p-block elements

- Elements in which the last electron enters in the “p” orbital are called p-block elements.
- In a p-sub shell, there are 3 orbitals that can accommodate 6 electrons, so it includes columns 13-18.
- ns^2np^{1-6} is the general electronic configuration of the elements on the p-block.
- The difference in the inner core greatly affects the physical and chemical properties.
- Oxidation state increases from left to right on the periodic table (due to the number of valence electrons)
- Inert pair effect is the effect when an element shows oxidation state at 2 units less than the group oxidation state. This tendency increases from top to bottom.
- Metallic character increases from top to bottom and decreases from left to right of the periodic group.
- The first member of the group differs from the other members due to the following reasons:
    - Abnormally small size
    - High electro-negativity
    - Absence of nd subshell
- 2^{nd} period elements of the block has a maximum covalency of 4. The 3^{rd} period has a 3d sub-shell, ie, the electrons from 3s and 3p can be excited to 3d sub-shell. So they show higher oxidation states also. 2^{nd} period elements due to their small size have a tendency to form $p\pi - p\pi$ bonds (multiple bonds).

Group-13 elements: (the boron family)

- Boron, Aluminium, Gallium, Indium, Thallium constitute the group.
- Boron is a non-metal, while the rest are all metals.
- Occurrence:
    - boron can be found as orthoboric acid, borax, kernite and has 2 isotopes $B^{10}\ (19\%) and\ B^{11}(81\%)$.
    - Aluminium being the most abundant metal in earth crust. The main ores are

        (i) Bauxite and
        (ii) Cryolite

    - Gallium indium and thallium are less abundant.

- They have ns^2np^1 electronic configuration in outermost shell.
- Atomic radii: atomic/ionic radii are smaller than those of corresponding to earth metals. The radii increase from top to bottom due to the addition of one shell in each successive period. Atomic radius of gallium is less than that of aluminium due to poor shielding effect of 'd' electrons.
- Ionisation enthalpy: the 1st IE of the 13th column element is less than the 1st IE of alkaline earth metal of the same period.
    - IE reduces from Boron to Aluminium due to the increase in size
    - IE increases between Aluminium and Gallium and also between Indium and Thallium due to the low screening effect.

- Electronegativity: decreases from Boron to Aluminium and then increases marginally.

Physical properties:

- Boron
  - Non metallic
  - Very hard
  - Black coloured solid
  - Strong crystalline lattice with very high melting point
- The rest are all soft metals with low melting point and high electrical conductivity.
- The density increases from boron to gallium.

Oxidation state:

- Boron due to its abnormally small size forms covalent compounds instead of ionic compounds.
- Aluminium forms ions and is a strong electro positive element.
- The tendency to show +1 oxidation state increases from Ga to Tl.

Reactivity with air:

- Boron is unreactive in air in its crystalline form, while amorphous boron on heating in air gives B2O3.

- Aluminium forms a thin layer of oxide on the surface that protects it from further oxidation.

$$4M + 3O_2 \longrightarrow 2M_2O_3$$

- When heated with nitrogen they give raise to nitrides.

$$3M + N_2 \longrightarrow M_3N_2$$

Nature of oxides:

- Oxide of boron is acidic in nature
- Aluminium and gallium oxides are amphoteric and
- Indium and thallium oxides are basic in nature.

Reactions with acid:

- Boron doesn't react with acids, while aluminium reacts to give salts and hydrogen.

- In concentrated nitric acid, aluminium becomes passive due to the formation of a protective oxide layer on the surface.

Reaction with alkalies:

- Boron doesn't react with aqueous alkali.
- Aluminium reacts with aqueous alkali to liberate hydrogen gas.

Reaction with halogens:

- Reacts with halogens to give trihalides.

Anomalous behaviour of BORON:

- It's a non-metal, while the other members are metals.
- Shows maximum covalency of 4, while others show a maximum covalency of 6.
- Only boron shows allotropy.
- Doesn't react to form cation in aqueous solution.
- Halides of boron are monomeric, halides of other members of the group are dimeric.
- Boron does not react with water or steam while other members react.
- Oxide of boron is acidic in nature.
- Boron is not attacked by non oxidising acids.
- Boron dissolves in nitiric acid, while the other members are all passive.

Important compounds of boron:

- Borax
- Orthoboric acid
- Diborane
- Borohydrides
- Boron trihalides.

The readers are requested to learn about the compounds of boron.

14^{th} column elements-carbon family:

- Covalent radii:
  - smaller than 13^{th} group due to increase in nuclear charge.
  - Atomic radii increases from C to Pb due to addition of shells.
  - Threes a substantial increase from C to Si, then there's small increase from Si to Pb due to poor shielding effect.
- Electronegativity:

- Greater than group 13
- The value is the same from Si to Pb.

- Physical properties:
  - All members are solids
  - Carbon and Silicon are non-metals
  - Germanium is a metalloid
  - Tin and lead are soft metals
- Chemical properties:
  - Oxidation state: +4 and +2 oxidation stateis shown by lower members due to non availability of ns electrons for bonding due to inert pair effect.
  - Compounds in the +4 oxidation state are covalent.
  - Tendency to show +2 oxidation state increases from Ge to Pb

  ➢ Reaction with oxygen:

    ✓ All members form oxides and dioxides.
    ✓ SiO exists at high temperature.
    ✓ Acidic nature of oxides decreases from top to bottom.

- Reactivity with water:

  - ✓ Carbon, silicon and germanium are not affected by water.
  - ✓ Tin reacts with steam
  - ✓ Lead is unaffected due to the formation of a protective oxide layer.

- Reaction with halogens:
  - ✓ Except carbon all other members react readily with halogens.
  - ✓ Most of halides in +4 oxidation states are covalent and the molecules have a tetrahedron shape.
  - ✓ Stability of dihalides increases from Ge to Pb.

Anomalous behaviour of CARBON:

- Carbon can show a maximum covalency of 4, other members can expand their covalence due to presence of their nd sub-shell.
- Due to small size and high electronegativity carbon has an ability to form $p\pi - p\pi$ bonds with itself and other atoms of small size.
- Carbon has highest tendency for catenation due to
  - Small
  - Strong C-C bond
  - Tendency of 'C' to show sp, sp^2,sp^3 hybridization.
  - Tendency to form $p\pi - p\pi$ bonds

- Carbon shows allotropic forms

ALLOTROPES OF CARBON:

- Diamond
- Graphite
- Fullerenes
- Carbon black
- Charcoal and coke