P-Block Elements

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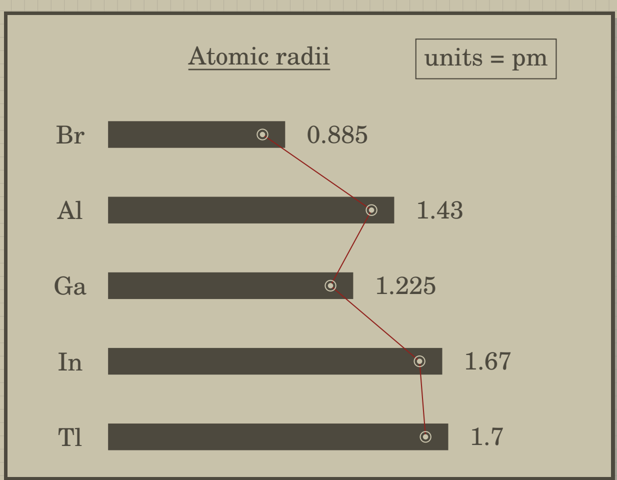
Group 13 (Boron family)

- Boron (B) : [He] $2s^2\ 2p^1$
- Aluminium (Al) : [Ne] $3s^2\ 3p^1\ 3d^0$
- Gallium (Ga) : [Ar] $3d^{10}\ 4s^2\ 4p^1\ 4d^0$
- Indium (In) : [Kr] $4d^{10}\ 5s^2\ 5p^1\ 5d^0$
- Thallium (Tl) : [Xe] $4f^{14}\ 5d^{10}\ 6s^2\ 6p^1\ 6d^0$

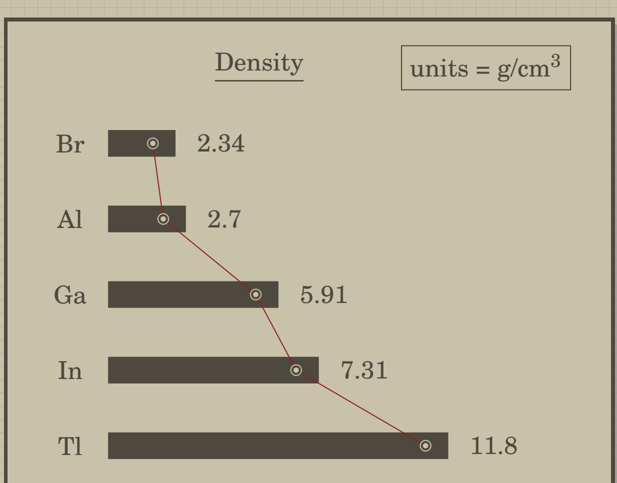
Physical Properties.

Atomic radii.



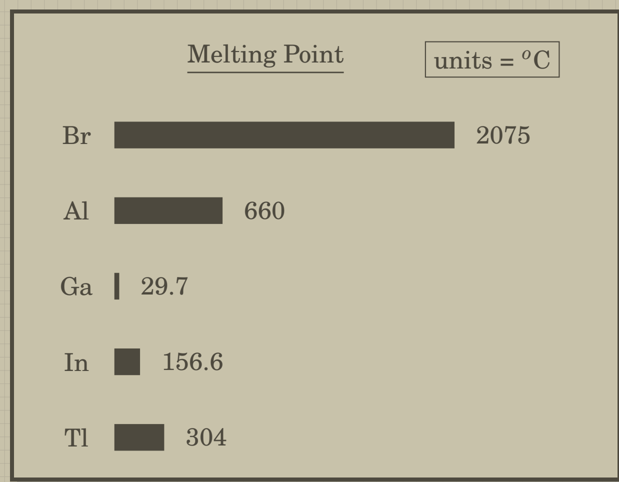
The atomic radius of gallium is lesser than aluminium due to the poor shielding effect of the d-orbital in the penultimate shell.

Density.

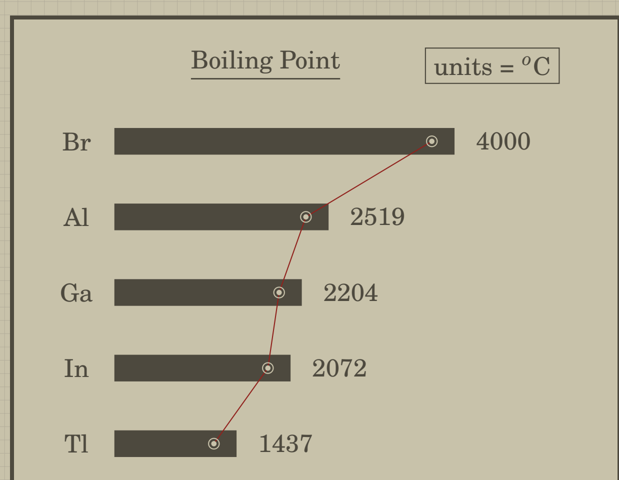


The density of Boron and Aluminium is low because of their low atomic masses compared to Gallium, Indium and Thallium.

Melting & Boiling Points.

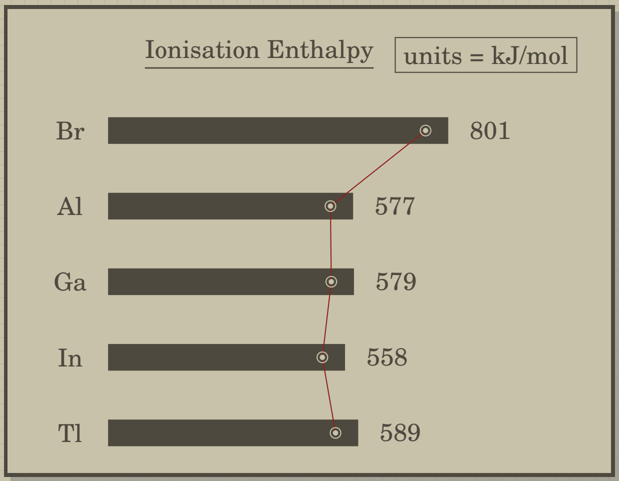


- The high melting point of Boron is high due to the fact that it exists as a giant covalent polymer in both solid and liquid state.
- Gallium has an unusual structure, leading to a low melting point.
- Other elements (Al, In, Tl) have a Close Packed Metal structure.



This shows that the strength of the intermolecular forces in the liquid state of the boron family decreases down the group.

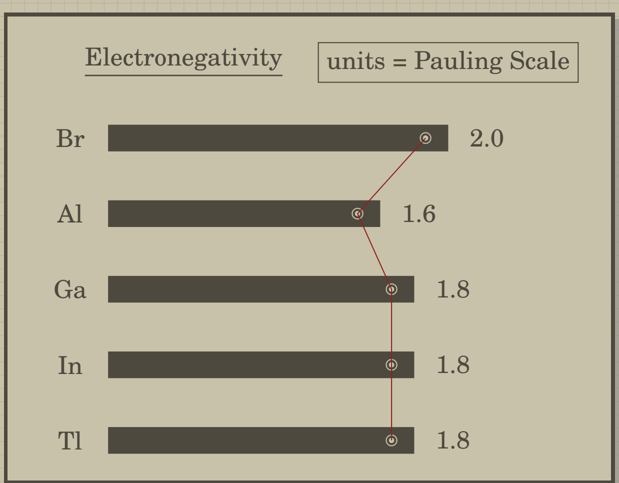
Ionisation Enthalpy.



The inconsistent trend is due to the poor shielding effect of d and f orbitals.

In case of Ga, the shielding effect leads to an increase in I.E from aluminium.

In case of Thallium (Tl), the presence of f orbital leads to increased I.E from indium.



This is due to the *discrepancies in the atomic radii*.

Oxidation state.

Other than boron, all other elements exhibit **+1** and **+3** oxidation states whereas boron exhibits only +3 oxidation state.

The stability of +3 oxidation state **decreases down the group** due to inert pair effect.

Chemical Properties.

Allotropy.

- Boron is the only element exhibiting allotropy in its group.
- It exists in both crystalline and amorphous form.
- It is unreactive in the crystalline form.

Reactivity towards Air.

1. Boron.

Amorphous boron, on heating in presence of air, reacts with oxygen and forms **Boron trioxide** (B_2O_3).

$$4\,B(s) + 3\,O_2(g) \xrightarrow{\Delta} 2\,B_2O_3(s)$$

At high temperatures, it reacts with nitrogen and forms **Nitrides**.

$$2\,B(s) + N_2(g) \xrightarrow{\text{High Temperature}} 2\,BN(s)$$

2. Aluminium.

Aluminium usually doesn't react with dry air. But, it forms a thin oxide layer on its surface **when reacted with moist air**.

$$4\,Al + 3\,O_2 \xrightarrow{\text{Moist Air}} 2\,Al_2O_3$$

It forms nitrides at high temperatures as well.

$$2\,Al + N_2 \xrightarrow{\text{high temperature}} 2\,AlN$$

3. Gallium & Indium. $\Longrightarrow$ These both are not affected by air.

4. Thallium. $\Longrightarrow$ It forms an oxide layer on its surface and hence it is **preserved in oil.**

Reactivity towards water.

1. Boron.

Boron is unaffected by air or water. But reacts with **red-hot steam**.

$$2\,B + \underset{\text{(steam)}}{3\,H_2O} \longrightarrow B_2O_3 + 3\,H_2$$

2. Aluminium.

Aluminium decomposes cold water if there is no oxide layer present.

$$\underset{\text{(No oxide layer)}}{2Al} + 3H_2O \longrightarrow Al_2O_3 + H_2$$

3. Gallium & Indium. $\Longrightarrow$ are not affected by cold or hot water, unless oxygen is present.

4. Thallium. forms a hydroxide in moist air.

$$4Tl + 2H_2O + O_2 \longrightarrow 4TlOH$$

Reacting with acids & alkalis.

1. Boron.

Boron doesn't react with acids or alkalis even at high temperatures.

2. Aluminium.

With an acid,

$$2Al\,(s) + 6HCl\,(aq) \longrightarrow 2Al\,(aq) + 6Cl\,(aq) + 3H_2(g)$$

With a base

$$2Al + 6NaOH + 6H_2O \longrightarrow 2Na^+ + [Al(OH)_4]^- + 3H_2$$

Thus, aluminium shows amphoteric nature.

Reactivity towards Halogens.

The Elements of group-13 react with halides and exhibit **trivalency** in these cases.

> Boron's halides are covalent whereas the halides of other elements are ionic. The covalent nature is due to the small size & high electronegativity of Boron.

Moreover, the halides of boron DOES NOT dimerize whereas the rest of the elements in the group form dimers either via *hydrogen or coordination bonds*.
