Chapter - 11

The p-Block Elements

Group 13 Elements

- Electronic configuration : ns^2np^1.
- **Oxidation states :** B and Al show an oxidation state of + 3 only while Gallium, Indium and Thallium show oxidation states of both + 1 and + 3. Further due to inert pair effect, as we more down the group, the stability of + 3 oxidation state decreases while that of H oxidation state increases.
- **Inert pair effect :** It is the reductance of the *s*-electrons of the valence shell to take part in bnding. It arises due to poor or ineffective shielding of the ns^2 electrons of the valence shell by the intervening *d* or *f* electrons. Inert pair effect increase down a group and thus the elements present in the lower part of the group show lower oxidation states which is two units less than the highest group oxidation state.
- **Halides :** All the elements of group 13 (except Tl) forms trihalidaesa of general formula MX_3 (X = F, Cl, Br, I).

  Boron trihalides exist as only monomers, whereas aluminium trihalides exist as dimers.
- **Nature of Trihalides :** The trihalides of group 13 elements have only six electrons in the valence shell and have a strong tendency to accept a pir of electrons to acquire the nearest inert gas configuration. So trihalides of group 13 elements behave as Lewis acids.
- **Borax :** It is $Na_2B_4O_7.10H_2O$.
- **Orthobaric acid (H_3BO_3) :** It is weak monobaric acid.
- Diborane (B_2H_6) : It is dimer of BH_3.

Group 14
Elements

- Electronic configuration : $ns^2\ np^2$
- **Oxidation states :** Group 14 elements shows + 2 and + 4 oxide state. As we move down the group stability of + 4 oxidation state decreases while of + 2 oxidation state increases.
- **Catenation :** The property of self linking of atoms of an element through covalent bonds to form straight or branched chains and rings of different size is called catenation. Among group 14 elements carbon shows maximum tendency for catenation. As we move down the group tendency to show catenation property decreases.
- **Formation of halides : (i) Tetrahalides :** All the elements of group 14 from tetrahalides of the general formula MX_4 where X = F, Cl, Br or I. All these tetrahalides are covalent compounds and have tetrahedral structure. The stability of these tetrahalides decreases as we move from C to Pb *i.e.*,

  $CX_4 > SiX_4 > GeX_4 > SnX_4 > PbX_4$

  (ii) **Dihalides :** All the elements of group 14 dihalides of the formula MX_2 where X = F, Cl, Br or I. The stability of these dihalides increases as we moved down the group from C to Pb. Dihalides are generally ionic in nature and behave as reducing agents. The reducing character decreases in the order $GeCl_2 > SnCl_2 > PbCl_2$.
- **Formation of oxides :** All the elements of this group from two types of oxides (i) monoxides, (ii) dioxide.

  (i) Monoxides : All the elements of group 14 form monoxides of the general formul MO *i.e.*, C, SiO, Geo, SnO and PbO. These oxides except SiO and GeO are quite stable. CO is neutral while SnO and GeO are amphoteric.

  (ii) **Dioxides :** All these elements from dioxides of the generaele formula MO_2. All thse dioxides can be prepared by heating the elements in oxygen except lead which forms lead monoxide. CO_2 is a monomeric, linear molecule and hence exists as a gas while the dioxides of all other elements are crystalline solid with high melting points due to the formation of three dimensional network of bonds.
- ***p*π-*p*π and *p*π-*d*π multiple bonding :** Amongst group 14 elements carbon shows a pronounced ability to form *p*π-*p*π multiple bonds with itself (*e.g.*, in graphite) and with other elements especially nitrogen and oxygen. Silicon and other heavier elements of this group show negligible tendency of this type.

$p\pi$-$p\pi$ multiple bonding has been observed particularly in case of silicon linked to oxygen and nitrogen. Thus trimethylamine $N(CH_3)_3$ is pyramidal (N is sp^3 hybridised) and is more basic whereas silicon compound trisilylamine $N(SiH_3)_3$ is planar (N is sp^2 hybridised) and is less basic. In this case, the lone pair of electrons on nitrogen atom is transferred to empty *d*-orbital of silicon $p\pi$-$d\pi$ overlapping leading to planar structure.

- **Diamond :** In it C is sp^3 hybridised.
- **Graphite :** In it C is sp^2 hybridised.
- **Fullerenes :** In it C is sp^2 hybridised.
- **Carbon monoxide :** $2C + O_2 \xrightarrow{\Delta} 2CO$. It is highly poisonous.
- **Carbon dioxide :** $C + O_2 \xrightarrow{\Delta} CO$. It causes green house effect.
- **Silicones :** Silicones are synthetic organosilican compounds containing repeated unit R_2SiO held by Si-O-Si linkages.

  Silicones are water repellent, heat resistant, chemically inert, resistant to oxidation and attack by organic acids and are good electrical insulators.

Group 13 Elements

1-Mark Questions

1. Mention two important ores of Boron.
2. Name the elements of group 13 which forms only covalent compounds.
3. Why the atomic radius of gallium is less than that of Al ?
4. Why does Boron forms electron deficient compounds ?
5. Boron does not exist as B^{3+} ion. Why ?
6. Why the trihalide of group 13 elements fume in moist air ?
7. Aluminium form $[AlF_6]^{3-}$ but boron does not form $[BF_6]^{3-}$.
8. Why baric acid is a monobaric acid ?
9. White fumes appear around the bottle of anhydrous $AlCl_3$. Give reason. [NCERT]
10. $AlCl_3$ exist as dimer while BCl_3 exist as monomer, why ?
11. Mention the type of hybridization of Boron in B_2H_6. [**Ans.** sp^3]
12. Write the formula of inorganic benzene.

13. Why aluminium utensils should not be kept in water overnight.[NCERT]
14. Explain what happens when baric acid is heated.
15. BCl_3 exists but BH_3 does not. Explain.

Group 14 Elements

16. Why $SnCl_4$ is more covalent than $SnCl_2$?
17. Why $PbCl_4$ is good oxidising agent ?
18. What are Germanes and Plumbanes ?
19. Give one example of Zeolite.
20. Mention the type of hybridization of carbon in diamond and graphite.
21. Why CCl_4 is insoluble in water but $SiCl_4$ is soluble in water. Explain.
22. Give two uses of silicones.
23. Why graphite is used as lubricant ? [NCERT]
24. Lead do not form PbI_4. Why ?
25. CO_2 is gas while SiO_2 is solid at room temperature. Explain why ?
26. Explain why silicon shows a higher covalency than carbon.
27. Out of carbon and silicon which can form multiple bonds and why ?
28. Write the formula of dry ice.
29. What is the basic building unit of all silicates ?
30. Graphite is a good conductor of electricity, but diamond is not. Why ?

Group 13 Elements

2-Mark Questions

1. Draw the structure of Diborane.
2. What happens when :
   (a) Borax is heated strongly.
   (b) Boric acid is added to water.
3. Write balanced chemical equations for :
   (a) $BF_3 + LiH \longrightarrow$
   (b) $B_2H_6 + NH_3 \longrightarrow$

4. Write chemical reactions to justify amphoteric nature of Al.
5. Suggest reason why the B-F bond length in BF_3 and BF_4^- differ.
6. Give reason :

   (i) BF_3 act as weak Lewis acid.

   (ii) Boron cannot show covalency more than four.
7. How can you explain higher stability of BCl_3 as compared to $TlCl_3$.
8. Give reason :

   (i) Aluminium alloys are used to make air craft body.

   (ii) Aluminium wire is used to make transmission cables. [NCERT]
9. Describe the shapes of BF_3 and BH_4^-. Assign the hybridization of boron in these species. [NCERT]
10. Explain the chemistry of borax bead test.

Group 14 Elements

11. $[SiF_6]^{2-}$ is known whereas $[SiCl_6]^{2-}$ not. Give reason. [NCERT]
12. Hydrolysis of $SiCl_4$ take place but of CCl_4 does not. Why ?
13. Account for the following :

    (a) CO_2 is gas while SiO_2 is solid at room temperature.

    (b) Solid CO_2 is known as dry ice.
14. Elemental silicon does not form graphite like structure as carbon does. Give reason.
15. Suggest a reason as to why CO is poisonous. [NCERT]
16. How is excessive content of CO_2 responsible for global warming ? [NCERT]
17. What is allotrophy ? Name two elements which exhibit allotrophy.
18. Write equations for the production of water gas and producer gas from coke.
19. Define Zeolite. Name the zeolite which converts alcohols directly into gasoline.

- Arrange the hybrides of group 14 elements in increasing order of :

  (a) Thermal stability

  (b) Reducing power.

Group 13
Elements

3-Mark Questions

1. Give reasons of the following :

(i) In diborane, two B—H—B bonds are different from common covalent bonds.

(ii) Aluminium metal shows amphoteric behaviour.

(iii) Quarts is used to develop extremely accurate clocks.

2. A certain salt X gives the following results :

(i) Its aqueous solution is alkaline to litmus.

(ii) It swells up to a glassy material Y on strong heating.

(iii) When conc. H_2SO_4 is added to a hot solution of X, white crystal of an acid Z separates out. Write equations for all the above reactions and identify X, Y and Z.

3. Write balanced equation for :

(i) $B_2H_6 + H_2O \longrightarrow$

(ii) $Al + NaOH \longrightarrow$

(iii) $NaOH + B_2H_6 \longrightarrow$

4. List two important properties in which Boron differs from the rest of the members of group. Mention the main reasons for the difference.

5. What are electron deficient compounds. Are BCl_3 and $SiCl_4$ electron deficien species ? Explain. [NCERT]

Group 14
Elements

6. Select the member(s) of group 14 that :

(i) Forms the most acidic dioxide.

(ii) Is commonly found in + 2 oxidation state.

(iii) Used as semiconductor.

7. What are allotropes ? Sketch the structure of two allotropes of carbon namely diamond and graphite.

8. Give suitable, reasons for the following :

(a) CO_2 turns lime water milky, but if passed for a long time, the solutionl become clear again.

(b) Graphite is a good conductor of electricity but diamond is insulator.

(c) Lead (IV) chloride is highly unstable towards heat.

9. (i) Write the resonance structure of CO_3^{2-} and HCO_3^-. [NCERT]

(ii) Write the name of thermodynamically most suitable form of carbon.

10. (i) Explain why is there a phenomenal decreases in ionisation enthalpy from carbon to silicon ? [NCERT]

(ii) Write an industrial application of silicones.

Group 13 Elements

5-Mark Questions

1. When metal X is treated with NaOH, a white precipitate 'A' is obtained, which is soluble in excess of NaOH to give soluble complex (B). Compound 'A' is soluble in dilute HCl to form compound 'C'. The compound 'A' when heated strongly gives 'D', which is used to extract metal. Identify X, A, B, C and D. Write suitable equations to support their identities. [NCERT]

2. (i) If B-Cl bond has dipoe moment explain why BCl_3 molecules has zero dipole moment.

(ii) A mixture of dil. NaOH and aluminium pieces is used to open drain. Give reason.

(iii) Aluminium wire is used to make transmission cables. Why ? [NCERT]

3. (i) Identify the compounds X and Y in the following reactions :

(a) $Na_2B_4O_7 + 2HCl + 5H_2O \rightarrow 2NaCl + X$

(b) $X \xrightarrow{370\ K} HBO_2 \xrightarrow{>370\ K} Y.$

(ii) Write the name of group 13 element which is used to measure high temperature.

(iii) Why in case of Thallium + 1 oxidation state is more stable than + 3.

Group 14
Elements

4. Compare the general trend in the following properties of the elements of group 13 and 14 :

(a) Atomic size, (b) Ionisation enthalpy, (c) Metallic character, (d) Oxidation states, (e) Nature of halides.

5. Name the following :

(a) The crystalline form of silica used in modern radio and T.V. broadcasting and mobile radio communication.

(b) The oxides of carbon whih form a complex with haemoglobin 300 times more faster than oxygen.

(c) The allotrope of carbon which has $O_f H^{\Theta} = 0$.

(d) A type of polymer is semiorganic in nature.

(e) Two man made silicates.