

I. Multiple Choice Questions (Type-I)

1. The element which exists in a 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

Solution:

Option (iii) is the answer.

2. Which of the following is a Lewis acid?

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

Solution:

Option (i) is the answer.

3. The geometry of a complex species can be understood from the knowledge of type of hybridisation of orbitals of the central atom. The hybridisation of orbitals of the central atom in $[\text{Be}(\text{OH})_4]$

—

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

Solution:

Option (i) is the answer.

4. Which of the following oxides is acidic?

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

Solution:

Option (i) is the answer

5. The exhibition of the 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 a central atom in MF_6

3—?

- (i) B
- (ii) Al
- (iii) Ga

(iv) In

Solution:

Option (i) is the answer.

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 a proton

(iv) combines with a proton from the water molecule

Solution:

Option (iii) is the answer.

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) $C \gg Si > Ge \approx Sn$

(iii) $Si > C > Sn > Ge$

(iv) $Ge > Sn > Si > C$

Solution:

Option (ii) is the answer.

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

(i) $MeSiCl_3$

(ii) Me_2SiCl_2

(iii) Me_3SiCl

(iv) Me_4Si

Solution:

Option (iii) is the answer.

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) $B > Al < Ga > In < Tl$

Solution:

Option (iv) is the answer.

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 on the same plane.

Solution:

Option (ii) is the answer.

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 , $\text{B}_3\text{N}_3\text{H}_6$

(ii) B_2O_3 , $\text{B}_3\text{N}_3\text{H}_6$

(iii) BF_3 , $\text{B}_3\text{N}_3\text{H}_6$

(iv) $\text{B}_3\text{N}_3\text{H}_6$, B_2H_6

Solution:

Option (i) is the answer.

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

(i) Pb

(ii) Si

(iii) Ti

(iv) Sn

Solution:

Option (ii) is the answer.

13. The most commonly used reducing agent is

(i) AlCl_3

(ii) PbCl_2

(iii) SnCl_4

(iv) SnCl_2

Solution:

Option (iv) is the answer.

14. Dry ice is

(i) Solid NH_3

(ii) Solid SO_2

(iii) Solid CO_2

(iv) Solid N_2

Solution:

Option (iii) is the answer.

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

Solution:

Option (ii) is the answer

II. Multiple Choice Questions (Type-II)

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

16. The reason for the 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

Solution:

Option (i) and (ii) are the answers.

17. The linear shape of CO₂ is due to _____.

- (i) sp³ hybridisation of carbon
- (ii) sp hybridisation of carbon
- (iii) pπ– pπ bonding between carbon and oxygen
- (iv) sp² hybridisation of carbon

Solution:

Option (ii) and (iii) are the answers.

18. Me₃SiCl is used during polymerisation of organic silicones because

- (i) the chain length of organic silicone polymers can be controlled by adding Me₃SiCl
- (ii) Me₃SiCl blocks the end terminal of a silicone polymer
- (iii) Me₃SiCl improves the quality and yield of the polymer
- (iv) Me₃SiCl acts as a catalyst during polymerisation

Solution:

Option (i) and (ii) are the answers.

19. Which of the following statements are correct?

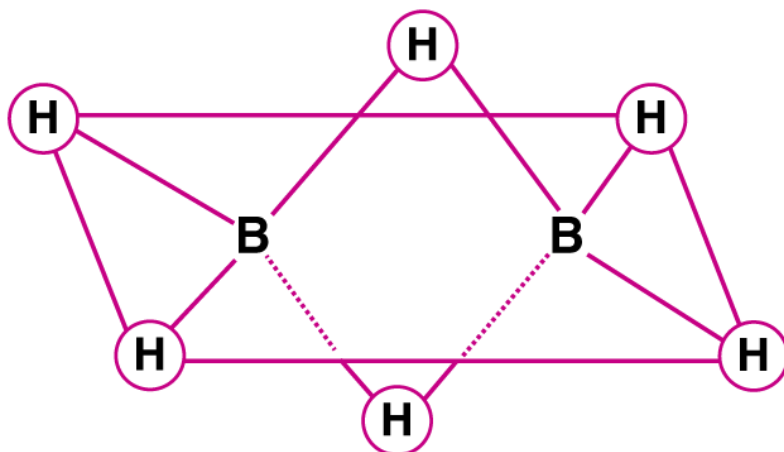
- (i) Fullerenes have dangling bonds
- (ii) Fullerenes are cage-like molecules
- (iii) Graphite is a thermodynamically most stable allotrope of carbon
- (iv) Graphite is slippery and hard and therefore used as a dry lubricant in Machines

Solution:

Option (ii) and (iii) are the answers.

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

- (i) The two bridged 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 centres 2 electron bonds;
- (iv) The four-terminal B–H bonds are two centre-two electron regular bonds.



Solution:

Option (i), (ii) and (iv) are the answers.

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

- (i) $\text{O} - \text{C} \equiv \text{O}$
- (ii) $\text{O} = \text{C} = \text{O}$
- (iii) $-\text{O} \equiv \text{C} - \text{O}^+$
- (iv) $-\text{O} - \text{C} \equiv \text{O}^+$

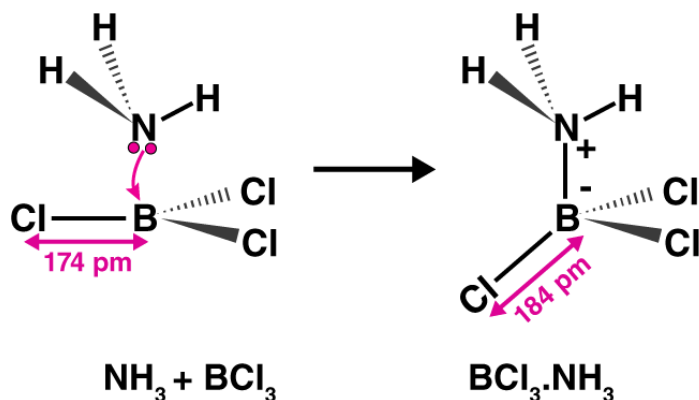
Solution:

Option (ii) and (iv) are the answers.

III. Short Answer Type

22. Draw the structures of $\text{BCl}_3 \cdot \text{NH}_3$ and AlCl_3 (dimer).

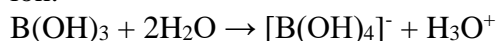
Solution:



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

Solution:

Boric acid is a weak monobasic acid and acts as a Lewis acid by accepting electrons from a hydroxyl ion.

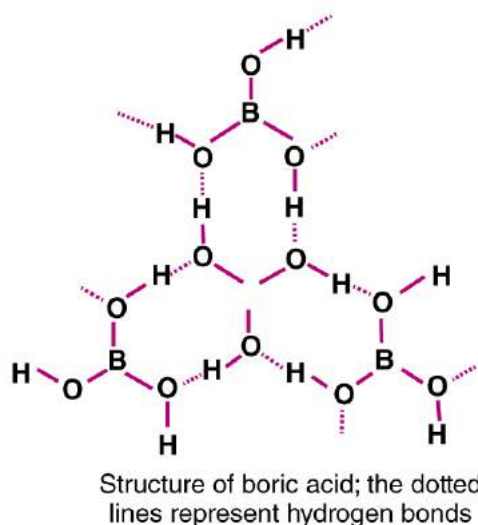


OH^- is accepted by the Boric acid and the formation of hydroxyl ion takes place.

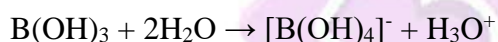
Thus, Boric acid act as a Lewis acid in water.

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?

Solution:



When boric acid reacts with water it forms $[\text{B(OH)}_4]^-$ species.



The hybridization of Boron in this species is sp^3 .

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

(i) BCl_3

(ii) AlCl_3

Solution:

(i) BCl_3 is an electron-deficient compound because it has 6 electrons in its outermost orbital and a vacant p orbital. Hence, it acts as Lewis acid and accepts a lone pair of electrons.

(ii) AlCl_3 forms a covalent bond with chlorine by forming three single bonds of chlorine as aluminium has three electrons in its valence shell and act as an electron-deficient compound and act as lewis acid.

26. Give reasons for the following:

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

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

Solution:

(i) CCl_4 is insoluble in water as water is polar and CCl_4 is non-polar. The carbon atom has no empty orbital to accept the electrons donated by oxygen in the water. SiCl_4 is easily hydrolyzed because Si has

an empty d orbital to accommodate the electrons from oxygen atom of water.

(ii) The energy difference between the Carbon-Carbon and silicon-silicon bond energy is very high i.e. the tendency of carbon to form catenation is greater than the silicon.

27. Explain the following :

(i) CO₂ is a gas whereas SiO₂ is solid.

(ii) Silicon forms SiF₆²⁻ ion whereas the corresponding fluoro compound of carbon is not known.

Solution:

(i) Silicon has a large size compared to carbon. It does not form good π overlapping. It forms four single covalent bonds with oxygen atoms. Each oxygen atom is linked with two Si atoms. Thus, a large giant molecule of a 3-d structure is formed whereas carbons form a double bond with oxygen atom due to π overlapping.

(ii) Silicon has lower energy 3-d orbital so it can expand its octet giving sp^3d^2 hybridization while d-orbitals are not present in the valence shell of carbon. It can undergo sp^3 -hybridisation only. The size of the carbon atom is very small to accommodate six F⁻ anions.

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.

Solution:

Due to the poor shielding of s orbital electrons by d and f orbitals, the tendency of s orbital to form the bond and will decreases down the group from group 13 and 14.

This property is called the inner pair effect. Thus, the +1 oxidation state in group 13 and +2 oxidation state in group 14 becomes more and more stable with increasing atomic number.

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

Solution:

Carbon can form stable $p\pi-p\pi$ bonding with itself and other small atoms like oxygen and nitrogen due to its small size. In carbon dioxide each oxygen atom is double-bonded with the carbon atom with $p\pi-p\pi$ overlapping. Silicon cannot form this bonding because of its large size.

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

Solution:

If a few tetrahedral Si atoms in a three-dimensional network structure of SiO₂ are replaced by an equal number of trivalent atoms, then one valence electron of each Si atom will become free.

As a result, the substitution of each Si atom by a trivalent atom will introduce one unit negative charge into the three-dimensional network structure of the SiO₂.

Thus, the SiO₂ structure will become negatively charged.

31. When BCl₃ is treated with water, it hydrolyses and forms [B(OH)₄]⁻ only whereas AlCl₃ in acidified aqueous solution forms [Al(H₂O)₆]³⁺ ion. Explain what is the hybridisation of boron and aluminium in these species?

Solution:



The 6 H₂O molecules get attach with Al i.e. donate 6 electron pair to the 3s, 3p and 3d orbital of Al³⁺

ion.

Thus, the hybridization of the Al atom in $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$ species is sp^3d^2 .

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, the reaction doesn't proceed. Explain the reason.

Solution:

Aluminium reacts both with acid and base to give hydrogen gas which burns in air with a pop sound. Nitric acid forms a thin layer of aluminium oxide on the surface of aluminium as it is a strong oxidizing agent. Thus, the further reaction is prevented and no hydrogen is liberated.

33. Explain the following :

- (i) Gallium has a higher ionisation enthalpy than aluminium.
- (ii) Boron does not exist as B^{3+} ion.
- (iii) Aluminium forms $[\text{AlF}_6]^{3-}$ ion but boron does not form $[\text{BF}_6]^{3-}$ 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) $\text{Tl}(\text{NO}_3)_3$ 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 graphite-like structure whereas carbon does.

Solution:

(i); Due to the ineffective shielding of valence electrons by the intervening 3d electrons, the effective nuclear charge on Ga is slightly higher than that on Al.

(ii); Boron has three electrons in the valence shell. Because of its small size and a high sum of the first three ionization enthalpies, it doesn't form B^{3+} ion

(iii); Aluminum has empty d-orbital to accommodate the electrons from the fluorine atom but boron has no empty d-orbital to accommodate the electrons.

(iv); Pb is the member of the group 14 of the periodic table (carbon family). The valence shell electronic configuration of this element is $\text{ns}^2 \text{np}^2$ type. Pb can show variable oxidation states of +2 and +4. On moving top to bottom in the group, the lower oxidation state i.e +2 is more stable than the higher one due to the inert pair effect.

Thus, Pb due to the inert pair effect (poor shielding of the inner electronic orbitals) shows +2 as a stable oxidation state rather than +4.

(v); On moving top to bottom in the group, the lower oxidation state i.e +2 is more stable than the higher one due to the inert pair effect.

Thus, Pb due to the inert pair effect shows +2 as stable oxidation state rather than +4. So, by accepting two electrons Pb^{4+} will get converted into Pb^{2+} . In the case of Sn, the inert pair effect is very less, the

+4 oxidation state is more stable than +2.

(vi); Fluorine has a very small size thus the electrons of the 2p orbital experiences the interelectronic repulsion. Thus, the electron coming out of the orbital does not experience much of the attraction from the nucleus hence the negative electron gain enthalpy of fluorine is less than that of chlorine.

(vii); Due to the poor shielding effect of the inner electronic orbitals, the +3 oxidation state of Tl is less stable than its +1 oxidation state.

Since in $\text{Tl}(\text{NO}_3)_3$, the oxidation state of Tl is +3, therefore, it can easily gain two electrons to form TlNO_3 in which the oxidation state of Tl is +1.

(viii); The catenation property depends on atom size and the M-M bond energy. Smaller the atomic radii and the greater the M-M bond energy, the greater is the tendency to show catenation. On moving down a group the atomic size increases and the M-M bond energy also reduces.

(ix); BF_3 does not hydrolyze completely. Instead, it hydrolyzes incompletely to form boric acid and fluoroboric acid. This is because the HF first formed reacts with H_3BO_3

Thus, BF_3 does not hydrolyze completely.

(x); Graphite is a macromolecule that is made up of hexagonal carbon rings.

This property is due to the catenation of the carbon atoms. Smaller the atomic radii and the greater the M-M bond energy, the greater is the tendency to show catenation.

On moving down a group the atomic size increases and the M-M bond energy also reduces.

Thus, Carbon shows the catenation whereas silica **does not**.

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



Solution:

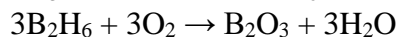
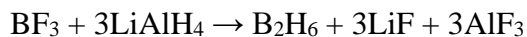
A is Borax which reacts with HCl in the presence of water to give Orthoboric acid(X).

Upon heating Orthoboric acid Gives metaboric and further on heating gives the compound Z i.e. Boron trioxide.

35. Complete the following chemical equations :



Solution:



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) The oxidation state of the 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

Solution:

- (i) is e
(ii) is c
(iii) is d
(iv) is a,b

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) Gallium	(b) The 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 a catalyst in petrochemical industries

Solution:

- (i) is c
(ii) is d
(iii) is a
(iv) is e
(v) is b

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

Column I	Column II
(i) Boron in $[\text{B}(\text{OH})_4]^-$	(a) sp^2
(ii) Aluminium in $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$	(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 $[\text{GeCl}_6]^{2-}$	

Solution:

- (i) is b
(ii) is c
(iii) is b
(iv) is a

(v) is b

(vi) is c

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 the 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.

Solution:

Option (i) 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.

Solution:

Option (ii) is correct.