Unit

11

THE p -BLOCK ELEMENTS

I. Multiple Choice Questions (Type-I)

1. The element which exists in liquid state for a wide range of temperature and can be used for measuring high temperature is

(i) B
(ii) Al
(iii) Ga
(iv) In

2. Which of the following is a Lewis acid ?

(i) $AlCl_3$
(ii) $MgCl_2$
(iii) $CaCl_2$
(iv) $BaCl_2$

3. The geometry of a complex species can be understood from the knowledge of type of hybridisation of orbitals of central atom. The hybridisation of orbitals of central atom in $[Be(OH)_4]^-$ and the geometry of the complex are respectively

(i) sp^3, tetrahedral
(ii) sp^3, square planar
(iii) sp^3d^2, octahedral
(iv) dsp^2, square planar

4. Which of the following oxides is acidic in nature?

(i) B_2O_3
(ii) Al_2O_3
(iii) Ga_2O_3
(iv) In_2O_3

5. The exhibition of highest co-ordination number depends on the availability of vacant orbitals in the central atom. Which of the following elements is **not** likely to act as central atom in MF_6^{3-}?

(i) B

(ii) Al

(iii) Ga

(iv) In

6. Boric acid is an acid because its molecule

(i) contains replaceable H^+ ion

(ii) gives up a proton

(iii) accepts OH^- from water releasing proton

(iv) combines with proton from water molecule

7. Catenation i.e., linking of similar atoms depends on size and electronic configuration of atoms. The tendency of catenation in Group 14 elements follows the order:

(i) C > Si > Ge > Sn

(ii) C >> Si > Ge ≈ Sn

(iii) Si > C > Sn > Ge

(iv) Ge > Sn > Si > C

8. Silicon has a strong tendency to form polymers like silicones. The chain length of silicone polymer can be controlled by adding

(i) $MeSiCl_3$

(ii) Me_2SiCl_2

(iii) Me_3SiCl

(iv) Me_4Si

9. Ionisation enthalpy ($\Delta_i H_1$ kJ mol^{-1}) for the elements of Group 13 follows the order.

(i) B > Al > Ga > In > Tl

(ii) B < Al < Ga < In < Tl

(iii) B < Al > Ga < In > Tl

(iv) B > Al < Ga > In < Tl

10. In the structure of diborane

(i) All hydrogen atoms lie in one plane and boron atoms lie in a plane perpendicular to this plane.

(ii) 2 boron atoms and 4 terminal hydrogen atoms lie in the same plane and 2 bridging hydrogen atoms lie in the perpendicular plane.

(iii) 4 bridging hydrogen atoms and boron atoms lie in one plane and two terminal hydrogen atoms lie in a plane perpendicular to this plane.

(iv) All the atoms are in the same plane.

11. A compound X, of boron reacts with NH_3 on heating to give another compound Y which is called inorganic benzene. The compound X can be prepared by treating BF_3 with Lithium aluminium hydride. The compounds X and Y are represented by the formulas.

(i) B_2H_6, $B_3N_3H_6$

(ii) B_2O_3, $B_3N_3H_6$

(iii) BF_3, $B_3N_3H_6$

(iv) $B_3N_3H_6$, B_2H_6

12. Quartz is extensively used as a piezoelectric material, it contains _____.

(i) Pb

(ii) Si

(iii) Ti

(iv) Sn

13. The most commonly used reducing agent is

(i) $AlCl_3$

(ii) $PbCl_2$

(iii) $SnCl_4$

(iv) $SnCl_2$

14. Dry ice is

(i) Solid NH_3

(ii) Solid SO_2

(iii) Solid CO_2

(iv) Solid N_2

15. Cement, the important building material is a mixture of oxides of several elements. Besides calcium, iron and sulphur, oxides of elements of which of the group (s) are present in the mixture?

(i) group 2

(ii) groups 2, 13 and 14

(iii) groups 2 and 13

(iv) groups 2 and 14

II. Multiple Choice Questions (Type-II)

In the following questions two or more options may be correct.

16. The reason for small radius of Ga compared to Al is _____.

(i) poor screening effect of *d* and *f* orbitals

(ii) increase in nuclear charge

(iii) presence of higher orbitals

(iv) higher atomic number

17. The linear shape of CO_2 is due to _____.

(i) sp^3 hybridisation of carbon

(ii) sp hybridisation of carbon

(iii) $p\pi - p\pi$ bonding between carbon and oxygen

(iv) sp^2 hybridisation of carbon

18. Me_3SiCl is used during polymerisation of organo silicones because

(i) the chain length of organo silicone polymers can be controlled by adding Me_3SiCl

(ii) Me_3SiCl blocks the end terminal of silicone polymer

(iii) Me_3SiCl improves the quality and yield of the polymer

(iv) Me_3SiCl acts as a catalyst during polymerisation

19. Which of the following statements are correct?

(i) Fullerenes have dangling bonds

(ii) Fullerenes are cage-like molecules

(iii) Graphite is thermodynamically most stable allotrope of carbon

(iv) Graphite is slippery and hard and therefore used as a dry lubricant in machines

20. Which of the following statements are correct. Answer on the basis of Fig.11.1.

(i) The two birdged hydrogen atoms and the two boron atoms lie in one plane;

(ii) Out of six B–H bonds two bonds can be described in terms of 3 centre 2-electron bonds.

(iii) Out of six B-H bonds four B-H bonds can be described in terms of 3 centre 2 electron bonds;

(iv) The four terminal B-H bonds are two centre-two electron regular bonds.

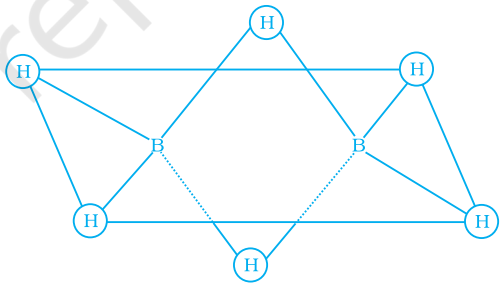

Fig. *11.1*

21. Identify the correct resonance structures of carbon dioxide from the ones given below :

(i) $O - C \equiv O$

(ii) $O = C = O$

(iii) $\overset{-}{O} \equiv C - O^+$

(iv) $\overset{-}{O} - C \equiv O^+$

III. Short Answer Type

22. Draw the structures of $BCl_3.NH_3$ and $AlCl_3$ (dimer).

23. Explain the nature of boric acid as a Lewis acid in water.

24. Draw the structure of boric acid showing hydrogen bonding. Which species is present in water? What is the hybridisation of boron in this species?

25. Explain why the following compounds behave as Lewis acids?

(i) BCl_3 (ii) $AlCl_3$

26. Give reasons for the following:

(i) CCl_4 is immiscible in water, whereas $SiCl_4$ is easily hydrolysed.

(ii) Carbon has a strong tendency for catenation compared to silicon.

27. Explain the following :

(i) CO_2 is a gas whereas SiO_2 is a solid.

(ii) Silicon forms SiF_6^{2-} ion whereas corresponding fluoro compound of carbon is not known.

28. The +1 oxidation state in group 13 and +2 oxidation state in group 14 becomes more and more stable with increasing atomic number. Explain.

29. Carbon and silicon both belong to the group 14, but inspite of the stoichiometric similarity, the dioxides, (i.e., carbon dioxide and silicon dioxide), differ in their structures. Comment.

30. If a trivalent atom replaces a few silicon atoms in three dimensional network of silicon dioxide, what would be the type of charge on overall structure?

31. When BCl_3 is treated with water, it hydrolyses and forms $[B(OH)_4]^-$ only whereas $AlCl_3$ in acidified aqueous solution forms $[Al(H_2O)_6]^{3+}$ ion. Explain what is the hybridisation of boron and aluminium in these species?

32. Aluminium dissolves in mineral acids and aqueous alkalies and thus shows amphoteric character. A piece of aluminium foil is treated with dilute hydrochloric acid or dilute sodium hydroxide solution in a test tube and on bringing a burning matchstick near the mouth of the test tube, a pop sound indicates the evolution of hydrogen gas. The same activity when performed with concentrated nitric acid, reaction doesn't proceed. Explain the reason.

33. Explain the following :

(i) Gallium has higher ionisation enthalpy than aluminium.

(ii) Boron does not exist as B^{3+} ion.

(iii) Aluminium forms $[AlF_6]^{3-}$ ion but boron does not form $[BF_6]^{3-}$ ion.

(iv) PbX_2 is more stable than PbX_4.

(v) Pb^{4+} acts as an oxidising agent but Sn^{2+} acts as a reducing agent.

(vi) Electron gain enthalpy of chlorine is more negative as compared to fluorine.

(vii) $Tl(NO_3)_3$ acts as an oxidising agent.

(viii) Carbon shows catenation property but lead does not.

(ix) BF_3 does not hydrolyse.

(x) Why does the element silicon, not form a graphite like structure whereas carbon does.

34. Identify the compounds A, X and Z in the following reactions :

(i) $A + 2HCl + 5H_2O \longrightarrow 2NaCl + X$

$$X \xrightarrow[370K]{\Delta} HBO_2 \xrightarrow[>370K]{\Delta} Z$$

35. Complete the following chemical equations :

$Z + 3\ LiAlH_4 \longrightarrow X + 3\ LiF + 3AlF_3$

$X + 6H_2O \longrightarrow Y + 6H_2$

$3X + 3O_2 \xrightarrow{\Delta} B_2O_3 + 3H_2O$

IV. Matching Type

In the following questions more than one correlation is possible between options of Column I and Column II. Make as many correlations as you can.

36. Match the species given in Column I with the properties mentioned in Column II.

Column I	**Column II**
(i) BF_4^-	(a) Oxidation state of central atom is +4
(ii) $AlCl_3$	(b) Strong oxidising agent
(iii) SnO	(c) Lewis acid
(iv) PbO_2	(d) Can be further oxidised
	(e) Tetrahedral shape

37. Match the species given in Column I with properties given in Column II.

Column I	**Column II**
(i) Diborane	(a) Used as a flux for soldering metals
(ii) Galluim	(b) Crystalline form of silica
(iii) Borax	(c) Banana bonds
(iv) Aluminosilicate	(d) Low melting, high boiling, useful for measuring high temperatures
(v) Quartz	(e) Used as catalyst in petrochemical industries

38. Match the species given in Column I with the hybridisation given in Column II.

Column I	Column II
(i) Boron in $[B(OH)_4]^-$	(a) sp^2
(ii) Aluminium in $[Al(H_2O)_6]^{3+}$	(b) sp^3
(iii) Boron in B_2H_6	(c) sp^3d^2
(iv) Carbon in Buckminsterfullerene	
(v) Silicon in SiO_4^{4-}	
(vi) Germanium in $[GeCl_6]^{2-}$	

V. Assertion and Reason Type

In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

39. ***Assertion (A):*** If aluminium atoms replace a few silicon atoms in three dimensional network of silicon dioxide, the overall structure acquires a negative charge.

Reason (R) : Aluminium is trivalent while silicon is tetravalent.

(i) Both A and R are correct and R is the correct explanation of A.

(ii) Both A and R are correct but R is not the correct explanation of A.

(iii) Both A and R are not correct

(iv) A is not correct but R is correct.

40. ***Assertion (A):*** Silicons are water repelling in nature.

Reason (R) : Silicons are organosilicon polymers, which have $(-R_2SiO-)$ as repeating unit.

(i) A and R both are correct and R is the correct explanation of A.

(ii) Both A and R are correct but R is not the correct explanation of A.

(iii) A and R both are not true.

(iv) A is not true but R is true.

VI. Long Answer Type

41. Describe the general trends in the following properties of the elements in Groups 13 and 14.

(i) Atomic size

(ii) Ionisation enthalpy

(iii) Metallic character

(iv) Oxidation states

(v) Nature of halides

42. Account for the following observations:

(i) $AlCl_3$ is a Lewis acid

(ii) Though fluorine is more electronegative than chlorine yet BF_3 is a weaker Lewis acid than BCl_3

(iii) PbO_2 is a stronger oxidising agent than SnO_2

(iv) The +1 oxidation state of thallium is more stable than its +3 state.

43. When aqueous solution of borax is acidified with hydrochloric acid, a white crystalline solid is formed which is soapy to touch. Is this solid acidic or basic in nature? Explain.

44. Three pairs of compounds are given below. Identify that compound in each of the pairs which has group 13 element in more stable oxidation state. Give reason for your choice. State the nature of bonding also.

(i) $TlCl_3$, TlCl

(ii) $AlCl_3$, AlCl

(iii) $InCl_3$, InCl

45. BCl_3 exists as monomer whereas $AlCl_3$ is dimerised through halogen bridging. Give reason. Explain the structure of the dimer of $AlCl_3$ also.

46. Boron fluoride exists as BF_3 but boron hydride doesn't exist as BH_3. Give reason. In which form does it exist? Explain its structure.

47. (i) What are silicones? State the uses of silicones.

(ii) What are boranes? Give chemical equation for the preparation of diborane.

48. A compound (A) of boron reacts with NMe_3 to give an adduct (B) which on hydrolysis gives a compound (C) and hydrogen gas. Compound (C) is an acid. Identify the compounds A, B and C. Give the reactions involved.

49. A nonmetallic element of group 13, used in making bullet proof vests is extremely hard solid of black colour. It can exist in many allotropic forms and has unusually high melting point. Its trifluoride acts as Lewis acid towards ammonia. The element exihibits maximum covalency of four. Identify the element and write the reaction of its trifluoride with ammonia. Explain why does the trifluoride act as a Lewis acid.

50. A tetravalent element forms monoxide and dioxide with oxygen. When air is passed over heated element (1273 K), producer gas is obtained. Monoxide of the element is a powerful reducing agent and reduces ferric oxide to iron. Identify the element and write formulas of its monoxide and dioxide. Write chemical equations for the formation of producer gas and reduction of ferric oxide with the monoxide.

ANSWERS

I. Multiple Choice Questions (Type-I)

1. (iii)	2. (i)	3. (i)	4. (i)	5. (i)	6. (iii)
7. (ii)	8. (iii)	9. (iv)	10. (ii)	11. (i)	12. (ii)
13. (iv)	14. (iii)	15. (ii)			

II. Multiple Choice Questions (Type-II)

16. (i), (ii)	17. (ii), (iii)	18. (i), (ii)
19. (ii), (iii)	20. (i), (ii), (iv)	21. (ii), (iv)

III. Short Answer Type

23. Boric acid acts as Lewis acid in water by accepting a pair of electrons from a hydroxyl ion :

$B(OH)_3 + 2HOH \longrightarrow [B(OH)_4]^- + H_3O^+$

24. Species present in water is $[B(OH)_4]^-$. Boron is sp^3 hybridised.

25. BCl_3 and $AlCl_3$ being electron deficient due to incomplete octet of central metal atom behave as Lewis acids.

26. CCl_4 is a covalent compound. Hence, insoluble in water whereas $SiCl_4$ is soluble because Si atom in $SiCl_4$ can accomodate the lone pair of electrons obtained from oxygen atom of water molecule in *d*-orbitals.

27. (i) Very high Si-O bond enthalpy and ionic character of Si-O bond.

(ii) Vacant 3*d* orbitals are available on Si atom to accomodate electrons and expand coordination number upto 6.

29. [**Hint :** In CO_2, carbon is *sp* hybridised and it is a linear molecule. In SiO_2, Si is tetrahedrally bonded to four oxygen atoms.]

30. Negative

32. [**Hint :** Conc. HNO_3 renders aluminium passive by forming a protective oxide layer on the surface.]

34. A : $Na_2B_4O_7$ (Borax)
X : H_3BO_3
Z : B_2O_3

35. A : BF_3
X : B_2H_6
Y ; H_3BO_3

IV. Matching Type

36. (i) → (e) (ii) → (c) (iii) → (d) (iv) → (a), (b)

37. (i)→ (c) (ii)→ (d) (iii)→(a) (iv)→(e) (v)→(b)

38. (i)→ (b), (ii) → (c), (iii) → (b), (iv) → (a) (v)→(b) (vi)→(c)

V. Assertion and Reason Type

39. (i) 40. (ii)

VI. Long Answer Type

45. [**Hint :** Absence of *d*-orbitals in boron.]

48. A = B_2H_6, B = $BH_3.NMe_3$, C = $B(OH)_3$ i.e. H_3BO_3.