p – Block Elements

Boron Family

1. B, Al Ga, In and Ti

2. Non–metallic nature of 'B' due to its small size and high ionisation energy.

3. Valence shell electronic configuration : ns^2np^1

Physical properties

(1) Melting points do not vary regularly and decrease from *B* to *Ga* and then increase.

(2) Boron has very high melting point because it exist as giant covalent polymer in both solid and liquid state.

(3) A regular increasing trend in density down the group is due to increase in size

(i). Ionization energy: IE_1 is less than that of group–II elements. IE_2 and IE_3 are very high. Down the group, IE decreases : The differences is small due to poor screening effect of intervening d–orbitals. IE of Ga is greater than that of Al.

(ii). Oxidation state: +3

B forms covalent compounds, e.g. BCl_3 in which the oxidation state is +3.

Due to inert pair effect, except 'B', others exhibit +1 oxidation state.

Chemical properties

i. Al shows both ionic and covalent behaviour, e.g.

$AlCl_3$ covalent, $[Al(H_2O)_6]^{3+}$ ionic.

ii. $4B + 3O_2 \longrightarrow 2B_2O_3$

iii. Hydroxide: $B(OH)_3 + H_2O \longrightarrow [B(OH)_4]^- + H^+$

iv. Halides : $2B + 3X_2 \longrightarrow 2BX_3$

vi. Formation of hydrides.

Boron forms two series of covalent hydrides: Boranes

B_nH_{n+4} and B_nH_{n+6}

Diborane, B_2H_6: $2BF_3 + 6LiH \xrightarrow{450K} B_2H_6 + 6LiF$

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

Carbon Family

1. C, Si, Ge, Sn, Pb. ns^2np^2

2. Physical properties:

i. Oxidation state : +4

ii. Catenation : C >> Si >> Ge ≈ Sn > Pb

3. Chemical properties

(i). Monoxides : (CO) – neutral

Structure of :C≡O: :

(CO_2, SiO_2) – acidic

(GeO_2, SnO_2) – amphoteric

(PbO_2) – basic

(ii). X_2 : $MX_4, PbBr_4$ and PbI_4 are not known.

Order of hydrolysis.

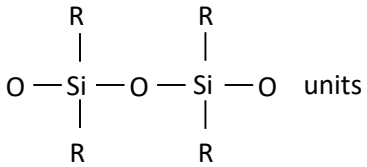
$$CCl_4 > SiCl_4 > GeCl_4 > SnCl_4 > PbCl_4$$

(iii). H_2 : MH_4

Thermal stability

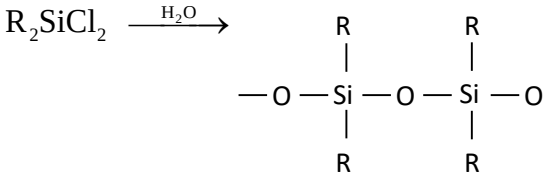
$$CH_4 > SiH_4 > GeH_4 > SnH_4 > PbH_4$$

4. Silicones : Organosilicon polymers containing



units

$$2\,RCl + Si \longrightarrow R_2SiCl_2$$



Uses : Water proof textiles, glass wares, lubricants, paints and varnishes, insulating materials.

Nitrogen Family

1. N, P, As Sb, Bi

Density : The density of these elements increases down the group

Melting point and boiling points

The melting point and boiling point of this group members decrease down the group.

Atomic radii and atomic volume

Both atomic radii and atomic volume increases gradually on moving down the group

Non-metallic nature : The non-metallic nature decreases along the group.

Electronegativity : The electronegativity decreases down the group.

Ionisation energy :The ionisation energy decreases regularly down the group;

2. Chemical properties

i. N_2 is inert and stable due to N ≡ N and non–availability of d–orbitals.

ii. Nitrogen is diatomic while, P, As and Sb form tetrahedral (P_4) molecules in their elemental state.

iii. Nitrogen forms multiples bonds $(p_\pi - p_\pi)$ with C, O.

iv. Oxides: Oxides of N and P are strongly acidic.

Oxides of As are weakly acidic.

Oxides of Sb are amphoteric.

Oxides of Bi are basic.

vi. Hydrides : MH_3

Down the group, covalent character, basicity and thermal stability decrease while reducing character increases.

$NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$

vii. Halides : MX_3 and MX_5

$$NCl_3 + 3H_2O \longrightarrow NH_3 + 3HOCl$$

Oxygen Family

1. O, S, Se, Te, Po

2. ns^2np^4

3. Physical properties

i. Atomic and ionic radii : Down the group : increases

ii. Ionisation energy: Down the group : decreases

iii. Electropositive or metallic character.

Down the group : metallic character increases

iv. Electronegativity : decrease down the group

v. Oxidation state: –2 for oxygen atom

S, Se and Te: +2, +4, +6

4. Chemical properties

i. Oxides: MO, MO_2, MO_3

ii. Hydrides : H_2O, H_2S, H_2Se, H_2Po

iii. Halides: OF_2, ClO_2, I_2O_5

$S + 3F_2 \longrightarrow SF_6$ sp^3d^2 octahedral

$2SCl_2 + 4NaF \longrightarrow SF_4 + 4NaCl + S$

$SF_4 + 2H_2O \longrightarrow SO_2 + 4HF$

Halogen Family

1. F, Cl, Br, I, At. ns^2np^5

2. Physical properties

i. Atomic radii : Small radii in their respective period, as they have maximum effective nuclear charge.

ii. Ionisation energy highest in the respective period till 17^{th} group. Down the group IE decreases.

iii. Electron affinity : Highest in the respective period. Chlorine has higher electron affinity than F. F has small size and inter−electron repulsion of the 2p electrons become very strong and the forth coming electron will experience much repulsion.

iv. Oxidising power : $F_2 > Cl_2 > Br_2 > I_2$

v. Oxidation state

F – 1 does not show positive oxidation state.

Others +1, +3, +5 and +7.

Chemical properties

i. Oxides:

$OF_2(-1)$ $Cl_2(0)$ $Br_2O(+1)$

$O_2F_2(-1)$ $Cl_2O_3(+3)$ $BrO_2(+4)$

$BrO_3(+6)$ I_2O_4

$Cl_2O_7(+7)$

ii. Oxyacids

a. Hypophalous acid, HOX

b. Halous acid, HXO_2

c. Halic acid, HXO_3

Acid strength:

$HClO_4 > HClO_3 > HClO_2 > HOCl$

iii. Interhalogen compounds.

	AX_3	AX_5	AX_7
AX			
CIF, BrF, IBr, ICI	ICl_3, ClF_3, BrF_3	ClF_5, BrF_5	IF_7

Linear	T–shaped	Square pyramidal	Pentagonal bipyramidal

Inter halogen compounds are more reactive than halogens due to the difference in electronegativities.

$KI + I_2 \longrightarrow K^+ + I_3^-$ (Linear)

Noble Gases

1. He, Be, Ar, Kr, Xe, Rn

2. ns^2np^6

5. Physical properties:

i. Atomic radii: Down the group : increases

ii. Ionisation energies: Down the group : decreases

iii. Electron affinity : zero

iv. Melting and boiling point : Down the group: increase due to increase in van der Wall's forces.

6. Chemical properties

i. $Xe + PtF_6 \longrightarrow [X^-][PtF_6^-]$

orange yellow

ii. Xenon oxides

$$6\,XeF_4 + 12\,H_2O \longrightarrow 4\,Xe + 2\,XeO_3 + 24\,HF + 3\,O_2$$

$$XeF_6 + 3\,H_2O \longrightarrow XeO_3 + 6\,HF$$

iii. Xenon oxyfluorides

$$XeF_4 + H_2O \longrightarrow XeOF_2 + 2\,HF$$

$$XeF_6 + H_2O \longrightarrow XeOF_4 + 2\,HF$$