissolves in mineral acids and aqueous alkalies and thus shows amphoteric nature.

$$2Al(s) + 6\,HCl(aq) \longrightarrow 2\,AlCl_3(aq) + 3H_2(g)$$

$$2Al(s) + 2NaOH(aq) + 6H_2O(l) \longrightarrow 2Na[Al(OH)_4](aq) + 3H_2(g)$$

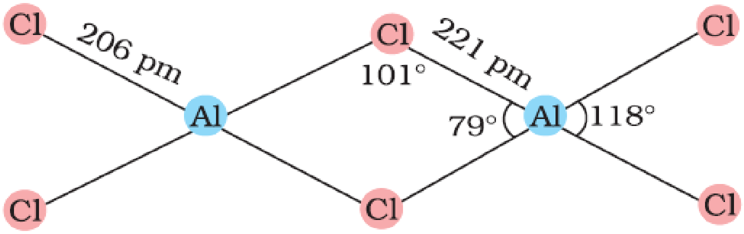
But it does not react with nitric acid due to the presence of the oxide layer on the surface.

Reactivity towards halogens: They react with halogens and form trihalides.

$$2E(s) + 3X_2(g) \longrightarrow 2EX_3(s)$$

$$2Al(s) + 3Cl_2(g) \longrightarrow 2AlCl_3(s)$$

$AlCl_3$ exists as dimer to attain stability.



Anhydrous aluminium chloride is partially hydrolysed with moisture to liberate fumes of HCl gas. So white fumes appears around the bottle of anhydrous $AlCl_3$

Some important compounds of Boron

1. **Borax [$Na_2B_4O_7.10H_2O$]:** It is a white crystalline solid with formula $Na_2B_4O_7$, $10H_2O$ (Sodium tetra borate decahydrate). It contains the tetra nuclear units $[B_4O_5(OH)_4]^{2-}$ and hence its correct formula is $Na_2[B_4O_5(OH)_4].8H_2O$.

It dissolves in water to give NaOH and Orthoboric acid. Since NaOH is a strong alkali and Orthoboric acid is weak acid, the solution is basic in nature.

$$Na_2B_4O_7 + 7H_2O \rightarrow 2NaOH + 4H_3BO_3$$

(Orthoboric acid)

On heating, borax first loses water molecules and swells up. On further heating it turns into a transparent liquid, which solidifies into glass like material known as *borax bead*.

$$Na_2B_4O_7.10H_2O \xrightarrow{\Delta} Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$$

(Sodium metaborate) (Boric anhydride)

The metaborate of many transition metals have characteristic colours and, therefore, ***borax bead test*** can be used to identify them in the laboratory.

2. **Ortho boric acid [H_3BO_3 or $B(OH)_3$]:** It is a white crystalline solid with soapy touch. It is prepared by acidifying an aqueous solution of borax.

$$Na_2B_4O_7 + 2HCl + 5H_2O \rightarrow 2NaCl + 4H_3BO_3$$

It is also obtained by the hydrolysis of boron halides or hydrides.

It is a weak monobasic non-protic acid. It acts as a Lewis acid by accepting electrons from a hydroxyl ion.

$$B(OH)_3 + 2H_2O \rightarrow [B(OH)_4]^- + H_3O^+$$

On heating above 370K, it forms metaboric acid (HBO_2) which on further heating gives boric oxide (B_2O_3).

$$H_3BO_3 \xrightarrow[\Delta]{} HBO_2 \xrightarrow[\Delta]{} B_2O_3$$

3. **Diborane (B_2H_6):** The simplest boron hydride is borane (BH_3), which exists as a dimer called Diborane (B_2H_6). It is prepared by treating BF_3 with Lithium aluminium hydride ($LiAlH_4$) in ether.

$$4BF_3 + 3\ LiAlH_4 \rightarrow 2B_2H_6 + 3LiF + 3AlF_3$$

In the laboratory, it is prepared by the oxidation of sodium borohydride with iodine.

$$2NaBH_4 + I_2 \rightarrow B_2H_6 + 2NaI + H_2$$

Diborane is prepared industrially by the reaction of BF_3 with sodium hydride.

$$2BF_3 + 6NaH \xrightarrow{450K} 2B_2H_6 + 6NaF$$

Diborane is a colourless, highly toxic gas. It catches fire spontaneously on exposure to air. It burns in oxygen to form B_2O_3 and evolve large amount of heat.

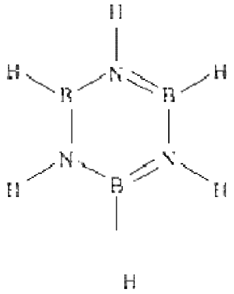
$$B_2H_6 + 3O_2 \rightarrow B_2O_3 + 3H_2O: \Delta H = -1976\ kJ/mol$$

It readily hydrolysed by water to give boric acid.

$$B_2H_6(g) + 6H_2O(l) \longrightarrow B(OH)_3(aq) + 6H_2(g)$$

Diborane react with ammonia to form $B_2H_6.2NH_3$ which on further heating gives ***Borazine ($B_3N_3H_6$) which is commonly known as inorganic benzene.*** Its structure is similar to benzene with alternate BH and NH groups.

$$3B_2H_6 + 6NH_3 \rightarrow 3\ B_2H_6.2NH_3 \rightarrow 2\ B_3N_3H_6 + 12H_2$$



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