BORON FAMILY

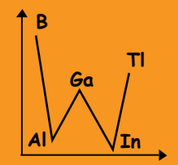
Non-metal ← 5 B — Most abundant metal, Third most element in earth crust (O > Si > Al > Fe)

Metal ←
- 13 Al
- 31 Ga — exists as Ga_2 molecules & thus low M.P (29.67° C) -liquid up to 2000° C. Used in high T thermometer
- 49 In
- 81 Tl
- 113 Nh — Radioactive

PHYSICAL PROPERTIES

Atomic radii
B < Ga < Al < In < Tl

Ionisation enthalpy
B > Tl > Ga > Al > In



Electronegativity
B > Tl > In > Ga > Al

- Ionic radii Decreases down the group
- Density Increases Down the group
- M.p decreases from B to Ga and then increases
  B > Al > Tl > In > Ga
- B.p Decreases down the group

CHEMICAL PROPERTIES

Reducing power Al>Ga>In>Tl

Stability order of O.S:

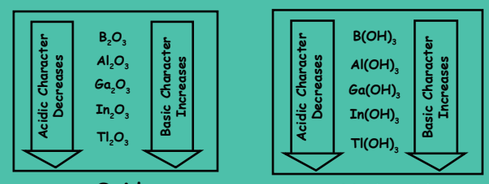
$Tl^{+1} > In^{+1} > Ga^{+1} > Al^{+1} > B^{+1}$ (Inert pair effect)

$B^{+3} > Al^{+3} > Ga^{+3} > In^{+3} > Tl^{+3}$

Tl^{+3} = Strong oxidant, Ga^{+1} = Strong reductant

Maximum covalency of B is 4 (absence of valence d orbitals)

Halides -Lewis acids (BF_3 < BCl_3 < BBr_3)

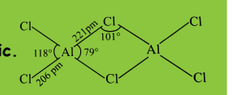


Oxides — Hydroxides

COMPOUNDS OF Al

$AlCl_3$

- $Al_2O_3 + 3C + 3Cl_2 \xrightarrow{heat} 2AlCl_3 + 3CO$
- Aqueous solution is acidic due to the formation of HCl.
  $AlCl_3 + 3H_2O \rightarrow Al(OH)_3 + 3HCl$
- Anhyd. $AlCl_3$ is covalent & dimeric.



Alum

M_2SO_4 $M^{III}_2(SO_4)_3$ $24H_2O$

M – Monovalent metal M^{III} – Trivalent metal

Examples:

Potash alum $K_2SO_4.Al_2(SO_4)_3.24H_2O$

Chrome alum $K_2SO_4.Cr_2(SO_4)_3.24H_2O$

Ferric alum $(NH_4)_2.SO_4\ Fe_2\ (SO_4)_3.24H_2O$

Each cation is surrounded by 6 H_2O

BORIC ACID

- Weak monobasic acid (Lewis acid)
  $H_3BO_3 + H_2O \rightarrow [B(OH)_4]^- + H^+$
- Heating effect:

$$H_3BO_3 \xrightarrow{273K} HBO_2 \xrightarrow{433K} H_2B_4O_7 \xrightarrow[hot]{red} B_2O_3$$

Metaboricacid — Tetraboric acid — Boron trioxide (Boric anhydride)

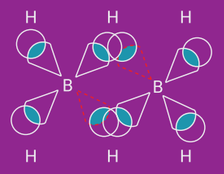
- Forms 6 H-bonds in aqueous solution.

DIBORANE

- Highly reactive: it catches fire
  $B_2H_6 + 3O_2 \rightarrow B_2O_3 + 3H_2O$, ΔH = -ve
- With water : $B_2H_6(g) + 6H_2O(l) \rightarrow 2B(OH)_3(aq) + 6H_2(g)$
- Reaction with ammonia :

$$B_2H_6 + 2NH_3 \xrightarrow[Excess\ NH3]{Low\ temp\ (-120°C)} [BH_2(NH_3)_2](BH_4) \xrightarrow{Heat} 2B_3N_3H_6 + 12H_2$$

Borazine or borazole (inorganic benzene)



two 3c-2e banana bond
four 2c-2e Terminal bonds

BORAX / TINCAL

$Na_2B_4O_7.10H_2O$ / $Na_2[B_4O_5(OH)_4].8H_2O$

- Aqueous solution of borax is alkaline in nature

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

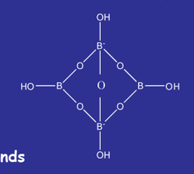
- Borax bead test (Detection of transition metal)

$$Na_2B_4O_7.10H_2O \xrightarrow{\Delta} Na_2B_4O_7 \xrightarrow{740°C} \underset{\text{Sodium Metaborate}}{2NaBO_2} + \underset{\text{Boric anhydride}}{B_2O_3}$$

Glassy mass (Borax bead)

T.M	Colour
Cu/Co	Blue

Uses : As flux
Water softening agent
As antiseptic
In making enamel
Manufactur of glass



- There are 5 B-O-B bridge bonds

P-BLOCK ELEMENTS

COMPOUNDS OF SILICON

SILICA

- SiO_2-sand, quartz (piezoelectric)
- Insoluble in H_2O & inert at room temp.
- Reacts with HF (etching of glass)
  $HF + SiO_2 \rightarrow SiF_4$
  $SiF_2 + 2HF \rightarrow H_4SiF_4$
- 3D Network Covalent Solid

SILICONES

- general formula $(R_2SiO)_n$
- $R_2SiCl_2 + H_2O \rightarrow R_2Si(OH)_2$ (Linear Chain Silicones)
- $RSiCl_3 \xrightarrow{H_2O} RSi(OH)_3$ (Cross linked silicones)
- $R_3SiCl \rightarrow$ stopping agent / Dimer

SILICATES

- Metal derivatives\ of silicic acid H_4SiO_4
- Basic unit is $(SiO_4)^{4-}$ Tetrahedral

ZEOLITES

- Sodium Aluminium silicates $(Na_2Al_2Si_2O_8.XH_2O)$
- (i) Used for Purification of H_2O to remove hardness of water
- (ii) ZSM 5 is a shape selective catalyst to convert alcohol to gasoline

CARBON FAMILY

1) Oxidation State: +2, +4, -2

Stability of +4: C > Si > Ge > Sn > Pb
Stability of +2: Pb > Sn > Ge > Si > C

2) Oxides

CO	Neutral	CO_2	Acidic
SiO	Neutral	SiO_2	Acidic
GeO	Acidic	GeO_2	Acidic
SnO	Amphoteric	SnO_2	Amphoteric
PbO (Litharge)	Amphoteric	PbO_2	Amphoteric

Halide

- Thermal stability order :
  $CCl_2 < SiCl_2 < GeCl_2 < SnCl_2 < PbCl_2$
  $CCl_4 > SiCl_4 > GeCl_4 > SnCl_4 > PbCl_4$
- CCl_4 can't be hydrolysed due to absence of valence d orbitals
- PbI_4 & $PbBr_4$ does not exist due to strong oxidising nature of Pb^{+4}

COMPOUNDS OF CARBON

CO

- $HCOOH \xrightarrow{conc.H_2SO_4} CO + H_2O$ (100% pure)
- Coal gasification
  $C + H_2O \longrightarrow CO + H_2$
  (steam) — Syn gas / Water gas
- Producer gas ($CO + N_2$)
- With Hb it forms 300 times stable Carboxy Hb (w.r.to oxyHb)

CO_2

- Solid CO_2 - Dry ice (Refrigerant)
- CO_2 in water gives carbonic acid (maintain pH 7.26-7.42)
- $NaOH + CO_2 \longrightarrow NaHCO_3$
- Used in soft drinks
- Used as fire extinguisher

ALLOTROPES OF CARBON

DIAMOND

- C-C bond length is 154 pm
- C is sp^3 hybridised
- Good thermal conductor
- Δ H of formation is 1.9KJ/mol
- Used as abrasive for sharpening of tools

GRAPHITE

- C-C bond length is 141.5pm
- Thermodynamically most stable due to $\Delta_R H$ = 0
- C is sp^2 hybridised
- Good electric conductor
- Hexagonal ring layers which are 340pm apart
- Used as dry lubricant in machines

FULLERENES

- C_{60}-C_{70} (Bucky balls)
- C is sp^2 hybridised
  C-C ⟶ 143.5pm
  C=C ⟶ 138.3pm
- C_{60} has 12 pentagons and 20 hexagons