# p-Block Elements

| **Level - 0** | **CBSE Pattern** |
|---|---|

**1.** Anhydrous aluminium chloride is partially hydrolysed by atmospheric moisture to liberate HCl gas.

Moist HCl appears white in colour. $AlCl_3(s) + 3H_2O(\ell) \longrightarrow Al(OH)_3(s) + 3HCl(g)$

**2.** Due to absence of d-orbitals, B at the maximum can accommodate 8 electrons or 4 pairs of electrons in its valence shell. In other words, B can have a maximum covalency of 4. Therefore, $BF_3$ can form $BF_4^-$ but never $BF_6^{3-}$ in which the covalency of B is 6.

**3.** The main reasons are :

**(i)** Due to smaller size of F as compared to Cl, six small F atoms can be easily accommodated around Si atom but six large Cl atoms cannot.

**(ii)** The lone pair of electrons on F are present in a smaller 2p-orbital but in Cl they are present on a larger 3p-orbital. Therefore, interaction of F lone pair electrons with d-orbitals of silicon are stronger than that of Cl lone pairs.

**4.** Diamond has three dimensional network structure involving strong $C-C$ bonds. These bonds are difficult to break and hence the melting point of diamond is very high.

**5.** Silicones are synthetic organosilicon compounds containing repeated $\left[\begin{array}{c} R \\ | \\ -O-Si- \\ | \\ R \end{array}\right]_n$ units held by $Si-O-Si$ linkages. They are hydrophobic (water-repellent) in nature.

**6.** The B atom in $BF_3$ has only 6 electrons in the valence shell and thus need two more electrons to complete its octet. Therefore, it easily accepts a pair of electrons from nucleophiles such as $F^-$, $(C_2H_5)_2O$, $RCH_2OH$ etc. and thus behaves as a Lewis acid.

**7.** It is not a protic acid since it does not ionize in $H_2O$ to give a proton :

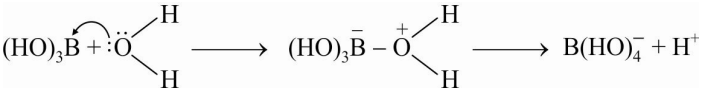
$$H_3BO_3 + H_2O \not\longrightarrow H_2BO_3^- + H_3O^+$$

Instead because of the small size of boron atom and presence of only six electrons in its valence shell, $B(OH)_3$ accepts a lone pair of electrons from the oxygen atom of the $H_2O$ molecule to form a hydrate

The +ve charge on the O-atom, in turn, pulls the electrons of the O—H bond towards itself thereby facilitating the release of a proton. As a result, $B(OH)_3$ acts as a weak monobasic Lewis acid and thus reacts with NaOH solution to form sodium metaborate.

$$B(OH)_3 + NaOH \longrightarrow Na^+[B(OH)_4]^- \text{ or } Na^+BO_2^- + 2H_2O$$

Sod. metaborate

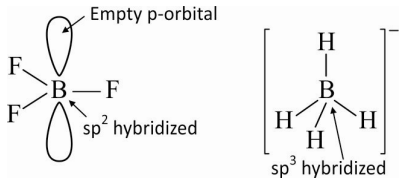


**8.** Boric acid, on heating, loses water in three different stages at different temperatures ultimately giving boron trioxide or boric anhydride.

$$\underset{\text{Boric acid}}{H_3BO_3} \xrightarrow{370\,K} \underset{\text{Metaboric acid}}{HBO_2} + H_2O$$

$$\underset{\text{Metaboric acid}}{4HBO_2} \xrightarrow[-H_2O]{410K} \underset{\text{Tetraboric acid}}{H_2B_4O_7} \xrightarrow{\text{Red heat}} \underset{\text{Boron trioxide}}{2B_2O_3} + H_2O$$

**9.** In $BF_3$, boron is $sp^2$ - hybridized and, therefore, $BF_3$ is a planar molecule. On the other hand, in $[BH_4]^-$ boron is $sp^3$ - hybridized and hence $[BH_4]^-$ is a tetrahedral species.

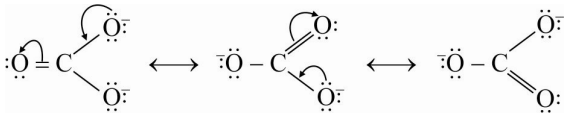



**10.** It dissolves both in acids and alkalies evolving dihydrogen.

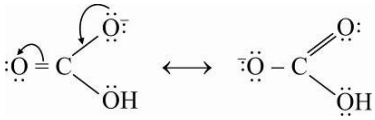
$$2Al(s) + 3H_2SO_4(aq) \longrightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$$

$$2Al(s) + 2\,NaOH(aq) + 6H_2O(\ell) \longrightarrow \underset{\text{Sod. tetrahydroxoaluminate (III)}}{2Na^+[Al(OH)_4]^-(aq)} + H_2(g)$$

**11.** Resonance structures of ion



Resonance structures of ion



**12.** **(a)** $sp^2$ **(b)** $sp^3$ **(c)** $sp^2$

**13.** $BF_3$ is a planar molecule in which B is $sp^2$ - hybridized. It has an empty 2p-orbital. F-atom has three lone pairs of electrons in the 2p-orbitals. Because of similar sizes, $p\pi - p\pi$ back bonding occurs in which a lone pair of electrons is transferred from F to B.

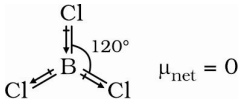
As a result of this back bonding, $B-F$ bond acquires some double bond character. In contrast, in $[BF_4]^-$ ion, B is $sp^3$ - hybridized and hence does not have an empty *p*-orbital available to accept the electrons donated by the F atom. Consequently, $[[BF_4]^-$, $B-F$ is a purely single bond. Since double bonds are shorter than single bonds, therefore, the $B-F$ bond length in $BF_3$ is shorter (130 pm) than $B-F$ bond length (143 pm) in $[BF_4]^-$.

**14.** Due to electronegativity difference between B (E. N. = 2.0) and Cl (E. N. = 3.0), the $B-Cl$ bond is polar and hence has a finite dipole moment. The overall dipole moment of a molecule, however, depends upon its geometry. Now $BCl_3$ is a planar molecule in which the three $B-Cl$ bonds are inclined at an angle of 120°. Therefore, the resultant of two $B-Cl$ bonds is cancelled by equal and opposite dipole moment of the third $B-Cl$ bond as shown below : As a result, overall dipole moment of $BCl_3$ is zero.

**15.** **(i)** Borax : $Na_2B_4O_7 \cdot 10H_2O$ **(ii)** Metaboric acid : $HBO_2$

**(iii)** Boric acid : $H_3BO_3$ **(iv)** Sodium metaborate : $NaBO_2$

**(v)** Inorganic Benzene : $B_3N_3H_6$ **(vi)** Inorganic graphite : BN




**16.** Due to poor shielding of the valence electrons of Ga by the inner 3d-electrons, the effective nuclear charge of Ga is greater in magnitude than that of Al. As a result. the electrons in gallium experience greater force of attraction by the nucleus than in Al and hence atomic size of Ga (135 pm) is slightly less than that of Al (143 pm).

**17.** Boron does not form $B^{3+}$ ion due to very high sum of $IE_1 + IE_2 + IE_3$

**18.** Absence of vacant d orbital and small size.

**19.** Catenation means self linking tendency of atoms to form chain. Carbon has maximum catenation power.

**20.** In the lungs, haemoglobin present in red blood cells combine with molecular oxygen loosely and reversibly to form oxyhaemoglobin.

$$\text{Haemoglobin} + O_2 \rightarrow \text{Oxyhaemoglobin}$$

Oxyhaemoglobin thus formed in the lungs then travels to different parts of the body through blood stream and delivers $O_2$ to the various tissues of the body. However, CO combines with haemoglobin irreversibly to form carboxyhaemoglobin which is about 300 times more stable than the oxyhaemoglobin.

$$\text{Haemoglobin} + CO \rightarrow \text{Carboxyhaemoglobin}$$

As a result, the oxygen carrying capacity of haemoglobin is destroyed and the man dies of suffocation. Thus, the highly poisonous nature of CO arise due to its ability to form a complex with haemoglobin which is about 300 times more stable than the oxygen-haemoglobin complex.

**21.** **(i)** Due to inert pair effect, Pb is more stable in +2 than in +4 oxidation state. Therefore, lead (II) chloride is more stable than lead (IV) chloride and hence lead (II) chloride does not react with $Cl_2$ to form lead (IV) chloride

**(ii)** Due to greater stability of +2 over +4 oxidation state because of inert pair effect, lead (IV) chloride on heating decomposes to give lead (II) chloride and $Cl_2$

**(iii)** Due to oxidising power of $Pb^{4+}$ ion and reducing power of $I^-$ ion, $PbI_4$ does not exist.

Alternatively, Pb-I bond initially formed during the reaction does not release enough energy to unpair $6s^2$ electrons and excite one of them to the higher $6p$-orbital to have four unpaired electrons around lead atom needed for formation of $PbI_4$.

**22.** **(a)** When borax is heated strongly, a transparent glassy bead which consists of sodium metaborate ($NaBO_2$) and boric anhydride is formed.

**(b)** Boric acid acts as a weak Lewis acid by accepting a hydroxide ion of water and releasing a proton into the solution.

**(c)** Dihydrogen is evolved.

**(d)** $BF_3$ being a Lewis acid accepts a pair of electrons from $NH_3$ to form the corresponding complex.

**23.** **(i)** $2BF_3 + 6LiH \longrightarrow \underset{\text{Diborane}}{B_2H_6} + 6LiF$

**(ii)** $\underset{\text{Diborane}}{B_2H_6} + 6H_2O \longrightarrow \underset{\text{Orthoboric acid}}{2H_3BO_3} + 6H_2$

**(iii)** $2NaH + B_2H_6 \longrightarrow \underset{\text{Sod. boronhydride}}{2Na^+[BH_4]^-}$

**(iv)** $\underset{\text{Orthoboric acid}}{H_3BO_3} \xrightarrow{\Delta} \underset{\text{Metaboric acid}}{HBO_2} + H_2O$

$$\underset{\text{Metaboric acid}}{4HBO_2} \xrightarrow[-H_2O]{\Delta} \underset{\text{Tetraboric acid}}{H_2B_4O_7} \xrightarrow{\Delta} \underset{\text{Boron trioxide}}{2B_2O_3} + H_2O$$

**(v)** $2Al + 2NaOH + 6H_2O \longrightarrow \underset{\text{Sod. tetrahydroxoaluminate (III)}}{2Na^+[Al(OH)_4]^-} + 3H_2$

**(vi)** $B_2H_6 + 2NH_3 \longrightarrow [BH_2(NH_3)_2]^+[BH_4]^-$

**24.** $CO_2$ is produced during combustion. It is utilized by plants during photosynthesis and $O_2$ is released into the atmosphere. As a result of this $CO_2$ cycle, a constant percentage of 21% $O_2$ is maintained in the atmosphere. However, if the concentration of $CO_2$ increases beyond 0.03% by volume in the atmosphere due to excessive combustion, some of the $CO_2$ will always remain unutilized. This excess $CO_2$ absorbs

heat radiated by the earth. Some of it is dissipated into the atmosphere while the remaining part is radiated back to the earth and other bodies present on the earth. As a result, temperature of the bodies on the earth increases. This is called green house effect and $CO_2$ is called a greenhouse gas. As a result of greenhouse effect, global warming occurs which has serious consequences.

**25.** **(i)** Al reacts with conc. $HNO_3$ to form a very thin film of aluminium oxide on its surface which protects it from further action.

Thus, Al becomes passive and hence aluminium containers can be used to transport conc. $HNO_3$

**(ii)** NaOH reacts with Al to evolve dihydrogen gas. The pressure of the gas thus produced can be used to open clogged drains.

**(iii)** Graphite has layered structure in which the different layers are held together by weak vander Waals forces and hence can be made to slip over one another. Therefore, graphite acts as a lubricant.

**(iv)** Diamond is very hard and hence can be used as an abrasive.

**(v)** Aluminium alloys such as duralumin is light, tough and resistant to corrosion and hence is used to make aircraft body.

**(vi)** Al reacts with $H_2O$ and dissolved $O_2$ to form a thin film of aluminium oxide.

A very small amount of $Al_2O_3$ may dissolve to give a few ppm of $Al^{3+}$ ions in the solution. Since $Al^{3+}$ ions are injurious to health, therefore, drinking water should not be kept in aluminium utensils overnight.

**(vii)** On weight to weight basis, aluminium conducts electricity twice as Cu. Therefore, it is used in transmission cables