

## The p-Block Elements

These are elements in which the last electron enters in the outer most p-subshell. They include elements of groups 13 to 18. Their general outer electronic configuration is  $ns^2np^{1-6}$  (except for He). Their maximum oxidation state = the total no. of valence electrons. They include metals, non-metals and metalloids.

**1. In group 13 elements, atomic radius increases down the group. But atomic radius of gallium is less than that of aluminium. Why?**

This is due to the presence of completely filled d-orbitals in Ga ( $\text{Ga} - [\text{Ar}] 3d^{10} 4s^2 4p^1$ ). The presence of 10 d-electrons offer only poor shielding effect for the outer electrons, from the increased nuclear charge. Thus atomic radius of gallium is less than that of aluminium.

**2. How can you explain the higher stability of  $\text{BCl}_3$  as compared to  $\text{TlCl}_3$ ?**

In  $\text{BCl}_3$ , B is in  $+3$  oxidation state. Since boron is a small atom and it contains 3 electrons in the outer most shell, it can easily show  $+3$  oxidation state. (It can form 3 B-Cl bonds). Down the group  $+1$  oxidation state becomes more common due to inert pair effect. It is the reluctance of s-electrons to participate in chemical binding. Thus only p-electrons take part in chemical reaction and hence Tl mainly shows  $+1$  oxidation state.

**3. What is inert pair effect? What is its consequence?**

It is the reluctance of s-electrons to participate in chemical binding. It is commonly seen in the elements of groups 13, 14 & 15. In these groups as the atomic size increases (i.e. down the group), the maximum oxidation state is two less than the group oxidation states.

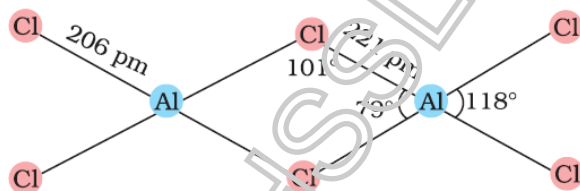
**4. What are electron deficient compounds? Explain with examples.**

The trivalent compounds formed by 13<sup>th</sup> group elements are called electron deficient compounds. In these compounds, the number of electrons around the central atom of the molecule is only 6. In order to attain stable octet configuration, they accept a pair of electrons and so they behave as Lewis acids.

e.g.  $\text{BF}_3$ ,  $\text{BCl}_3$ ,  $\text{AlCl}_3$ ,  $\text{B}_2\text{H}_6$  etc.

**5. Give the structure of aluminium chloride ( $\text{AlCl}_3$ )?**

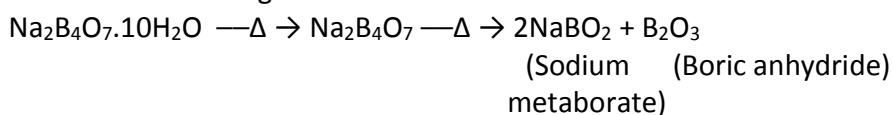
In  $\text{AlCl}_3$ , there are only six electrons around the central atom Al. In order to attain stability, it exists as dimer  $[\text{AlCl}_3]_2$ .



**6. What is Borax? What is the action of heat on it?**

It is a white crystalline solid with formula  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$  (Sodium tetra boratedecahydrate). It contains the tetranuclear units  $[\text{B}_4\text{O}_5(\text{OH})_4]^{2-}$  and hence its correct formula is  $\text{Na}_2[\text{B}_4\text{O}_5(\text{OH})_4] \cdot 8\text{H}_2\text{O}$ .

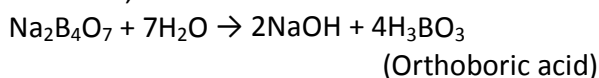
On heating, borax first loses water molecules and swells up. On further heating it turns into a transparent liquid, which solidifies into glass like material known as borax bead.



The metaborates of many transition metals have characteristic colours and, therefore, borax bead test can be used to identify them in the laboratory.

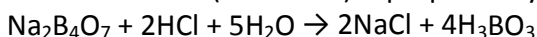
**7. A aqueous solution of borax is basic in nature. Justify.**

Borax dissolves in water to give NaOH and orthoboric acid. Since NaOH is a strong alkali and orthoboric acid is weak acid, the solution is basic in nature.



**8. Give the preparation and structure of ortho boric acid?**

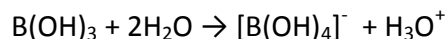
Orthoboric acid (boric acid) is prepared by acidifying an aqueous solution of borax.



It is also obtained by the hydrolysis of boron halides or hydrides.

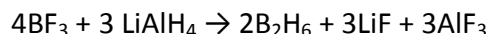
**9. Ortho boric acid is monobasic even though it contains three hydrogen atoms. Why?**

Orthoboric acid is a weak monobasic non-protic acid. It acts as a Lewis acid by accepting electrons from a hydroxyl ion.

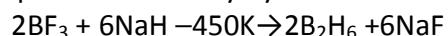


**10. Give the preparation and structure of diborane.**

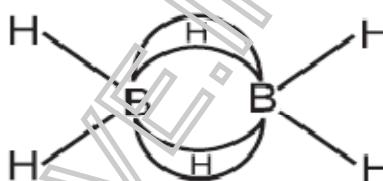
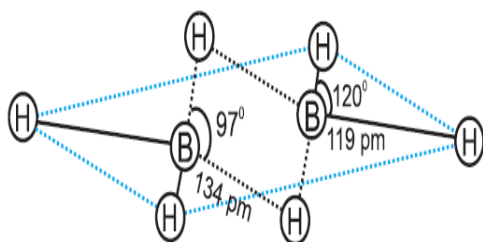
Diborane is the simplest boron hydride. It is prepared by treating  $\text{BF}_3$  with Lithium aluminium hydride ( $\text{LiAlH}_4$ ) in ether.



Diborane is prepared industrially by the reaction of  $\text{BF}_3$  with sodium hydride.

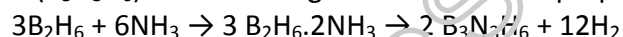


In diborane, each boron atom is in  $\text{sp}^3$  hybridisation. The two boron atoms and 4 hydrogen atoms lie in one plane. These four H atoms are called terminal hydrogen. The other two hydrogen atoms lie one above and one below this plane. These H atoms are called bridging hydrogen atoms. The four terminal B-H bonds are regular two centre-two electron bonds while the two bridge (B-H-B) bonds are three centre- two electron (3c-2e) bonds. Thus diborane is an electron deficient compound.

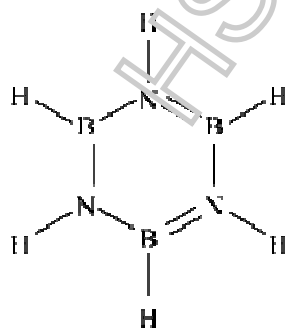


**11. What is inorganic benzene? Give its preparation?**

Borazine ( $\text{B}_3\text{N}_3\text{H}_6$ ) is called inorganic benzene. It is prepared by the reaction of ammonia with diborane



Its structure is similar to benzene with alternate B-N and NH groups.



**12.  $\text{CCl}_4$  cannot be hydrolysed. Why?**

In  $\text{CCl}_4$ , there is no vacant d-orbitals in Carbon. Thus it cannot accommodate the lone pairs of electrons donated by oxygen atoms. So it cannot be hydrolysed.

**13. Give the anomalous behaviour of carbon.**

C shows anomalous properties due to its smaller size, higher electronegativity, higher ionisation enthalpy and unavailability of d orbitals. some of the anomalous properties of C are:

1. The maximum covalency of C is four. While other elements of group 14 can extend their covalency beyond 4 due to the presence of vacant d-orbitals.

- Carbon has unique ability to form  $\pi$ – $\pi$  multiple bonds with itself and with other atoms of small size and high electronegativity.
- Carbon atoms have the tendency to link with one another through covalent bonds to form chains and rings. This property is called catenation. But other elements have less catenation property.
- $\text{CCl}_4$  cannot be hydrolysed, but the tetrahalides of other elements can be hydrolysed.

#### 14. What is allotropy? Explain the allotropes of carbon?

The existence of an element in two or more forms with same chemical properties but with different physical properties is known as allotropy. C exists in crystalline and amorphous allotropes. The important crystalline allotropes of C are diamond, graphite and fullerene.

a) **Diamond:** In diamond, each carbon atom undergoes  $\text{sp}^3$  hybridisation and linked to four other carbon atoms in a tetrahedral manner. So it has a rigid three dimensional network of carbon atoms. It is very difficult to break covalent bonds and, therefore, diamond is a hardest substance on the earth. It is used as an abrasive for sharpening hard tools, in making dies and in the manufacture of tungsten filaments for electric light bulbs.

b) **Graphite:** Graphite has a layered structure. Different layers are held by weak van der Waals forces. Each layer contains planar hexagonal rings of carbon atoms. Here each carbon atom is in  $\text{sp}^2$  hybridisation and makes three C-C sigma bonds with three neighbouring carbon atoms. Fourth electron forms a  $\pi$  bond. These electrons are delocalised and are mobile. Therefore graphite conducts electricity. Due to layered structure, it is very soft and slippery. For this reason graphite is used as a dry lubricant in machines running at high temperature.

c) **Fullerenes:** These are the cage like spherical molecules of formula  $\text{C}_{60}$ ,  $\text{C}_{70}$ ,  $\text{C}_{76}$ ,  $\text{C}_{84}$  etc. These are prepared by heating of graphite in an electric arc in the presence of inert gases like helium or argon.

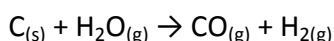
The most commonly known fullerene is  $\text{C}_{60}$ , which is known as Buckminster fullerene. It contains twenty six- membered rings and twelve five membered rings. A six membered ring is fused with six or five membered rings but a five membered ring can only fuse with six membered rings. All the carbon atoms are equal and they undergo  $\text{sp}^2$  hybridisation. Each carbon atom forms three sigma bonds with other three carbon atoms. The remaining electron at each carbon is delocalised in molecular orbitals. This gives an aromatic character to the molecule.

Graphite is the most stable allotrope of carbon.

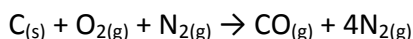
Amorphous forms of carbon are charcoal, coke and carbon black.

#### 15. What are water gas and producer gas. Give any one of their use?

A mixture of carbon monoxide and hydrogen is called water gas or synthesis gas. It is prepared by passing steam over red hot coke at about 1273K.



A mixture of carbon monoxide and nitrogen is called producer gas. It is prepared by passing air over red hot coke at about 1273K.



Both these gases are used as industrial fuels.

#### 16. Suggest a reason for the toxicity of CO?

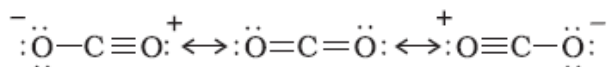
In CO, there are one sigma and two pi bonds between carbon and oxygen ( $:\text{C} \equiv \text{O}:$ ). Because of the presence of lone pair on carbon, CO molecule acts as an electron donor and reacts with metals. So it can easily form a complex with haemoglobin (carboxy haemoglobin). It is about 300 times stabler than oxyhaemoglobin complex. This prevents haemoglobin in RBC from carrying oxygen round the body.

#### 17. What is dry ice? Give its use?

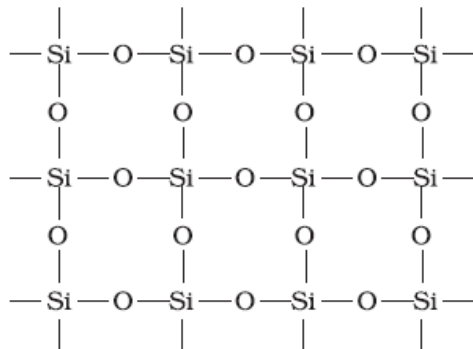
Dry ice is solid carbon dioxide. It is obtained by cooling  $\text{CO}_2$  under pressure. It sublimes directly to the vapour phase without liquefying. It does not wet the surface on which it sublimes. So it is called dry ice. It is used as a refrigerant for ice-cream and frozen food.

**18. CO<sub>2</sub> is a gas, while SiO<sub>2</sub> is a solid. Account for this?**

In CO<sub>2</sub> molecule, C atom undergoes sp hybridisation. So it has a linear shape. It exists as discrete (separate) molecules and there is only a weak attractive force between different CO<sub>2</sub> molecules. The resonance structures of CO<sub>2</sub> are:

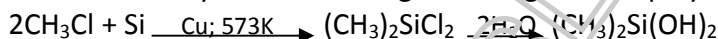


But in silica (SiO<sub>2</sub>), each silicon atom undergoes sp<sup>3</sup> hybridisation. Here each Si atom is tetrahedrally surrounded by 4 oxygen atoms. So it has a three dimensional network structure and hence it is a solid.

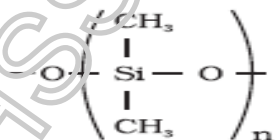
**19. What are silicones? Give their preparation?**

They are a group of organosilicon polymers, which have (-R<sub>2</sub>SiO-) as a repeating unit. The starting materials for the manufacture of silicones are alkyl or aryl substituted silicon chlorides, R<sub>n</sub>SiCl<sub>(4-n)</sub> (where R is alkyl or aryl group).

When methyl chloride reacts with silicon in the presence of copper as a catalyst at a temperature 573K, dimethyl dichlorosilane [(CH<sub>3</sub>)<sub>2</sub>SiCl<sub>2</sub>] and other methyl substituted chlorosilanes are formed. Hydrolysis of dichlorosilane followed by condensation gives straight chain polymers.



$n(\text{CH}_3)_2\text{Si}(\text{OH})_2$  polymerisation



They are water repelling in nature. They have in general high thermal stability, high dielectric strength and resistance to oxidation and chemicals. So they are used as sealant, greases, electrical insulators and for water proofing of fabrics. Being biocompatible they are also used in surgical and cosmetic plants.

**20. What are Silicates?**

These are compounds of Si in which each silicon atom is bonded to four oxygen atoms in tetrahedral manner. In silicates, either the discrete SiO<sub>4</sub><sup>4-</sup> units are present or a number of such units are joined together by sharing oxygen atoms. When silicate units are linked together, they form chain, ring, sheet or three-dimensional structures.

**21. What are zeolites? Mention its uses?**

Zeolites are aluminosilicates of metals. These are widely used as a catalyst in petrochemical industries for cracking of hydrocarbons and isomerisation. E.g. the zeolite ZSM-5 is used to convert alcohols directly into gasoline. Hydrated zeolites are used as ion exchangers in softening of hard water.

