The p-Block Elements

1. **Group 13 Elements: The Boron Family**
2. **Some Important Compounds of Boron**
3. **Uses of Boron and Aluminium and their Compounds**
4. **Group 14 Elements: The Carbon Family**
5. **Some Important Compounds of Carbon and Silicon**
6. **Uses of Compounds of Carbon and Silicon**

Elements in which the last electron enters in to any one of the three p-orbitals of their outermost shells are called p-block elements.

p-Block of the periodic table is unique in terms of having all types of elements – metals, non-metals and metalloids. There are six groups of p-block elements in the periodic table numbering from 13 to 18.

Their valence shell electronic configuration is ns2 np1–6(except for He). Differences in the inner core of their electronic configuration greatly influence their physical and chemical properties. As a consequence of this, a lot of variation in properties among these elements is observed.

In addition to the group oxidation state, these elements show other oxidation states differing from the total number of valence electrons by unit of two.

While the group oxidation state is the most stable for the lighter elements of the group, lower oxidation states become progressively more stable for the heavier elements. The combined effect of size and availability of d orbitals considerably influences the ability of these elements to form π-bonds.

While the lighter elements form $p\pi - p\pi$ bonds, the heavier ones form $d\pi - p\pi$ or $d\pi$ $d\pi$ bonds. Absence of d orbital in second period elements limits their maximum covalence to 4 while heavier ones can exceed this limit.

Group 13 Elements: The Boron Family

- Members of this group are: boron (B), aluminum (Al), gallium (Ga), indium (In) & thallium (Tl).
- Boron is a typical non-metal and the other members are metals.
- There is availability of 3 valence electrons $\left(2s^2\, 2p^1\right)$ for covalent bond formation using four orbitals $\left(2s,\, 2p_x, 2p_y\; 2p_2\right)$ leads to the so called **electron deficiency** in boron compounds. This electron deficiency makes them good electron acceptor and thus boron compounds behave as **Lewis acids.**
- Boron forms covalent molecular compounds with dihydrogen as boranes, the simplest of which is **diborane**, B^2H^6.
- Diborane contains two bridging hydrogen atoms between two boron atoms; these bridge bonds are considered to be **three-centre two-electron bonds**.

The important compounds of boron with dioxygen are boric acid and borax.

- Boric acid, $B(OH)_3$ is a weak monobasic acid; it acts as a Lewis acid by accepting electrons from hydroxyl ion.
- Borax is a white crystalline solid of formula $Na_2\left[B_4O_5(OH)_4\right] \cdot 8H_2O$. The borax bead test gives characteristic colours of transition metals.

Aluminium exhibits +3 oxidation state. Aluminium oxide is amphoteric. Aluminium halides, e.g., AlCl3 is dimer, acts as Lewis acid.

Atomic and ionic radii

- The elements of this group have smaller size than the corresponding elements of second group.
- On moving down the group, atomic and ionic radii increases due to the addition of new shells

Ionization energies

- The first ionization energies of group 13 elements are less than the corresponding members of the alkaline earths.
- The sharp decrease in ionization energies from B to Al is due to increase in size.

Electropositive or metallic character

- The elements of group 13 are less electropositive as compared to elements belonging to group 2.
- On moving down the group the electropositive (metallic) character increases because ionization energy decreases. For e.g., Boron is a non-metal, all other elements are typical metals.

Oxidation States:

With heavier elements, +1 oxidation state gets progressively stabilised on going down the group. This is a consequence of the so called inert pair effect.

Group 14 Elements: The Carbon Family

Carbon is a typical non-metal forming covalent bonds employing all its four valence electrons $\left(2s^2 2p^2\right)$. It shows the property of catenation, the ability to form chains or rings, not only with C–C single bonds but also with multiple bonds (C=C or C≡C).

The tendency to catenation decreases as C>>Si>Ge ~ Sn >Pb. Carbon provides one of the best examples of allotropy. Three important allotropes of carbon are diamond, graphite and fullerenes.

- Diamond: In diamond each carbon atom undergoes sp hybridisation. Each carbon atom is tetrahedrally linked to four other carbon atoms.
- Graphite: carbon is sp2-hybridized. It has two dimensional sheet like structure having number of hexagonal rings fused together. Graphite conducts electricity along the sheet.
- Fullerenes: is a form of carbon having a large spheroidal molecule made of a hollow cage of sixty or more atoms. Fullerenes are produced chiefly by the action of an arc discharge between carbon electrodes inside inert atmosphere.

The members of the carbon family mainly exhibit +4 and +2 oxidation states; compounds in +4 oxidation states are generally covalent in nature. The tendency to show +2 oxidation state increases among heavier elements. Lead in +2 state is stable whereas in +4 oxidation state it is a strong oxidising agent. Carbon also exhibits negative oxidation states.

It forms two important oxides: CO and CO_2. Carbon monoxide is neutral whereas CO_2 is acidic in nature. Carbon monoxide having lone pair of electrons on C forms metal carbonyls. It is deadly poisonous due to higher stability of its haemoglobin complex as compared to that of oxyhaemoglobin complex. Carbon dioxide as such is not toxic. However, increased content of CO_2 in atmosphere due to combustion of fossil fuels and decomposition of limestone is feared to cause increase in 'green house effect'. This, in turn, raises the temperature of the atmosphere and causes serious complications such as melting of glaciers.

Silica, silicates and silicones are important class of compounds and find applications in industry and technology.

Silicon dioxide has covalent three dimensional network. Each silicon atom is covalently bonded in a tetrahedral form to four oxygen atoms.

Silicones: Silicones are the synthetic organo-silicon polymers.

Silicates: are exist in nature in the form of zeolites, mica and asbestos, etc.