

# The p-Block Elements (Group 13 and 14)

# **GROUP 13 - THE BORON FAMILY**

Property	В	Al	Ga	In	Tl
Atomic number $(Z)$	5	13	31	49	81
Atomic radius (Å)	0.82	1.18	1.26	1.44	1.48
Radius of trivalent ion (Å)	0.20	0.50	0.62	0.80	0.95
Electronegativity (Pauling scale)	2.0	1.5	1.6	1.7	1.8
Oxidation states	+3	+3	+1, +3	+1, +3	+1, +3

- Inert pair effect: It is the tendency of having less availability of 'ns' electrons in bonding on account of their penetration in (n − 1)d-subshell. On descending the group, the inert pair effect increases and a lower oxidation state which is two less than the highest oxidation state becomes more stable in group 13 to 16.

# **Hydrides**

- **◆** B forms covalent hydrides,  $B_nH_{n+4}$  and  $B_nH_{n+6}$  called boranes.
- Al and In → polymeric hydride → (AlH<sub>3</sub>)<sub>n</sub> and (InH<sub>3</sub>)<sub>n</sub> decomposes on heating.
- B, Al and Ga have the tendency to form complex anionic hydrides like Li[AlH<sub>4</sub>], Li[BH<sub>4</sub>], Li[GaH<sub>4</sub>] etc. due to the presence of a nascent p-orbital in their outermost shells due to which these readily accepts electron pair from the hydride ion (H̄) as MH<sub>3</sub> + H̄ → [MH<sub>4</sub>] [Here, M = Al, Ga and B]

# **Oxides and Hydroxides**

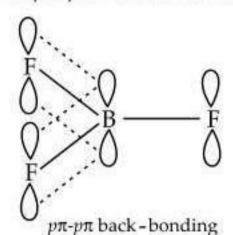
Oxides (M<sub>2</sub>O<sub>3</sub> type) :

 $B_2O_3 \rightarrow More acidic$   $Al_2O_3$  and  $Ga_2O_3 \rightarrow Amphoteric$  $In_2O_3$  and  $Tl_2O_3 \rightarrow Highly basic$ 

Hydroxides [M(OH)<sub>3</sub>] type:
 Tl → Tl(OH)<sub>3</sub> and TlOH

# Halides

- All the halides of group 13 elements are known except Tl(III) iodide.
- BF<sub>3</sub> and BCl<sub>3</sub> → Gases at room temperature.
   BBr<sub>3</sub> → Volatile liquid; BI<sub>3</sub> → Solid
- The trihalides of all the elements of this group act as Lewis acids.
  - $B > Al > Ga > In \rightarrow Electron accepting tendency$
- Lewis acidity:  $BF_3 < BCl_3 < BBr_3 < BI_3$ Because electron-density around boron in  $BF_3$  increases due to  $p\pi$ - $p\pi$  back-bonding.



- The tendency of back donation decreases to BCl<sub>3</sub> and BBr<sub>3</sub> because the energy difference between fully-filled orbital of halogen (Cl-3p, Br-4p) and vacant orbital of B-2p increases.
- Trihalides of Al exist in dimeric form both in vapour state and in non-polar solvent.
- ◆ [AlF<sub>6</sub>]<sup>3-</sup>, [GaCl<sub>6</sub>]<sup>3-</sup> and [InCl<sub>6</sub>]<sup>3-</sup> are formed due to the availability of vacant *d*-orbital in central atoms.
- Due to the small size and inability to accommodate electron, BCl<sub>3</sub> does not change from covalent compound to ion formation in aqueous solution (as occurs in AlCl<sub>3</sub>).
- Al, Ga, In and Tl ions exist as octahedral aqua ions
  i.e., [M(OH<sub>2</sub>)<sub>6</sub>]<sup>3+</sup> in aqueous solution and many salts
  like halides, sulphates, nitrates and perchlorates exist
  as hydrates.
- Aluminium sulphates form double salts called alum with salts of other metals.
- Alums [M<sub>2</sub>SO<sub>4</sub>·M<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>·24H<sub>2</sub>O] → used for softening of hard water and as mordant in dying and printing of textiles.

# **Some Important Chemical Reactions**

$$Al_{2}O_{3} + 6HCl \longrightarrow 2AlCl_{3} + 3H_{2}O$$

$$Al_{2}O_{3} + 2NaOH \longrightarrow 2Na_{3}BO_{3} + 3H_{2}O$$

$$B_{2}O_{3} + 6NaOH \longrightarrow 2Na_{3}BO_{3} + 3H_{2}O$$

$$4BCl_{3} + 3LiAlH_{4} \longrightarrow 3LiCl + 3AlCl_{3} + 2B_{2}H_{6}$$

$$Na_{2}B_{4}O_{7} \cdot 10H_{2}O \xrightarrow{heat} Na_{2}B_{4}O_{7} + 10H_{2}O$$

$$\xrightarrow{heat} 2NaBO_{2} + B_{2}O_{3}$$

$$2NaBH_{4} + I_{2} \longrightarrow B_{2}H_{6} + 2NaI + H_{2}$$

$$2AlN + 6H_{2}O \longrightarrow 2Al(OH)_{3} + 2NH_{3}$$

$$Cr_{2}O_{3} + 2Al \longrightarrow Al_{2}O_{3} + 2Cr$$

$$Al^{3+} + 3NH_{4}OH \longrightarrow Al(OH)_{3(s)}$$

$$\xrightarrow{NaOH} NaAlO_{2} + 2H_{2}O$$

#### Abnormal behaviour of boron :

Boron is a high melting solid containing  $B_{12}$  units. The  $B_{12}$  units icosahedron structure, a solid figure with 12 vertices and 20 equilateral triangles.

Crystalline boron is chemically very inert, it is not affected by acids or oxidising agents. Fused NaOH attacks it above 500°C giving NaBO<sub>2</sub> and H<sub>2</sub>.

Oxidising acids like HNO<sub>3</sub> and conc. H<sub>2</sub>SO<sub>4</sub> dissolve boron but boron remains inert in its reaction with HCl.

$$2B + 3H_2SO_4 \longrightarrow 2H_3BO_3 + 3SO_2$$

- Hydrides of boron like hydrides of silicon are spontaneously flammable volatile compounds.
- The common halides of boron and silicon are mostly gases.
- Boron oxide is acidic in nature.

# Extraction of boron :

▶ Crystalline boron of high purity is obtained by reduction of volatile boron compounds BCl<sub>3</sub> or BBr<sub>3</sub> with H<sub>2</sub>. On the other hand, when B<sub>2</sub>O<sub>3</sub> is reduced with Mg give amorphous boron.

### **Boranes**

- The compound B<sub>2</sub>H<sub>6</sub>·2NH<sub>3</sub> is ionic and exists as [H<sub>3</sub>N → BH<sub>2</sub> ← NH<sub>3</sub>]<sup>+</sup> [BH<sub>4</sub>]<sup>−</sup> and forms borazine on heating.
- Boron nitride (inorganic graphite) structure resembles graphite.
- Boranes are electron deficient compounds.

# Borazine or Borazole or Inorganic Benzene (B<sub>3</sub>N<sub>3</sub>H<sub>6</sub>)

$$3BCl_3 + 4NH_4Cl \rightarrow B_3N_3H_6 \leftarrow 3NaBH_4 + 4NH_4Cl$$

### **Boric Acid**

- There are three types of boric acids :
  - ► Orthoboric acid (H<sub>3</sub>BO<sub>3</sub>)

- Metaboric acid (HBO<sub>2</sub>)
- Pyroboric acid (H<sub>2</sub>B<sub>4</sub>O<sub>7</sub>)

### Orthoboric acid

# **◆** Preparation:

- ► From borax  $Na_2B_4O_7 + H_2SO_4 + 5H_2O \rightarrow 4H_3BO_3 + Na_2SO_4$
- From boron nitride BN + 3H<sub>2</sub>O → H<sub>3</sub>BO<sub>3</sub> + NH<sub>3</sub>

## Properties:

- It is a very weak monobasic acid. B(OH)<sub>3</sub> + H<sub>2</sub>O → [B(OH)<sub>4</sub>] + H
- ▶ Effect of heat on boric acid

$$H_3BO_3 \xrightarrow{100^{\circ}C} HBO_2 + H_2O$$

Metaboric acid

 $4HBO_2 \xrightarrow{140^{\circ}C} H_2B_4O_7 + H_2O$ 

Pyroboric acid

 $H_2B_4O_7 \xrightarrow{300^{\circ}C} 2B_2O_3 + H_2O$ 

Region axide

Aluminium is extracted electrolytically from bauxite. Purified bauxite (melting point 2050°C) is dissolved in cryolite and electrolysed at 950°C. Electrolyte contains 80-85% Al<sub>2</sub>O<sub>3</sub>, CaF<sub>2</sub> – 5 to 7%, AlF<sub>3</sub> – 5 to 7%. Li<sub>2</sub>CO<sub>3</sub> is also used to lower the melting point.

# General chemical behaviour:

 Oxides and hydroxides of aluminium : Al forms oxide M<sub>2</sub>O<sub>3</sub> and hydroxide. M(OH)<sub>3</sub> which are amphoteric in nature.

# **Alums**

- General formula :  $M(I) M'(III) (SO_4)_2 \cdot 24H_2O$ and  $[M(H_2O)_6]^+$ ,  $[M'(H_2O)_6]^{3+}$  and  $SO_4^{2-}$  in 1 : 1 : 2 ratio. e.g.  $M(I) = K^+$  or  $NH_4^+$ ,  $M'(III) = Al^{3+}$
- Used as mordant in dyeing.

# **GROUP 14 - THE CARBON FAMILY**

Property	C	Si	Ge	Sn	Pb
Atomic number (Z)	6	14	32	50	82
Atomic radius (Å)	0.77	1.17	1.22	1.41	1.44
Electronegativity	2.5	1.8	1.8	1.8	1.9
Oxidation states	+4	+4	+2,+4	+ 2, + 4	+ 2, + 4

# **Properties**

- Catenation : C >> Si > Ge ≈ Sn >> Pb
- Complex formation: Except C, all other elements form complexes due to presence of vacant d-orbitals in them i.e., these behaves as Lewis acids.

e.g., 
$$SiF_4 \xrightarrow{forms} [SiF_6]^{2-}$$
, octahedral structure,

 $sp^3d^2$  hybridisation.

# Allotropic forms:

 $C \rightarrow$  crystalline and microcrystalline.

 $Si \rightarrow crystalline$  and amorphous.

 $Ge \rightarrow 2$  crystalline forms.

 $Sn \rightarrow 3$  solid forms  $\rightarrow$  grey tin, white tin and rhombic tin.

**Multiple bonding**: C has strong tendency to show  $p\pi$ - $p\pi$  multiple bond either with itself (C = C, C ≡ C) or with atoms like N, O (C ≡ N, C = O, etc.). Carbon does not have d-orbitals and never forms  $d\pi$ - $p\pi$  or  $d\pi$ - $d\pi$  bonds. On the other hand silicon forms  $d\pi$ - $d\pi$  bonds.

### Oxides:

Oxides	Nature	
CO <sub>2</sub> , SiO <sub>2</sub> , GeO <sub>2</sub>	Acidic	
SnO, SnO <sub>2</sub> , PbO, PbO <sub>2</sub>	Amphoteric	

#### Halides:

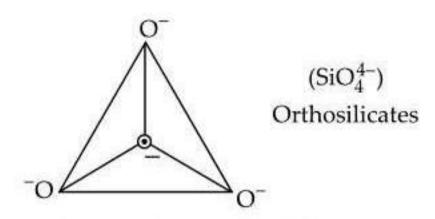
- CF<sub>4</sub> and CCl<sub>4</sub> are very unreactive compounds, but as the halogen increases in size the stability of the carbon tetrahalides towards thermal decomposition decreases.
- With the exception of the carbon compounds, tetrahalides are hydrolysed by water. The reaction is thermally favoured for CX<sub>4</sub>, but the carbon atom is sterically shielded by the halogen atoms.
- With the exception of the carbon compounds, tetrahalides are Lewis acids, and able to form hexahalide anions.
- The dihalides become increasingly more important going down the group, and for lead these are more stable than the tetrahalides.
- ► Stability:  $CX_4 > SiX_4 > GeX_4 > SnX_4 > PbX_4$

# Silicones:

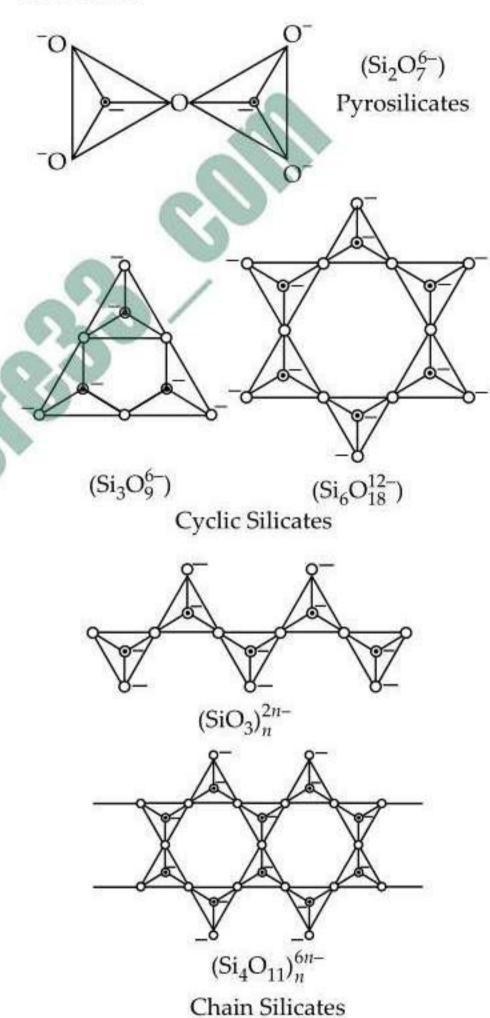
- ► General formula : (R<sub>2</sub>SiO)<sub>n</sub>
- The starting material for the manufacture of silicones is alkyl substituted chlorosilanes.
- ► They are polymeric compounds containing Si—O—Si linkages and R<sub>2</sub>SiO repeating units.
- ➤ These may be linear, cyclic or cross-linked.
- These have very high thermal stability and are called high temperature polymers (R may be alkyl or phenyl group).

# Silicates:

- ► The basic structural unit of silicates is SiO<sub>4</sub><sup>4−</sup> in which silicon atom is bonded to four oxygen atoms in tetrahedron fashion.
  - e.g. zeolites, feldspar, mica, asbestos.
- ▶ In silicates either the discrete unit is present or a number of such units are joined together *via* corners by sharing 1, 2, 3 or 4 oxygen atoms per silicate units.



When silicate units are linked together, they form chain, ring, sheet or three-dimensional structures.



## Zeolites :

- These are the three-dimensional aluminosilicates in which some of the Si atoms are replaced by Al<sup>3+</sup> ions and the negative charge is balanced by cations such as Na<sup>+</sup>, K<sup>+</sup> or Ca<sup>2+</sup> etc.
- They are often used as ion exchangers in softening of hard water and as catalysts in petrochemical industries.



# EXAM DRILL



- In Goldschmidt aluminothermic process, reducing agent used is
  - (a) coke
- (b) Al powder
- (c) Na
- (d) Ca
- The electronic configuration of four elements are given below. Which element does not belong to the same family?
  - (a) [Xe]  $4f^{14}5d^{10}6s^2$
- (b) [Kr]  $4d^{10}5s^2$
- [Ne]  $3s^23p^5$
- (d) [Ar]  $3d^{10}4s^2$
- Which of the following does not exist in free form?
  - (a) BF<sub>3</sub>
- (b) BH<sub>3</sub>
- (c) BCl<sub>3</sub>
- (d) BBr<sub>3</sub>
- In diborane, banana bond is formed between
  - (a) 2 electrons, 3 atoms
- (b) 2 electrons, 1 atom
- (c) 2 electrons, 2 atoms
- (d) 1 electron, 2 atoms.
- The formula of corundum is
  - (a)  $Al_2O_3$
- (b) Al<sub>2</sub>O<sub>3</sub>·H<sub>2</sub>O
- Al<sub>2</sub>O<sub>3</sub>·2H<sub>2</sub>O
- (d) Al<sub>2</sub>O<sub>3</sub>·3H<sub>2</sub>O
- Match the column I with column II and mark the appropriate choice.

Column I		Column II	
(A)	Used as lubricant	(i)	Carbon dioxide
(B)	Oxide with three-dimensional structure	(ii)	Graphite
(C)	Used in solar cells	(iii)	Silica
(D)	Anhydride of carbonic acid	(iv)	Silicone

- (a)  $(A) \rightarrow (iv)$ ,  $(B) \rightarrow (iii)$ ,  $(C) \rightarrow (ii)$ ,  $(D) \rightarrow (i)$
- (b)  $(A) \rightarrow (iv)$ ,  $(B) \rightarrow (i)$ ,  $(C) \rightarrow (iii)$ ,  $(D) \rightarrow (ii)$
- (c)  $(A) \rightarrow (iii), (B) \rightarrow (ii), (C) \rightarrow (i), (D) \rightarrow (iv)$
- (d)  $(A) \rightarrow (ii), (B) \rightarrow (iii), (C) \rightarrow (iv), (D) \rightarrow (i)$
- Which of the following is not easily hydrolysed?
- (a) CCl<sub>4</sub>
- (b) SiCl<sub>4</sub> (c) SnCl<sub>4</sub>
- (d) PbCl₄
- Which of the following oxide is basic?
  - (a) SiO<sub>2</sub>
- (b)  $SnO_2$  (c)  $CO_2$
- (d) Li<sub>2</sub>O
- The main factor responsible for acidic nature of BF<sub>3</sub> is
  - $p\pi$ - $d\pi$  back-bonding (a)
  - (b) three centre-electron bonds in BF<sub>3</sub>
  - large electronegativity of F (c)
  - $p\pi$ - $p\pi$  back-bonding.
- 10. Which among the following has the tendency to form covalent compounds?
  - Calcium
- (b) Beryllium
- Strontium (c)
- (d) Magnesium

- 11. Which one of the following is incorrect?
  - (a) Boron halides are all monomeric while those of Al are dimeric.
  - (b) Boron halides and aluminium halides exist as monomeric halides.
  - Boron halides and aluminium halides are Lewis acids.
  - (d) B<sub>2</sub>O<sub>3</sub> alone is acidic while Al<sub>2</sub>O<sub>3</sub> is amphoteric.
- 12. Electrolytic reduction of alumina to aluminium by Hall-Heroult process is carried out
  - (a) in the presence of NaCl
  - (b) in the presence of fluorite
  - (c) in the presence of cryolite which forms a melt with lower melting temperature
  - (d) in the presence of cryolite which forms a melt with higher melting temperature.
- 13. Which of the following hydroxides is acidic in nature?
  - (a) Be(OH)<sub>2</sub>
- (b) Mg(OH)<sub>2</sub>
- (c) B(OH)<sub>3</sub>
- $Al(OH)_3$
- 14. AlCl<sub>3</sub> is a
  - (a) weak protonic acid
- (b) strong protonic acid
- (c) Lewis acid
- (d) Lewis base.
- 15. Arrange CCl<sub>4</sub>, AlCl<sub>3</sub>, PCl<sub>5</sub> and SiCl<sub>4</sub> according to ease of hydrolysis.
  - (a) CCl<sub>4</sub> < SiCl<sub>4</sub> < PCl<sub>5</sub> < AlCl<sub>3</sub>
  - (b) AlCl<sub>3</sub> < CCl<sub>4</sub> < PCl<sub>5</sub> < SiCl<sub>4</sub>
  - (c) CCl<sub>4</sub> < AlCl<sub>3</sub> < PCl<sub>5</sub> < SiCl<sub>4</sub>
  - (d) CCl<sub>4</sub> < AlCl<sub>3</sub> < SiCl<sub>4</sub> < PCl<sub>5</sub>
- 16. In silicon dioxide
  - (a) each silicon atom is surrounded by four oxygen atoms and each oxygen atom is bonded to two silicon atoms
  - each silicon atom is surrounded by two oxygen atoms and each oxygen atom is bonded to two silicon atoms
  - (c) silicon atom is bonded to two oxygen atoms
  - (d) there are double bonds between silicon and oxygen atoms.
- 17. Which is/are true statements?
  - (a) Diamond is unaffected by conc. acids but graphite reacts with hot conc. HNO3.
  - (b) CO is toxic because it forms a complex with haemoglobin in the blood.
  - (c) C<sub>3</sub>O<sub>2</sub>, carbon suboxide, is a foul-smelling gas.
  - (d) All are true statements.
- 18. In the reaction  $B_2O_3 + C + Cl_2 \rightarrow A + CO$ . The A is
  - (a) CCl<sub>4</sub>
- (b) BCl<sub>3</sub> (c) BCl<sub>2</sub>
- (d)  $B_2Cl_2$
- **19.** The tendency of BF<sub>3</sub>, BCl<sub>3</sub> and BBr<sub>3</sub> to behave as Lewis acid decreases in the sequence
  - (a)  $BCl_3 > BF_3 > BBr_3$
- (b)  $BBr_3 > BCl_3 > BF_3$
- $BBr_3 > BF_3 > BCl_3$
- (d)  $BF_3 > BCl_3 > BBr_3$

- 20. Which of the following shows a pattern of bonding in silicones?
  - (a) Si C Si O Si
- (b) Si C Si C Si
- Si O Si O Si
- (d) Si Si Si Si
- 21. The incorrect statement among the following is
  - (a) the first ionization potential of Al is less than the first ionization potential of Mg
  - (b) the second ionization potential of Mg is greater than the second ionization potential of Na
  - the first ionization potential of Na is less than the first ionization potential of Mg
  - (d) the third ionization potential of Mg is greater than the third ionization potential of Al.
- 22. B<sub>2</sub>H<sub>6</sub> consists of
  - (a) covalent and ionic bond
  - (b) covalent and 3 centre two electron bond
  - (c) metallic and covalent
  - (d) only covalent.
- The hydration energy of Mg<sup>2+</sup> ions is higher than that of
  - $Al^{3+}$ (a)
- (b) Be<sup>2+</sup>
- (c)  $Na^{+}$
- (d) none of these.
- 24. Borax on heating strongly above its melting point melts to a liquid which then solidifies to a transparent mass commonly known as borax bead. The transparent glassy mass consists of
  - (a) mixture of sodium metaborate and boric anhydride
  - (b) boric anhydride
  - sodium metaborate
  - (d) sodium pyroborate.
- 25. Dry powder fire extinguisher contains
  - sand
- (b) sand and Na<sub>2</sub>CO<sub>3</sub>
- sand and baking soda (d) sand and K<sub>2</sub>CO<sub>3</sub>. (c)
- 26. Name the two type of the structure of silicate in which one oxygen atom of  $[SiO_4]^4$  is shared?
  - (a) Linear chain silicate (b) Sheet silicate
- - Pyrosilicate (c)
- (d) Three dimensional
- 27. The bonds present in borazole  $(B_3N_3H_6)$  are
  - $9\sigma$ ,  $6\pi$ (a)
- (b)  $12\sigma$ ,  $3\pi$
- $6\sigma$ ,  $9\pi$
- (d)  $15 \sigma$  only.
- 28. Boron does not form B3+ ions whereas Al forms Al3+ ions. This is because
  - (a) the size of B atom is smaller than that of Al
    - (b) the sum of  $IE_1 + IE_2 + IE_3$  of B is much higher than that of Al
    - (c) the sum of  $IE_1 + IE_2 + IE_3$  of Al is much higher than that of B
    - (d) both (a) and (b).
- 29. Diamond is hard because
  - all the four valence electrons are bonded to each carbon atom by covalent bonds
  - (b) it is a giant molecule
  - (c) it is made up of carbon atoms
  - (d) it cannot be burnt.

- 30. Which is not correct?
  - (a) Ge(OH<sub>2</sub>) is amphoteric.
  - (b) GeCl<sub>2</sub> is more stable than GeCl<sub>4</sub>.
  - (c) GeO<sub>2</sub> is weakly acidic.
  - (d) GeCl<sub>4</sub> in HCl forms [GeCl]<sup>2-</sup> ion.
- 31. AlCl<sub>3</sub> is covalent while AlF<sub>3</sub> is ionic. This fact can be justified on the basis of
  - (a) valence bond theory
- (b) crystal structure
- (c) lattice energy
- (d) Fajan rule.
- 32. What would you observe if excess of dilute NaOH solution is added and shaken with an aqueous solution of aluminium chloride?
  - (a) A permanent white precipitate is formed immediately.
  - (b) No change at first but a white precipitate is formed on standing.
  - A white precipitate is formed which later dissolves.
  - a green precipitate which turns red on standing in air.
- 33. Which of the following exists as a dimer?
  - (a) Aluminium chloride (b) Sodium bromide
  - (c) Methyl iodide
- (d) Magnesium chloride
- 34. A metal M forms chlorides in +2 and +4 oxidation states. Which of the following statements about these chlorides is correct?
  - (a) MCl<sub>2</sub> is more volatile than MCl<sub>4</sub>.
  - MCl<sub>2</sub> is more soluble in anhydrous ethanol than  $MCl_4$ .
  - (c) MCl<sub>2</sub> is more ionic than MCl<sub>4</sub>.
  - (d) MCl<sub>2</sub> is more easily hydrolysed than MCl<sub>4</sub>.
- 35. Extraction of aluminium from aluminium oxide (Al<sub>2</sub>O<sub>3</sub>) is best done by
  - (a) electrolytic reduction of Al<sub>2</sub>O<sub>3</sub>
  - (b) reduction of Al<sub>2</sub>O<sub>3</sub> with carbon
  - (c) reduction of Al<sub>2</sub>O<sub>3</sub> with sodium
  - (d) reduction of Al<sub>2</sub>O<sub>3</sub> with CO.
- Lead poisoning in the body can be removed by
  - (a) EDTA in the form of calcium dihydrogen salt
  - (b) cis-platin
  - Zeisse's salt
  - (d) DMG.
- 37. Quartz is an example of
  - (a) chain silicate
- (b) infinite sheet silicate
- framework silicate
- (d) cyclic silicate.
- 38. Aluminium on reaction with aqueous KOH solution gives
  - (a)  $KO_2 + H_2$
- (b)  $KAlO_2 + H_2$
- (c)  $K_2O + H_2$
- (d)  $KAlO_2 + H_2O$
- 39. Consider the following reaction:

$$BF_3 \xrightarrow{Al_2Cl_6} (A) \xrightarrow{gas} (B) \xrightarrow{H_2O} (C)$$

Select the incorrect statement.

- (a) The compound (A) is BCl<sub>3</sub>.
- (b) The compound (C) is B<sub>2</sub>(OH)<sub>4</sub>.
- The compound (C) is  $B(OH)_3$ .
- (d) The compound (B) is B<sub>2</sub>Cl<sub>4</sub>.

- In Goldschmidt aluminothermic process, thermite contains
  - (a) 3 parts of Fe<sub>2</sub>O<sub>3</sub> and 2 parts of Al
  - (b) 3 parts of Al<sub>2</sub>O<sub>3</sub> and 4 parts of Al
  - (c) 3 parts of Fe<sub>2</sub>O<sub>3</sub> and 1 part of Al
  - (d) 1 part of Fe<sub>2</sub>O<sub>3</sub> and 1 part of Al.
- The stability of dihalides of Si, Ge, Sn and Pb increases steadily in the sequence
  - (a)  $GeX_2 \ll SiX_2 \ll SnX_2 \ll PbX_2$
  - (b)  $SiX_2 \ll GeX_2 \ll PbX_2 \ll SnX_2$
  - (c)  $SiX_2 \ll GeX_2 \ll SnX_2 \ll PbX_2$
  - (d)  $PbX_2 << SnX_2 << GeX_2 << SiX_2$
- **42.** In  $SiF_6^{2-}$  and  $SiCl_6^{2-}$  which one is known and why?
  - (a)  $SiF_6^{2-}$  because of small size of F
  - (b) SiF<sub>6</sub><sup>2-</sup> because of large size of F
  - (c) SiCl<sub>6</sub><sup>2-</sup> because of small size of Cl
  - (d) SiCl<sub>6</sub><sup>2-</sup> because of large size of Cl

- **43.**  $\operatorname{SnCl}_2 + \operatorname{HgCl}_2 \longrightarrow (A) + \operatorname{SnCl}_4$  White ppt.
  - $(A) + \operatorname{SnCl}_2 \longrightarrow (B)$ Grey

A and B are

- (a) HgCl<sub>4</sub>, Hg
- (b) Hg<sub>2</sub>Cl<sub>2</sub>, Hg
- (c) SnCl<sub>4</sub>, Sn
- (d) Sn<sub>2</sub>Cl<sub>2</sub>, Sn
- 44. In graphite, additional electrons are
  - (a) localised on each C-atom
  - (b) localised on every third C-atom
  - (c) present in anti-bonding orbital
  - (d) delocalised forming extended π-bonding system.
- **45.** Which one of the following statements about the zeolites is false?
  - (a) They are used as cation exchangers.
  - (b) They have open structure which enables them to take up small molecules.
  - (c) Zeolites are aluminosilicates having three dimensional network.
  - (d) Some of the SiO<sub>4</sub><sup>4-</sup> units are replaced by AlO<sub>4</sub><sup>5-</sup> and AlO<sub>6</sub><sup>9-</sup> ions in zeolites.

# **DAY 11 OMR SHEET**

Time: 45 min

# INSTRUCTIONS

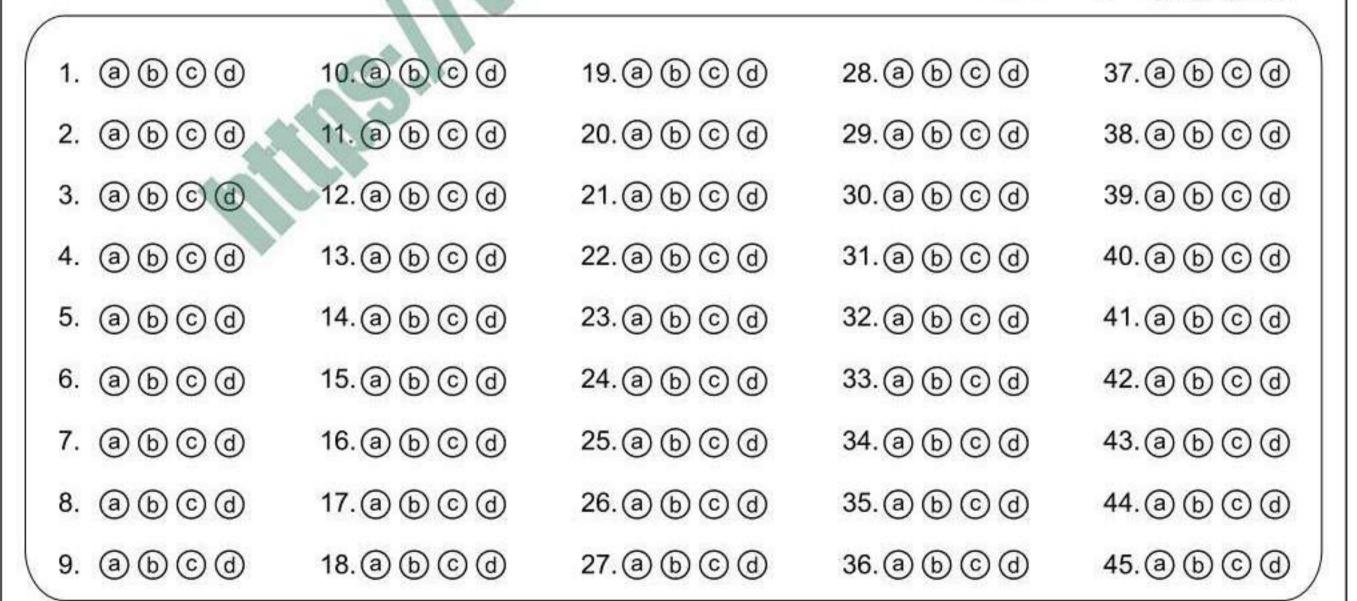
- Use HB pencil only and darken each circle completely.
- If you wish to change your answer, erase the already darkened circle completely and then darken the
  appropriate circle.
- Mark only one choice for each question as indicated.

Correct marking

**b**© **d** 

Wrong marking

**8 9 0 0** 



- (1) Number of questions attempted : \_\_\_\_\_ (3) Marks scored : \_\_\_\_\_
- (2) Number of questions correct : \_\_\_\_\_

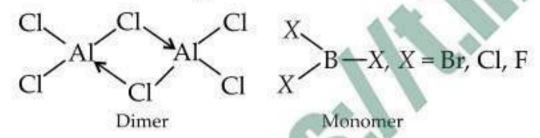
For every correct answer award yourself 4 marks. For every incorrect answer deduct 1 mark.



# HINTS & SOLUTIONS



- 1. (b): All powder is a reducing agent in thermite process.
- **2. (c)** : Electronic configuration in option (c) is different and belongs to *p*-block whereas other elements belong to *d*-block.
- **3. (b)** : Boron forms hydrides with general formula  $B_nH_{n+4}$  but  $BH_3$  exists as  $B_2H_6$ .
- 4. (a)
- 5. (a): Al<sub>2</sub>O<sub>3</sub> in anhydrous form is called corundum.
- 6. (d)
- 7. (a) : CCl<sub>4</sub> cannot be hydrolysed easily due to the absence of *d*-orbitals which results in inability of C to extend its coordination number.
- **8. (d)** : SiO<sub>2</sub> and CO<sub>2</sub> are acidic in nature. SnO<sub>2</sub> is an amphoteric and Li<sub>2</sub>O is basic oxide.
- 9. (d):  $p\pi$ - $p\pi$  back-bonding is responsible for acidic nature of boron halides. Smaller atoms show more backbonding.
- **10. (b)** : Beryllium has a tendency to form covalent salts due to its smaller size and higher ionization enthalpy.
- 11. (b): Trihalides of boron are monomeric, whereas halides of Al like AlCl<sub>3</sub> exist as dimers, Al<sub>2</sub>Cl<sub>6</sub>.



12. (c)

13. (c) :  $B(OH)_3$  i.e.  $H_3BO_3$  acts as a weak acid in an aqueous solution.

$$H \longrightarrow B(OH)_3 \Longrightarrow [B(OH)_4]^- + H^+$$

- **14. (c)** : AlCl<sub>3</sub> is electron deficient molecule and have tendency to accept a pair of electrons to achieve stable electronic configuration and thus, behave as Lewis acid.
- **15. (d)**: Ease of hydrolysis of given halides follows the order:  $CCl_4 < AlCl_3 < SiCl_4 < PCl_5$
- 16. (a)
- (d): Graphite reacts with conc. HNO<sub>3</sub> due to presence of mobile electrons.
- 18. (b):  $B_2O_3 + 3C + 3Cl_2 \rightarrow 2BCl_3 + CO$
- 19. (b)
- **20.** (c) : Silicones contain Si O Si linkages.
- 21. (b): The removal of second electron from Mg gives it a closed shell configuration which gives it stability whereas

the removal of second electron from Na breaks its closed shell configuration. So, higher amount of energy is required. So second ionization potential of Mg is lesser than that of Na.

- **22. (b)** : According to molecular orbital theory, each of the two boron atoms is in  $sp^3$  hybrid state. Of the four hybrid orbitals, three have one electron each while the fourth is empty. Two of the four orbitals of each of the boron atom overlap with two terminal hydrogen atoms forming two normal  $B-H\sigma$ -bonds. One of the remaining hybrid orbital (either filled or empty) of one of the boron atoms; 1s orbital of hydrogen atom (bridge atom) and one of hybrid orbitals of the other boron atom overlap to form a delocalised orbital covering the three nuclei with a pair of electrons. Such a bond is known as three centre two electron bonds.
- 23. (c): Mg<sup>2+</sup> has smaller size than Na<sup>+</sup> and thus has higher hydration energy than Na<sup>+</sup>.

24. (a): 
$$Na_2B_4O_7 . 10H_2O \xrightarrow{Heat}$$
 2NaBO<sub>2</sub> +  $B_2O_3$   
Borax Sodium Boric anhydride

- **25. (c)**: Mixture of sand (SiO<sub>2</sub>) and baking soda (NaHCO<sub>3</sub>) is used as a dry powder fire extinguisher.
- **26.** (c) : Pyrosilicate contains two units of  $SiO_4^{4-}$  joined along a corner containing oxygen atom.

- **27. (b)** : There are six B-N, three B-H and three N-H sigma bonds and three B-N pi bonds in borazole.
- **28. (d)** : Boron atom is smaller in size and therefore, the sum of  $IE_1 + IE_2 + IE_3$  (3659 kJ mol<sup>-1</sup>) for B is much higher than that of Al (2744 kJ mol<sup>-1</sup>). Hence B does not form B<sup>3+</sup> ions.
- **29.** (a) : In diamond, each carbon atom is in  $sp^3$ -hybridized state and linked to four other carbon atoms tetrahedrally by strong covalent bonds. So diamond is a hard substance.
- **30. (b)** : Ge<sup>4+</sup> is more stable than Ge<sup>2+</sup>, thus GeCl<sub>4</sub> is more stable than GeCl<sub>2</sub>.
- **31. (d)** : Smaller the size of anion (F ), lesser will be its polarisability and hence more is the ionic character. Thus AlCl<sub>3</sub> is covalent while AlF<sub>6</sub> is ionic-Fajan rule.

32. (c) : 
$$AlCl_3 + 3NaOH \longrightarrow Al(OH)_3 + 3NaCl$$
  
 $Al(OH)_3 + NaOH \longrightarrow NaAlO_2 + 2H_2O$   
soluble

- 33. (a) : AlCl<sub>3</sub> exists as Al<sub>2</sub>Cl<sub>6</sub>.
- 34. (c) 35. (a) 36. (a)
- **37. (c)** : Quartz is a covalent crystal having a framework of silicates, *i.e.*, a three dimensional network when all the four oxygen atoms of each of SiO<sub>4</sub> tetrahedron are shared.
- 38. (b) :  $2Al + 2KOH + 2H_2O \longrightarrow 2KAlO_2 + 3H_2$ This is called Uyeno's method for the preparation of pure hydrogen.
- 39. (c) : (a) is correct  $2BF_3 + Al_2Cl_6 \rightarrow 2BCl_3 + Al_2F_6$
- (b) is correct  $B_2Cl_4 + 4H_2O \longrightarrow B_2(OH)_4 + 4HCl$
- (d) is correct 2BCl<sub>3</sub>  $\xrightarrow{\text{gas}}$  B<sub>2</sub>Cl<sub>4</sub> + Cl<sub>2</sub>

- **40. (c)** : In Goldschmidt aluminothermic process, thermite contains 3 parts of Fe<sub>2</sub>O<sub>3</sub> and 1 part of Al.
- **41. (c)** : Due to inert pair effect, tendency to exhibit +2 oxidation state increases as we move down the group.
- **42.** (a) : Due to small size of  $F^-$ , silicon forms complex ion.
- 43. (b):  $SnCl_2 + 2HgCl_2 \longrightarrow Hg_2Cl_2 + SnCl_4$ White ppt.  $Hg_2Cl_2 + SnCl_2 \longrightarrow 2Hg + SnCl_4$ Grey.
- **44. (d)** : In graphite, carbon is in  $sp^2$  hybridised state and the additional p-electron from each carbon forms an extended delocalised  $\pi$ -bonding system encompassing the entire layer, this makes graphite a good conductor.
- 45. (d)

