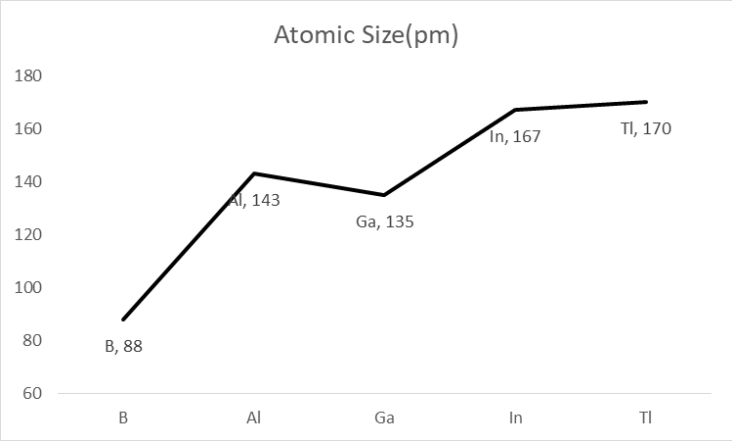
Atomic Size:



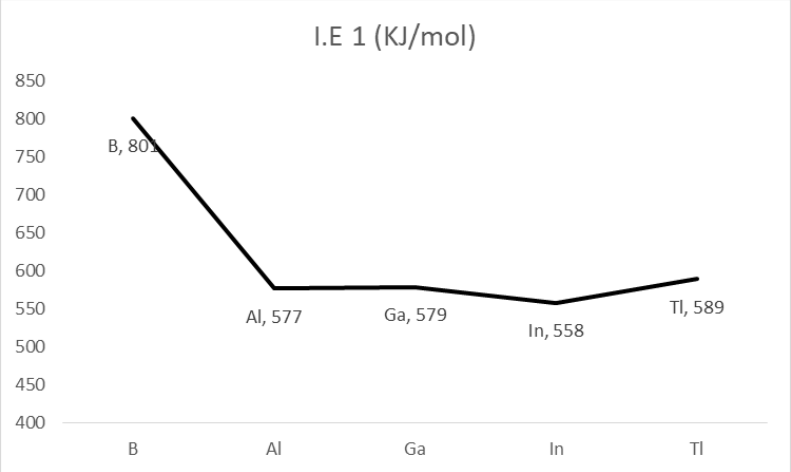
Q. Why size of Ga is approximately equal to Al or size of gallium is slightly lower than Al ?

Ionization Energy:

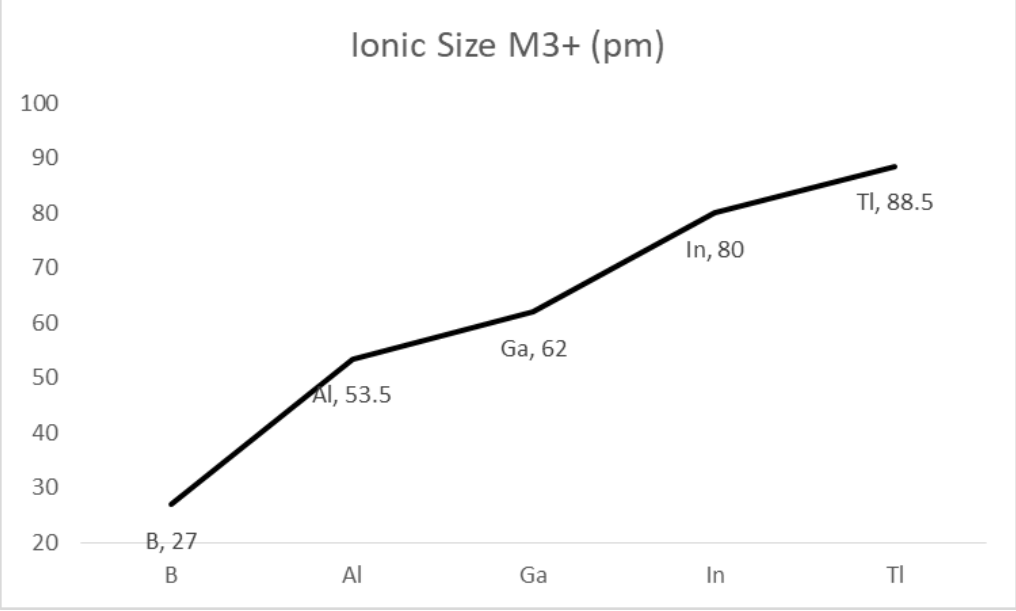
We know,

$I.E = f^n(n, Z_{eff}$, penetration effect & stability of config)

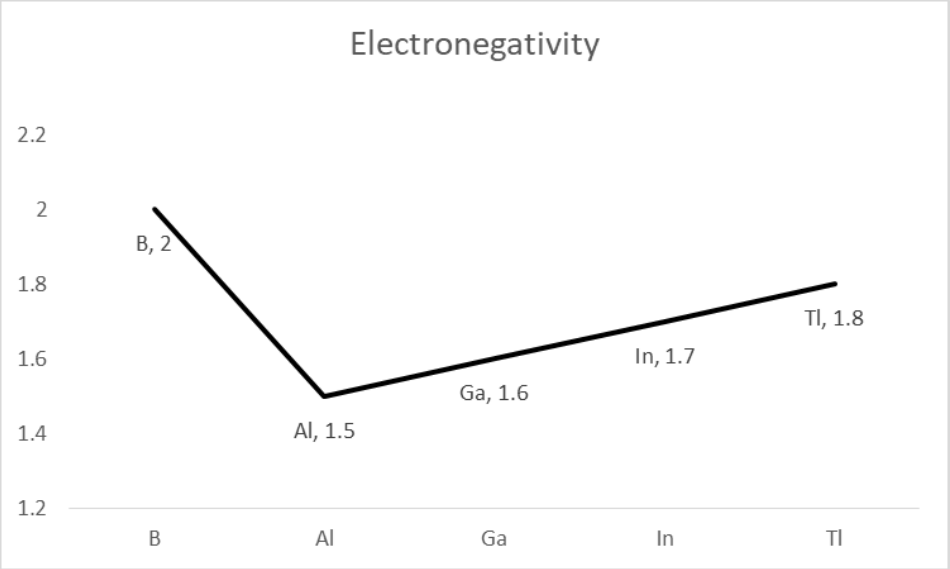
General trend: $I.E_1 < < I.E_2 < I.E_3 <<< I.E_4 < I.E_5$



Ionic Size:



Electronegativity:



Oxidation Number:

Element	O. N
B	+3
Al	+3
Ga	+3, +1
In	+3, +1
Tl	+3, +1

Chemical Properties:

Inert pair effect:

The reluctance of ns electron pair of outermost shell of a heavy p block element to take part in bonding is called inert pair effect.

Due to this effect heavy p-block element show variable oxidation number.

For Group 13, General configuration: ns^2np^1

- **Reluctance ns^2 of outermost shell electrons to participate in bonding. So, down the group stability of lower oxidation state is increases.**
- **Inert pair effect starts from elements of 4^{th} period but become significant from elements of 6^{th} period.**

Compounds of group 13 elements:

In trivalent state they generally form electron deficient molecules. So, behaves like Lewis acid.

E.g - BF_3, BCl_3 etc. To achieve stability they accept lone pairs and behave like Lewis base.

Q. Anhydrous $AlCl_3$ is covalent, from data given below predict whether it would remain covalent or become ionic in aqueous solution.

$$(\text{Ionization energy of } AlCl_3 = 5137 \text{ KJ/mol},$$

$$\Delta H_{(hydration\ of\ Al^{3+})} = -4665\, KJ/mol;$$

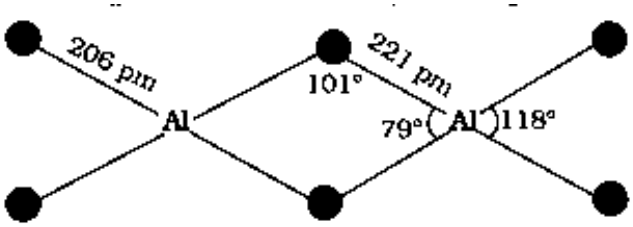
$$\Delta H_{(hydration\ of\ Cl^{-})} = -381\, KJ/mol;$$

IIT 1997

Q. Which is better lewis acid BCl_3 or $AlCl_3$?

Q. Arrange BF_3, BCl_3 & BBr_3 according to their decreasing strength of Lewis acid.

Note: $AlCl_3$ form dimer.



The Elements:

- Boron naturally occurs as Borax ($Na_2B_4O_5(OH)_4.8H_2O$) & Kernite ($Na_2B_4(OH)_4.2H_2O$), from which the impure element is obtained.
- Aluminum most important mineral is Bauxite (complex mixture of Hydrated aluminum hydroxide & aluminum oxide)
- Gallium oxide occurs as impurity in bauxite.
- In & Tl occur in trace amounts in many minerals.

p-block elements ranges from metal to non-metal, through metalloids. (B is nonmetal, Al is amphoteric character & Ga, In,Tl are metals)

Anomalous Property of Boron:

Boron show diagonal relationship with Si.

1. B and Si form acidic oxides, B_2O_3 & SiO_2. (Al form amphoteric oxide)
2. B & Si form flammable gaseous hydrides (aluminum hydride is solid)

Amorphous Boron is brown powder. Amorphous boron of low purity called Moissan boron, obtained by reducing B_2O_3 with Mg or Na at high temperature.

$$Na_2[B_4O_5(OH)_4].8H_2O \xrightarrow{acid} H_3BO_3$$

$$\xrightarrow{\Delta} B_2O_3 \xrightarrow{Mg\ or\ Na} 2B + 3MgO$$

Crystalline Boron forms shiny black crystals. Difficult to obtain pure crystalline boron due to its high M.P.

$$2BCl_3 + 3H_2 \xrightarrow{red\ hot\ W} 2B + 6HCl$$

Reaction of Boron:

- Pure crystalline boron is very unreactive.

- Boron does not reactb with acid and base at low temperature. At high temp^{r} attacked by Na_2O_2 & mixture of hot conc. HNO_3 & H_2SO_4
- Finely divided amorphous boron is more reactive (containing some impurity)
- $2B + N_2 \longrightarrow 2BN$

  BN is similar to graphite, slippery white solid with layer structure similar too graphite.
- $4B + 3O_2 \longrightarrow 2B_2O_3$

Reaction of Aluminum:

- Aluminum dissolve in dil. Mineral acids producing H_2 gas

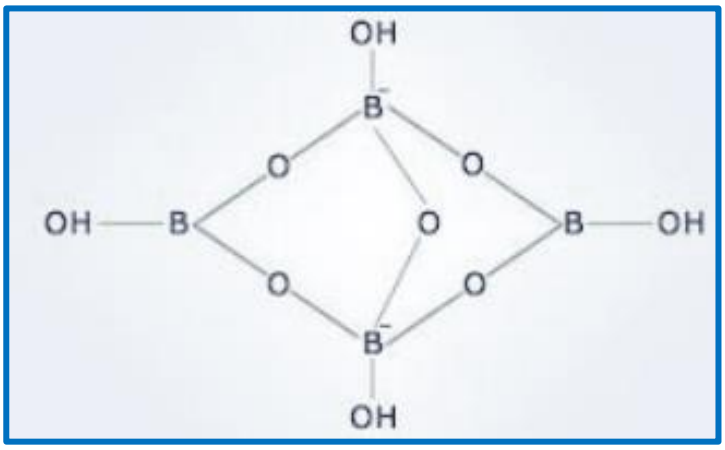
  $2Al + 6HCl = 2Al^{3+} + 6Cl^{-} + 3H_2$
- Conc. HNO3 renders metal passive (produce protective layer of oxides on the surface)
- Al also dissolves in NaOH

$$2Al + 2NaOH + 6H_2O \longrightarrow \underbrace{2NaAl(OH)_4}_{or\ 2NaAlO_2.2H_2O} + 3H_2$$

Important compounds of Boron:

Borax: $Na_2B_4O_7.10H_2O$ or $Na_2B_4O_5(OH)_4.8H_2O$

Structure:



Property of Borax:

- $Na_2B_4O_7 + 7H_2O \longrightarrow 2NaOH + 4H_3BO_3$
- Borax is a white crystalline solid

Q. Find incorrect statement–

A. Two B-atoms are SP^2 hybridisation

B. Two B-atoms are SP^3 hybridisation

C. Five B-O-B bond are present

D. All B-atoms are SP^3 hybridisation

Borax Bead Test:

$$Na_2B_4O_7.10H_2O \longrightarrow Na_2B_4O_7 + 10H_2O$$

$$Na_2B_4O_7 \xrightarrow{\Delta} \underbrace{2NaBO_2 + B_2O_3}_{\text{Glassy bead}}$$

$$CoO + B_2O_3 \longrightarrow \underbrace{Co(BO_2)_2}_{\text{Blue}}$$

$$MnO + B_2O_3 \longrightarrow \underbrace{Mn(BO_2)_2}_{\text{Violet}}$$

$$NiO + B_2O_3 \longrightarrow \underbrace{Ni(BO_2)_2}_{\text{reddish brown}}$$

Use:

1. in making of hard borosilicate glass
2. to make sodium peroxoborate (used as used as brightner in washing powder)
3. used as antiseptic
4. used in softening of water

Boron Hydride:

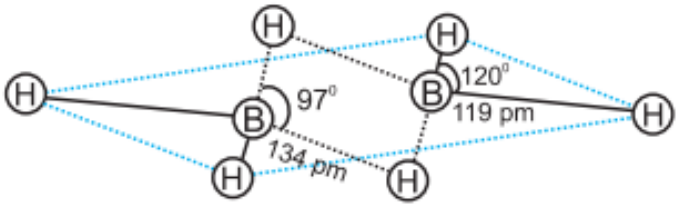
Simplest boron hydride – diborane (B_2H_6)

Diborane (B_2H_6):

- Colorless toxic gas,
- Highly flammable, catches fire spontaneously in air

$$B_2H_6 + 3O_2 \longrightarrow B_2O_3 + 3H_2O$$

Structure of diborane:



Preparation:

Lab method:

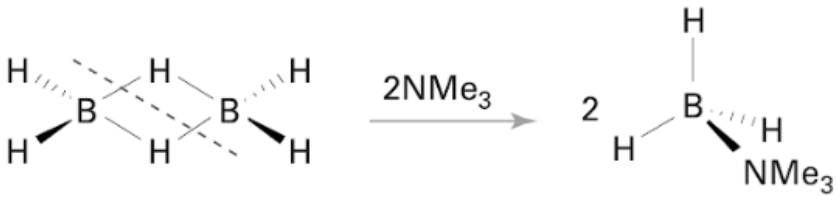
- $$4BF_3 + 3LiAlH_4 \longrightarrow 2B_2H_6 + 3LiF + 3AlF_3$$

  (Synthesis is carried out in vaccum because in air catches fire)
- $$2NaBH_4 + I_2 \longrightarrow B_2H_6 + 3NaI + H_2$$

  Large scale:
- $$2BF_3 + 6NaH \xrightarrow[450K]{} B_2H_6 + 6NaF$$

Reactions of diborane:

1. Hydrolysis by water: $B_2H_6 + 6H_2O \longrightarrow 2H_3BO_3 + 6H_2$
2. $B_2H_6 + 2NMe_3 \longrightarrow 2BH_3.NMe_3$

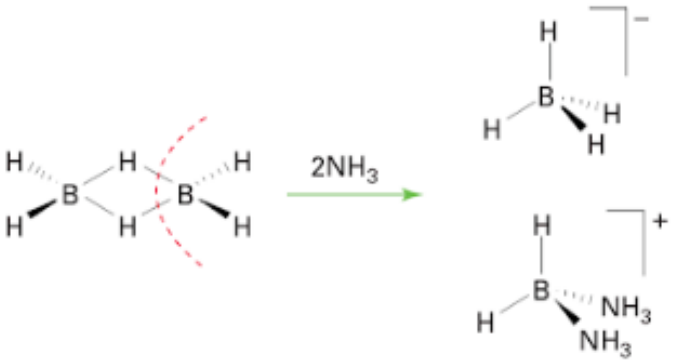


(Symmetrical cleavage)

3. $3B_2H_6 + 6NH_3 \longrightarrow 3[BH_2(NH_3)_2]^+[BH_4]^-$

$3[BH_2(NH_3)_2]^+[BH_4]^- \xrightarrow{\Delta}$

$\underbrace{2N_3B_3H_6}_{\text{Borazine or inorganic benzene}} + 12H_2$



(unsymmetrical Cleavage)

Q. **The two types of bonds present in B_2H_6 are covalent and _____.**

[IIT-JEE, 1994]

Q. **Compound X on reduction with 21.72% gives a hydride Y containing 21.72% hydrogen along with other products. Compound Y reacts with air explosively resulting in boron trioxide. Identify X and Y. Give balanced reactions involved in the formation of Y and its reaction with air. Draw the structure of Y.**

[IIT-JEE, 2001]