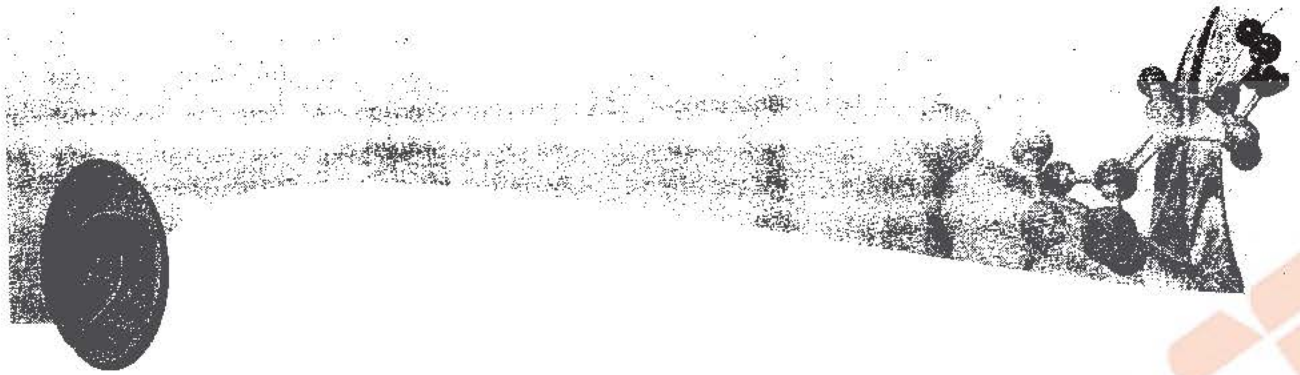


# Chemical Bonding (Part-B)

## JEE (Main) Exercises

### Single Correct Answer Type

1. In which of the following is the O—N—O bond angle highest?
   (a) $NO_2$ (b) $NO_2^+$
   (c) $NO_2^-$ (d) $NO_3^-$
2. Which of the following has higher bond dipole moment?
   (a) H—C (b) N—O
   (c) P—H (d) None of these
3. Which of the following orbital is more directional?
   (a) *s*-orbital (b) *p*-orbital
   (c) *sp*-orbital (d) None of these
4. Select the incorrect geometry for hybridization:
   (a) $sp$ = linear (b) $sp^3d$ = T.B.P.
   (c) $sp^3d^2$ = P.B.P (d) All are correct
5. In benzene, what is the hybridization on each carbon atom?
   (a) $sp^2$ (b) $sp^3$
   (c) $sp^3d$ (d) $sp$
6. What hybridization is expected on the central atom of each of the following molecules?
   (i) $BeH_2$ (ii) $CH_2Br_2$
   (iii) $PF_6^-$ (iv) $BF_3$
   (a) $sp^2$, $sp$, $sp^3$, $sp^2$ (b) $sp$, $sp^3$, $sp^3d$, $sp^2$
   (c) $sp$, $sp^3$, $sp^3d^2$, $sp^2$ (d) $sp^2$, $sp$, $sp^2$, $sp^3$
7. Predict the geometry of the following species and describe the hybridization on the central atom:
   (i) $PbCl_4$ (ii) $SbF_6^-$
   (iii) $BH_4^-$ (iv) $PCl_3$
   (a) Tetrahedral $sp^2$, octahedral $sp^3d^3$, tetrahedral $sp^3$, tetrahedral $sp^3$, respectively
   (b) Tetrahedral $sp^3$, octahedral $sp^3d^2$, tetrahedral $sp^3$, tetrahedral $sp^3$, respectively
   (c) Tetrahedral $sp^3$, octahedral $sp^3d^2$, tetrahedral $sp^3$, pyramidal $sp^3$, respectively
   (d) Trigonal planar $sp^2$, octahedral $sp^3d^2$, tetrahedral $sp$, tetrahedral $sp^2$, respectively
8. What is the value of 1D in SI units?
   (a) $3.336 \times 10^{-30}$ cm (b) $33.36 \times 10^{-30}$ cm
   (c) $333.6 \times 10^{-30}$ cm (d) None of these
9. Arrange the following types of interactions in order of increasing stability (covalent, van der Waals' force, hydrogen bonding):
   (a) Hydrogen bonding < covalent < van der Waals' force
   (b) Covalent < hydrogen bonding < van der Waals' force
   (c) Hydrogen < van der Waals' force < covalent bonding
   (d) van der Waals' force < hydrogen bonding < covalent
10. Which of the following is the correct order of strength of H-bonding in the given compound?

(a) $HF < NH_3$ (b) $H_2O > H_2O_2$
(c) $H_2O_2 > H_2O$ (d) $NH_3 > H_2O$

**11.** Which of the following molecule has a planar structure?
(a) $O_2SF_2$ (b) $OSF_2$
(c) $XeF_4$ (d) $ClO_4^-$

**12.** What is the shape of $ClF_2^-$ ion?
(a) Bent (b) Linear
(c) Pyramidal (d) None of these

**13.** Which of the following molecule is not hypovalent but completes its octet?
(a) $AlCl_3$ (b) $AlBr_3$
(c) $AlF_3$
(d) All are hypovalent and complete their octet

**14.** Which of the following species are planar?
(a) $I_3^-$, $XeF_2$, $ClF_3$ (b) $H_2O$, $\bar{O}Cl$, $ICl_2^+$
(c) $XeF_5^-$, $XeF_4$, $BF_3$ (d) All are correct

**15.** In which of the following molecules are all the bonds not of equal length?
(a) $BCl_3$ (b) $PF_5$
(c) $CF_4$ (d) $SF_6$

**16.** The pair having similar geometry is:
(a) $BH_3$, $NH_3$ (b) $BeH_2$, $H_2O$
(c) $CH_4$, $CCl_4$ (d) $IF_5$, $PF_5$

**17.** Which of the following molecules is not tetrahedral?
(a) $CF_4$ (b) $SF_4$
(c) $CH_4$ (d) $SiF_4$

**18.** Which of the following pair does not have similar geometries?
(a) $CH_4$, $CCl_4$ (b) $BF_3$, $NH_3$
(c) $H_2O$, $H_2S$ (d) $PCl_5$, $SbCl_5$

**19.** Which type of shape is found in $SF_2$ molecule?
(a) V-shaped (b) Bipyramidal
(c) Linear (d) Irregular tetrahedron

**20.** Which of the following molecule/ion has a triangular pyramidal shape?
(a) $BF_3$ (b) $H_3O^+$
(c) $NO_3^-$ (d) $CO_3^{2-}$

**21.** Graphite has a two-dimensional layer structure and the nearest layers are joined together by:
(a) Electrovalent bonds (b) Covalent bonds
(c) van der Waals' forces (d) Metallic bonds

**22.** In $XeF_2$, $XeF_4$, and $XeF_6$, the number of lone pairs on Xe, respectively, is:
(a) 2, 3, 1 (b) 1, 2, 3
(c) 4, 1, 2 (d) 3, 2, 1

**23.** The correct sequence of decrease in bond angles of following hydrides is:
(a) $NH_3 > PH_3 > AsH_3 > SbH_3$
(b) $NH_3 > AsH_3 > PH_3 > SbH_3$
(c) $SbH_3 > AsH_3 > PH_3 > NH_3$
(d) $PH_3 > NH_3 > AsH_3 > SbH_3$

**24.** A lone pair of electrons in an atom implies:
(a) A pair of valence electrons
(b) A pair of electrons
(c) A pair of electrons involved in bonding
(d) A pair of electrons not involved in bonding

**25.** Which of the following is soluble in water?
(a) $CS_2$ (b) $C_2H_5OH$
(c) $CCl_4$ (d) $CHCl_3$

**26.** Which one of the following groupings represents a collection of isoelectronic species?
[At. No.: Cs = 55, Br = 35]
(a) Be, $Al^{3+}$, $Cl^-$ (b) $Ca^{2+}$, $Cs^+$, Br
(c) $Na^+$, $Ca^{2+}$, $Mg^{2+}$ (d) $N^{3-}$, $F^-$, $Na^+$

**27.** The pair of species having identical shapes for molecules of both species is:
(a) $BF_3$, $PCl_3$ (b) $PF_5$, $IF_5$
(c) $CF_4$, $SF_4$ (d) $XeF_2$, $CO_2$

**28.** Which of the following ion is not tetrahedral in shape?
(a) $BF_4^-$ (b) $NH_4^+$
(c) $SF_4$ (d) $CF_4$

**29.** Which of the following are arranged in the decreasing order of dipole moment?
(a) $CH_3Cl$, $CH_3Br$, $CH_3F$ (b) $CH_3Cl$, $CH_3F$, $CH_3Br$
(c) $CH_3Br$, $CH_3Cl$, $CH_3F$ (d) $CH_3Br$, $CH_3F$, $CH_3Cl$

**30.** Paramagnetism of oxygen is explained on the basis of which of the following electronic configuration?
(a) $1s^2 2s^2 2p^6$ (b) $1s^2 2s^2 2p^4$
(c) $1s^2 2s^2$ (d) None of these

**31.** An example of a polar covalent compound is:
(a) KCl (b) NaCl
(c) $CCl_4$ (d) HCl

**32.** Among the following, the molecule with the highest dipole moment is:
(a) $CH_3Cl$ (b) $CH_2Cl_2$
(c) $CHCl_3$ (d) $CCl_4$

33. Shape of $O_2F_2$ is similar to that of:
(a) $C_2F_2$ (b) $H_2O_2$
(c) $H_2F_2$ (d) $C_2H_2$

34. The states of hybridization of boron and oxygen atoms in boric acid ($H_3BO_3$), respectively, are:
(a) $sp^2$ and $sp^2$ (b) $sp^2$ and $sp^3$
(c) $sp^3$ and $sp^2$ (d) $sp^3$ and $sp^3$

35. Decreasing order of C—C length in I. $C_2H_4$, II. $C_2H_2$, III. $C_6H_6$, IV. $C_2H_6$ is:
(a) IV > III > I > II (b) I > II > IV > III
(c) II > I > IV > III (d) IV > I > III > II

36. Which carbon is more electronegative?
(a) $sp^3$-hybridized carbon
(b) $sp$-hybridized carbon
(c) $sp^2$-hybridized carbon
(d) Always same irrespective of its hybrid state

37. Which of the following is least volatile?
(a) HF (b) HCl
(c) HBr (d) HI

38. Which of the following is not electron deficient?
(a) $NH_3$ (b) $BF_3$
(c) $AlCl_3$ (d) $BH_3$

39. Lattice energy of ionic compounds depends upon:
(a) Packing of ions only
(b) Charge and size of ions
(c) Charge on ion only
(d) Size of ions only

40. Which of the following gives the correct arrangement of compounds based on their bond strength?
(a) HF > HCl > HBr > HI (b) HI > HBr > HCl > HF
(c) HF > HBr > HCl > HI (d) HCl > HF > HBr > HI

41. Ionic compounds are formed most easily with:
(a) Low E.A., high I.E. (b) High E.A., low I.E.
(c) Low E.A., low I.E. (d) High E.A., high I.E.

42. Which of the following gas is linear?
(a) $CO_2$ (b) $SO_2$
(c) $NO_2$ (d) $SO_3$

43. Correct order of boiling point is:
(a) HF > HI > HBr > HCl
(b) HF > HBr > HI > HCl
(c) HCl > HBr > HI > HF
(d) HCl > HI > HBr > HF

44. Correct order of bond length is:
(a) $CO_3^{2-} > CO_2 > CO$ (b) $CO_2 > CO > CO_3^{2-}$
(c) $CO > CO_2 > CO_3^{2-}$ (d) None of these

45. Which molecule is only electron donor?
(a) $NH_3$ (b) $BF_3$
(c) $PF_5$ (d) $AsF_5$

46. Which of the following is $sp^3$-hybridized?
(a) $NH_3$ (b) $BeH_2$
(c) $PCl_5$ (d) $AlCl_3$

47. Among the following bonds, which has the most polar character?
(a) C — O (b) C — Br
(c) C — F (d) C — S

48. Octet rule is not valid for which of the following molecule?
(a) $CO_2$ (b) $H_2O$
(c) $O_2$ (d) CO

49. Which of the following has a giant covalent structure?
(a) $PbO_2$ (b) $SiO_2$
(c) NaCl (d) $AlCl_3$

50. In which of the following is the angle between the two covalent bonds greatest?
(a) $CO_2$ (b) $CH_4$
(c) $NH_3$ (d) $H_2O$

51. The correct order regarding the electronegativity of hybrid orbitals of carbon is:
(a) $sp < sp^2 > sp^3$ (b) $sp < sp^2 < sp^3$
(c) $sp > sp^2 < sp^3$ (d) $sp > sp^2 > sp^3$

52. The lattice energy order for lithium halide is:
(a) LiF > LiCl > LiBr > LiI
(b) LiCl > LiF > LiBr > LiI
(c) LiBr > LiCl > LiF > LiI
(d) LiI > LiBr > LiCl > LiF

53. π-Bonding occurs in each of the following except:
(a) $CO_2$ (b) $C_2H_4$
(c) $CN^-$ (d) $CH_4$

54. The structure of $XeF_4$ is:
(a) Planar (b) Tetrahedral
(c) Square planar (d) Pyramidal

55. Compound formed by $sp^3d$-hybridization will have which of the following structure?
(a) Trigonal bipyramidal (b) T-shaped
(c) Linear
(d) Either of these depending on the number of lone pair of electrons on central atom

56. Which bond is more polar?
(a) Cl — Cl (b) N — F
(c) C — F (d) O — F

**57.** Which of the following has the highest bond angle?
(a) $H_2O$ (b) $H_2S$
(c) $NH_3$ (d) $PH_3$

**58.** Which of the following has the lowest bond angle?
(a) $NH_3$ (b) $BeF_2$
(c) $H_3O^+$ (d) $CH_4$

**59.** Coordiante compounds are formed by:
(a) Transfer of electrons (b) Sharing of electrons
(c) Donation of electron pair
(d) None of these

**60.** Compounds formed by $sp^3d^2$-hybridization will have which of the following geometry?
(a) Square planar (b) Octahedral
(c) Trigonal bipyramidal (d) Pentagonal bipyramidal

**61.** As compared to covalent compounds, electrovalent compounds generally have:
(a) High m.pt. and low b.pt.
(b) Low m.pt. and high b.pt.
(c) High m.pt. and high b.pt.
(d) Low m.pt. and low b.pt.

**62.** Which of the following statement is not correct?
(a) Pi-bond always exists with sigma-bond according to V.B.T.
(b) Pi-bond can exist independently according to V.B.T.
(c) Pi-bond is weaker than sigma-bond
(d) Sigma-bond is less reactive than pi-bond

**63.** Which hybridization results in nonplanar orbitals?
(a) $sp$ (b) $sp^2$
(c) $sp^3$ (d) $dsp^2$

**64.** For which of the following hybridization is the bond angle maximum?
(a) $sp^2$ (b) $sp$
(c) $sp^3$ (d) $dsp^2$

**65.** Among liq HF, liq $NH_3$, $CH_4$, $CH_3OH$, and $N_2O_4$, intermolecular hydrogen bond is expected in:
(a) All (b) All leaving one
(c) Three (d) None of these

**66.** $CO_2$ is isostructural with:
(a) $SnCl_2$ (b) $HgCl_2$
(c) $H_2O$ (d) $SCl_2$

**67.** Which of the following has the shortest carbon–carbon bond length?
(a) $C_6H_6$ (b) $C_2H_6$
(c) $C_2H_4$ (d) $C_2H_2$

**68.** Which group of atoms have nearly the same atomic radius?
(a) Na, K, Rb, Cs (b) Li, Be, B, C
(c) Fe, Co, Ni (d) F, Cl, Br, I

**69.** Which set have the strongest tendency to form anions?
(a) Ga, In, Te (b) Na, Mg, Al
(c) N, O, F (d) V, Cr, Mn

**70.** A molecule in which $sp^2$-hybrid orbitals are used by the central atom in forming covalent bond is:
(a) $He_2$ (b) $SO_2$
(c) $PCl_5$ (d) $N_2$

**71.** Which has a zero dipole moment?
(a) ClF (b) $PCl_3$
(c) $SiF_4$ (d) $CFCl_3$

**72.** The hybridization of carbon atoms in C—C single bond of $CH \equiv C - CH = CH_2$ is:
(a) $sp^3$–$sp^3$ (b) $sp^2$–$sp^3$
(c) $sp$–$sp^2$ (d) $sp^3$–$sp$

**73.** Which has the lowest anion to cation size ratio?
(a) LiF (b) NaF
(c) CsI (d) CsF

**74.** In allene structure, three carbon atoms are joined by:
(a) Three σ- and three π-bonds
(b) Two σ- and one π-bond
(c) Two σ- and two π-bonds
(d) Three π- bonds only

**75.** H-bonding is not present in:
(a) Glycerine (b) Water
(c) $H_2S$ (d) HF

**76.** Which species has the maximum number of lone pair of electrons on the central atom?
(a) $ClO_3^-$ (b) $XeF_4$
(c) $SF_4$ (d) $I_3^-$

**77.** Which of the following has a regular tetrahedral geometry?
(a) $SF_4$ (b) $BF_4^-$
(c) $XeF_4$ (d) $ClF_3$

**78.** Which of the following has the least bond energy?
(a) $H_2$ (b) $Mg_2$
(c) $F_2$ (d) $O_2^{2-}$

**79.** Which is the best description of a covalent bond?
(a) Electrons are simultaneously attracted by more than one nucleus
(b) Filled orbitals of two or more atoms overlap one another

(c) Unoccupied orbitals of two or more atoms overlap one another

(d) Oppositely charged ions attract one another

**80.** Deduce the geometry of each of the following molecules:

(i) $NH_3$ (ii) $C_2H_4$ (iii) $ClO_3^-$

(a) Pyramidal, pyramidal, tetrahedral

(b) Pyramidal, tetrahedral, pyramidal

(c) Pyramidal, planar, tetrahedral

(d) Pyramidal, planar, pyramidal

**81.** What are the hybridization states of each carbon atom-(s) in the following molecules?

(i) $CH_3\overset{*}{C}H_2CH_2CH_3$

(ii) $CH_2 = CH - CH = CH_2$

(iii) $CH_3\overset{*}{C}H = CH - CH_3$

(iv) $H - \overset{*}{C} \equiv C - H$

(a) $sp^3, sp^2, sp, sp^3$ (b) $sp^3, sp^2, sp^2, sp$

(c) $sp^2, sp^3, sp, sp^2$ (d) $sp^3, sp, sp^2, sp^2$

**82.** Determine the geometry of each of the following molecules and hybridization about the central atom:

(i) $BeF_2(g)$ (ii) $AlH_3$ (iii) $CH \equiv CH$

(a) *sp* linear, $sp^2$ trigonal planar, $sp^2$ planar, respectively

(b) $sp^2$ planar, *sp* linear, $sp^2$ planar, respectively

(c) *sp* trigonal planar, $sp^2$ linear, $sp^2$ planar, respectively

(d) *sp* linear, $sp^2$ trigonal planar, *sp* linear, respectively

**83.** What is the hybridization of $CH_2^{2+}$ ion?

(a) $sp^2$ (b) $sp^3$

(c) *sp* (d) $sp^3d$

**84.** What is the hybridization and shape of $XeO_3$ and $ClO_4^-$, respectively?

(a) $sp^3$ tetrahedral, $sp^3$ tetrahedral

(b) $sp^3$ tetrahedral, $sp^3$ pyramidal

(c) $sp^3$ pyramidal, $sp^3$ tetrahedral

(d) None of these

**85.** Which of the following molecule has a see-saw geometry?

(a) $I_3^-$ (b) $ICl_2^-$

(c) $ClF_3^-$ (d) $IO_2F_2^-$

**86.** The dipole moment of HBr is $2.60 \times 10^{-30}$ cm and the interatomic spacing is 1.41 Å. What is the per cent ionic character of HBr?

(a) 10.11% (b) 9.11%

(c) 11.5% (d) 15%

**87.** A diatomic molecule has a dipole moment of 1.2 D, if its bond distance is 1.0 Å. What fraction of an electronic charge *e* exists on each atom?

(a) 20% of *e* (b) 21% of *e*

(c) 19% of *e* (d) 25% of *e*

**88.** Which of the possible molecule/species is having maximum values for dipole moment (where "A" is the central atom)?

(a) $AX_3$ (having one lone pair on central atom)

(b) $AX_4$ (tetrahedral)

(c) $AX_4Y$ (having no lone pair on central atom)

(d) Cannot be predicted

**89.** Which of the following is an incorrect match?

(a) $SiF_4$ : Can act as Lewis acid

(b) Benzyne : All C-atoms are $sp^2$-hybridized

(c) $PBr_3$ : Nonpolar

(d) CHF = C = CHF : Nodal planes of $\pi$-bonds are not lying in the same plane

**90.** Which of the following two species have the same shape?

(I) $NI_3$ (II) $I_3^-$ (III) $SO_3^{2-}$ (IV) $NO_3^-$

(a) I and II (b) II and III

(c) III and I (d) I and IV

**91.** $SbF_5$ reacts with $XeF_4$ and $XeF_6$ to form ionic compounds $[XeF_3^+][SbF_6]^-$ and $[XeF_5^+][SbF_6^-]$. The geometry of $XeF_3^+$ ion and $XeF_5^+$ ion, respectively, is:

(a) Square pyramidal, T-shaped

(b) Bent T-shaped, square pyramidal

(c) See-saw, square pyramidal

(d) Square pyramidal, see-saw

**92.** Which of the following is a neutral oxide?

(a) NO (b) $NO_2$

(c) $N_2O_3$ (d) $N_2O_5$

**93.** Which of the following is isoelectronic and isostructural with $CO_2$?

(a) $NO_2$ (b) $NO_3^-$

(c) $NO_2^-$ (d) $N_2O$

**94.** Which out of $SO_4^{2-}$, $SF_4$, and $SF_2$ does not undergo $sp^3$-hybridization?

(a) $SO_4^{2-}$ (b) $SF_2$ and $SO_4^{2-}$

(c) $SF_2$ (d) $SF_4$

**95.** In a system, the formation of chemical bond always decreases its:

(a) Kinetic energy (b) Potential energy

(c) Repulsive forces (d) Coordinate bond

**96.** Which one of the following arrangements of molecules is correct on the basis of the dipole moment?
(a) $BF_3 > NF_3 > NH_3$ (b) $NF_3 > BF_3 > NH_3$
(c) $NH_3 > BF_3 > NF_3$ (d) $NH_3 > NF_3 > BF_3$

**97.** Fluorine molecule is formed by:
(a) The axial *p–p* orbital overlap
(b) The side ways *p–p* orbital overlap
(c) The *s–s* orbital overlap
(d) The *s–p* orbital overlap

**98.** Which of the following has $sp^2$-hybridization?
(a) $SO_2$ (b) $H_2O$
(c) $NH_3$ (d) $SO_3^{2-}$

**99.** Chemical bond implies:
(a) Repulsion
(b) Attraction
(c) Attraction and repulsion
(d) None of these

**100.** In $OF_2$, the number of bond pairs and lone pairs of electrons is, respectively:
(a) 2, 6 (b) 2, 8
(c) 2, 10 (d) 2, 9

**101.** Which of the following does not contain a coordinate bond?
(a) $BH_4^-$ (b) $NH_4^+$
(c) $CO_3^{2-}$ (d) $H_3O^+$

## JEE (Advanced) Exercises

### Single Correct Answer Type

**1.** Which of the following are isoelectronic and isostructural: $NO_3^-, CO_3^{2-}, ClO_3^-, SO_3$?
(a) $NO_3^-$ and $CO_3^{2-}$ (b) $SO_3$ and $NO_3^-$
(c) $ClO_3^-$ and $CO_3^{2-}$ (d) $CO_3^{2-}$ and $SO_3$

**2.** Which one of the following is a planar molecule?
(a) $NH_3$ (b) $H_3O^+$
(c) $BCl_3$ (d) $PCl_3$

**3.** If the molecule of HCl were totally polar, the expected value of dipole moment is 6.12 D but the experimental value is 1.03 D. Calculate the percentage ionic character:
(a) 17 (b) 83
(c) 50 (d) 0

**4.** Element *X* is strongly electropositive and element *Y* is strongly electronegative. Both are univalent. The compound formed would be:
(a) $X^+ Y^-$ (b) $X^- Y^+$
(c) $X^- Y$ (d) $X \rightarrow Y$

**5.** Two ice cubes are pressed over each other and united to form one cube. Which force is responsible for holding them together?
(a) van der Waals' forces (b) Covalent attraction
(c) Hydrogen bond formation
(d) Dipole–dipole attraction

**6.** Multiple covalent bonds exist in the molecule of:
(a) $F_2$ (b) $H_2$
(c) $N_2$ (d) $C_2H_6$

**7.** The type of bonds present in $CuSO_4 \cdot 5H_2O$ are ..... only:
(a) Electrovalent and covalent
(b) Electrovalent and coordinate
(c) Electrovalent, covalent, coordinate, and H-bond
(d) Covalent and coordinate

**8.** Carbon atoms in $C_2(CN)_4$ are:
(a) *sp*-hybridized (b) $sp^2$-hybridized
(c) *sp*-and $sp^2$-hybridized
(d) *sp*, $sp^2$, and $sp^3$-hybridized

**9.** A triple bond is made of:
(a) One σ- and two π-bonds
(b) Two σ- and one π-bond
(c) Three σ- and three π-bonds
(d) One σ- and four π-bonds

**10.** The bonds present in $N_2O_5$ are:
(a) Ionic (b) Covalent and coordinate
(c) Covalent (d) Ionic and covalent

**11.** In which of the following molecules are all bonds not equal?
(a) $AlF_3$ (b) $NF_3$
(c) $ClF_3$ (d) $BF_3$

**12.** The hybridizations of atomic orbitals of nitrogen in $NO_2^+$, $NO_3^-$ and, $NH_4^+$ are:
(a) *sp*, $sp^3$, and $sp^2$, respectively
(b) *sp*, $sp^2$, and $sp^3$, respectively
(c) $sp^2$, *sp*, and $sp^3$, respectively
(d) $sp^2$, $sp^3$, and *sp*, respectively

**13.** The shape of $ClO_4^-$ ion is:
(a) Square planar (b) Square pyramidal
(c) Tetrahedral (d) Trigonal bipyramidal

14. Which of the following species has a linear shape?
(a) $NO_2^+$ (b) $O_3$
(c) $NO_2^-$ (d) $SO_2$

15. Which of the following is not isostructural with $SiCl_4$?
(a) $PO_4^{3-}$ (b) $NH_4^+$
(c) $SCl_4$ (d) $SO_4^{2-}$

16. Which of the following has $sp^2$-hybridization?
(a) $CO_2$ (b) $SO_2$
(c) $N_2O$ (d) CO

17. Intramolecular hydrogen bonding is found in:
(a) Salicyldehyde (b) Water
(c) Acetaldehyde (d) Phenol

18. Which combination is best explained by the coordinate covalent bond?
(a) $H_2 + I_2$ (b) $Mg + \frac{1}{2}O_2$
(c) Cl + Cl (d) $H^+ + H_2O$

19. Two elements $X$ and $Y$ have following electronic configurations:
$X = 1s^2, 2s^2\ 2p^6, 3s^2\ 3p^6, 4s^2$ and
$Y = 1s^2, 2s^2\ 2p^6, 3s^2\ 3p^5$
The compound formed by the combination of $X$ and $Y$ is:
(a) $XY_2$ (b) $X_5Y_2$
(c) $X_2Y_5$ (d) $XY_5$

20. The hybridization of carbon in diamond, graphite, and acetylene is:
(a) $sp^3, sp^2, sp$ (b) $sp^3, sp, sp^2$
(c) $sp^2, sp^3, sp$ (d) $sp, sp^3, sp^2$

21. The angle between two covalent bonds is maximum in:
(a) $CH_4$ (b) $H_2O$
(c) $CO_2$ (d) $SO_3$

22. $CO_2$ has the same geometry as:
(i) $HgCl_2$ (ii) $NO_2$ (iii) $SnCl_4$ (iv) $C_2H_2$
(a) (i) and (iii) (b) (ii) and (iv)
(c) (i) and (iv) (d) (iii) and (iv)

23. Which of the following is an electron-deficient compound?
(a) $NH_3$
(b) ICl
(c) $BCl_3$ (d) $PCl_3$

24. The bond between atoms of two elements of atomic number 37 and 53 is:
(a) Covalent (b) Ionic
(c) Coordinate (d) Metallic

25. The weakest among the following is:
(a) Ionic bond (b) Covalent bond
(c) Metallic bond (d) van der Waals' forces

26. An atom with atomic number 20 is most likely to combine chemically with the atom whose atomic number is:
(a) 11 (b) 16
(c) 18 (d) 10

27. Which of the following molecules will have a dipole moment?
(a) $CO_2$ (b) $CCl_2$
(c) $XeF_2$ (d) $BeF_2$

28. Which of the following molecules does not possess a permanent electric dipole moment?
(a) $H_2S$ (b) $SO_2$
(c) $SO_3$ (d) $CS_2$

29. Among the following metals, interatomic forces are probably the weakest in:
(a) Cu (b) Ag
(c) Zn (d) Hg

30. The octet rule is not followed in:
(a) $F_2$ (b) NaF
(c) $CaF_2$ (d) $BF_3$

31. In which of the following is the bond angle maximum?
(a) $NH_3$ (b) $NH_4^+$
(c) $PCl_3$ (d) $SCl_2$

32. Which one of the following molecules will form a linear polymeric structure due to H-bonding:
(a) HCl (b) $H_2O$
(c) $H_2S$ (d) $NH_3$

33. Which among the following has the largest dipole moment?
(a) $NH_3$ (b) $H_2O$
(c) HI (d) $SO_3$

34. In which of the following pairs is the bond angle 109° 28′?
(a) $[NH_4^+], [BF_4^-]$ (b) $[NH_4^+], [BF_3]$
(c) $NH_3, [BF_4^-]$ (d) $[NH_3], [BF_3]$

35. The pair of species having identical shape of both species is:
(a) $BF_3, PCl_3$ (b) $PF_5, IF_5$
(c) $CF_4, SF_4$ (d) $XeF_2, CO_2$

36. Which pair of molecules will have a permanent dipole moment for both members?

(a) $NO_2$ and $O_3$ (b) $SiF_4$ and $CO_2$

(c) $SiF_4$ and $NO_2$ (d) $NO_2$ and $CO_2$

**37.** The percentage *s*-character of the central atom in beryllium fluoride is:

(a) 25% (b) 33.3%

(c) 50% (d) 20%

**38.** In which of the following sets do we have $sp^3d$-hybridization?

(a) $XeF_2$, $IBr_3$, $XeO_3$ (b) $IBr_3$, $SF_5^+$, $SF_5^-$

(c) $XeF_2$, $IBr_3$, $SF_5^+$ (d) $SF_5^+$ and $SF_5^-$

**39.** Select the correct order for covalent radii:

(a) Octahedral radii > linear radii > tetrahedral radii

(b) Octahedral radii > tetrahedral radii > linear radii

(c) Linear radii > tetrahedral radii > octahedral radii

(d) Tetrahedral radii > octahedral radii > linear radii

**40.** Which molecule among $AX_3$, $AX_4$, $AX_5$, and $AX_6$ is most likely to have a trigonal bipyramidal structure if *A* has no lone pair?

(a) $AX_3$ (b) $AX_5$

(c) Both (a) and (b) (d) $AX_6$

**41.** Which of the following structure is analogous of $SO_3^{2-}$?

(a) $F_2SeO$ (b) $F_2SeO_2$

(c) $SO_4^{2-}$ (d) $SO_2$

**42.** Select the correct statement:

(a) $SF_4$, $CH_4$, $SiCl_4$, and $CCl_4$ have tetrahedral structure

(b) $BF_3$, $ClF_3$, and $ICl_3$ have trigonal planar structure

(c) $XeF_2$, $BeCl_2$, and $ICl_2^-$ have linear structure

(d) All are correct

**43.** Compare $F-\hat{I}-O$ and $F_{axial}-\hat{I}-F_{axial}$ bond angle in $IOF_3$ molecule:

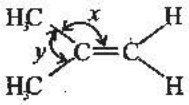
(a) $F-\hat{I}-O > F_{axial}-\hat{I}-F_{axial}$

(b) $F_{axial}-\hat{I}-F_{axial} > F-\hat{I}-O$

(c) $F_{axial}-\hat{I}-F_{axial} = F-\hat{I}-O$

(d) None of these

**44.** Compare bond angles *x* and *y* from the following molecule:



(a) $x > y$ (b) $y > x$

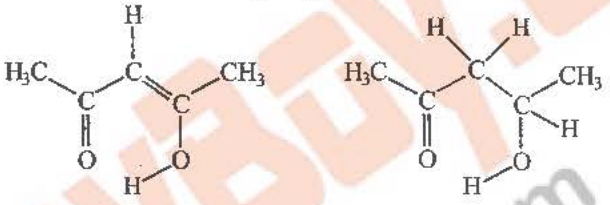
(c) $x = y$ (d) $x = y = 120°$

**45.** The dipole moment of LiH is $1.964 \times 10^{-29}$ cm and the interatomic distance between Li and H in this molecule is 1.596 Å. What is the per cent ionic character in LiH?

(a) 78.6% (b) 86.7%

(c) 8.67% (d) 76.8%

**46.** The two molecules indicated below are capable of intramolecular hydrogen bonding which is likely to form more stable hydrogen bonds.



(*A*) (*B*)

(a) *A* has higher H-bonding

(b) *B* has higher H-bonding

(c) Both *A* and *B* have equal H-bonding

(d) None of these

**47.** The $HF_2^-$ ion exists in the solid state and also in liquid HF solution but not in dilute aqueous solution because:

(a) In aqueous solution, there is hydrogen bonding but each HF molecule hydrogen bond with the much more prevalent $H_2O$ present instead of other HF molecules, and $H_3O^+$ and $F^{\ominus}$ are much more likely to be formed

(b) HF is weaker acid than $H_2O$

(c) HF has H-bonding

(d) None of these

**48.** $SbF_5$ reacts with $XeF_4$ and $XeF_6$ to form ionic compounds $[XeF_3^+][SbF_6]^-$ and $[XeF_5^+][SbF_6^-]$. The geometry of $XeF_3^+$ ion and $XeF_5^+$ ion, respectively, is:

(a) Square pyramidal, T-shaped

(b) Bent T-shaped, square pyramidal

(c) See-saw, square pyramidal

(d) Square pyramidal, see-saw

**49.** Select the correct option for following statements:

(I) $sp^3$ hybrid orbitals are at 90° to one another

(II) $sp^3d^2$ adjacent hybrid orbitals are at 90° to one another

(III) $sp^2$ hybrid orbitals are at 120° to one another

(IV) Bond order of N—O bond in $NO_3^-$ is $1\frac{1}{3}$

(a) T F T F (b) T T F F

(c) F T T T (d) F T F T

**50.** Which of the following is an example of a planar molecule having a net dipole moment?

(a) $NF_3$ (b) $ClF_3$

(c) $XeO_3$ (d) $SO_3$

**51.** Dipole moment is shown by:

(a) 1, 4-dichlorobenzene

(b) *cis*-1, 2-dichlorobutene

(c) *trans*-1, 2-dichlorobutene

(d) *trans*-2, 3-dichloro-2-butene

**52.** Which of the following has $p\pi$–$d\pi$ bonding?

(a) $NO_3^-$ (b) $SO_3^{2-}$

(c) $BO_3^{3-}$ (d) $CO_3^{2-}$

**53.** The electronegativities of F, Cl, Br, and I are 4.0, 3.0, 2.8, and 2.5, respectively. The hydrogen halide with a high percentage of ionic character is:

(a) HF (b) HCl

(c) HBr (d) HI

**54.** The nodal plane in the π-bond of ethene is located in:

(a) The molecular plane

(b) A plane parallel to the molecular plane

(c) A plane perpendicular to the molecular plane which bisects the carbon–carbon sigma bond at right angle

(d) A plane perpendicular to the molecular plane which contains the carbon–carbon σ-bond.

**55.** Which one of the following pairs of molecules will have a permanent dipole moments for both members?

(a) $NO_2$ and $O_3$ (b) $SiF_4$ and $CO_2$

(c) $SiF_4$ and $NO_2$ (d) $NO_2$ and $CO_2$

**56.** In the hypothetical molecule $AX_2L_n$ (where $A$ is central atom, $X$ is surrounding atom, $L$ is lone pair, $n$ is the number of lone pair), for which possible value of "$n$" will the dipole moment of the molecule be minimum?

(a) Zero (b) 1

(c) 2 (d) 4

**57.** Which of the following is arranged in the increasing order of enthalpy of vaporization?

(a) $NH_2$, $PH_3$, $AsH_3$ (b) $AsH_3$, $PH_3$, $NH_3$

(c) $NH_3$, $AsH_3$, $PH_3$ (d) $PH_3$, $AsH_3$, $NH_3$

**58.** The number of π-bonds and σ-bonds in the Lewis structure of $SO_3$ is:

(a) 3 σ, 3 π (b) 3 σ, 2 π

(c) 3 σ, 1 π (d) None of these

**59.** In $BrF_3$ molecule, the lone pairs occupy equatorial position to minimize:

(a) Lone pair–bond pair repulsion only

(b) Bond pair–bond pair repulsion only

(c) Lone pair–lone pair repulsion and lone pair–bond pair repulsion

(d) Lone pair–lone pair repulsion only

**60.** The correct order of bond angles (smallest first) in $H_2S$, $NH_3$, $BF_3$, and $SiH_4$ is:

(a) $H_2S < SiH_4 < NH_3 < BF_3$

(b) $NH_3 < H_2S < SiH_4 < BF_3$

(c) $H_2S < NH_3 < SiH_4 < BF_3$

(d) $H_2S < NH_3 < BF_3 < SiH_4$

**61.** The molecular shapes of $SF_4$, $CF_4$, and $XeF_4$ are:

(a) Different with 0, 1, and 2 lone pairs of electrons on central atom, respectively

(b) Different with 1, 0, and 2 lone pairs of electrons on central atom

(c) Same with 2, 0, and 1 lone pairs

(d) Same with 1, 1 lone pair in each case

**62.** In silicon dioxide:

(a) One Si atom is bonded to two O atoms

(b) There are double bonds between Si and O atoms

(c) Each Si atom is surrounded by four O atoms and each oxygen atom is bonded to two Si atoms

(d) Each Si atom is surrounded by two O atoms and each O is bonded to two Si atoms

**63.** Which of the following statement is incorrect for the dipole moment measurement of the compound?

(a) It helps to predict the percentage ionic character in a bond

(b) It helps to predict the shape of the moelcule

(c) It helps to predict the particular *cis trans* isomers

(d) It helps to predict the bond energies of all bonds within the moelcule

**64.** Which of the following contains both polar and nonpolar covalent bonds?

(a) $NH_4Cl$ (b) HCN

(c) $H_2O_2$ (d) $CH_4$

**65.** An $sp^3$ hybrid orbital contains:

(a) 1/4 *s*-character (b) 1/2 *s*-character

(c) 2/3 *s*-character (d) 3/4 *s*-character

**66.** Which contains a coordinate and a covalent bond?

(a) $BaCl_2$ (b) $NH_4Cl$

(c) HCl (d) $H_2O$

**67.** An atom of one element $A$ has three electrons in its

outermost shell, and that of *B* has six electrons in the outermost orbit. The formula of the compound formed by these two will be:

(a) $A_3B_6$ (b) $A_2B$

(c) $A_2B_3$ (d) $A_3B_2$

**68.** Dative bond is present in:

(a) $SO_3$ (b) $NH_3$

(c) $BaCl_2$ (d) $N_2$

**69.** Which of the following pair of species is not isostructural?

(a) $KrF_2$, $ICl_2^-$ (b) $SO_3$, $SO_3^{2-}$

(c) $CO_3^{2-}$, $BO_3^{3-}$ (d) $SiO_4^{4-}$, $IO_4^-$

**70.** If "*n*" number of $H_3PO_4$ molecules are polymerized to produce chain molecule and ring molecule separately, then the number of P–O–P linkages formed is, respectively:

(a) *n* and $(n-1)$ (b) $(n-1)$ and $(n-1)$

(c) $(n \quad 1)$ and *n* (d) *n* and *n*

**71.** The molecule having zero dipole moment is:

(a) $CH_3Cl$ (b) $CH_2Cl_2$

(c) $CHCl_3$ (d) $CCl_4$

**72.** The solubility of KCl is relatively more in (where D in dielectric constant):

(a) $C_6H_6$ (D = 0) (b) $(CH_3)_2CO$ (D = 2)

(c) $CH_3OH$ (D = 32) (d) $CCl_4$ (D = 0)

**73.** If a molecule $MX_3$ has a zero dipole moment, the sigma bonding orbitals used by *M* (at. no. < 21) are:

(a) Pure *p* (b) *sp*-hybrid

(c) $sp^2$-hybrid (d) $sp^3$-hybrid

**74.** In which molecule are all atoms coplanar?

(a) $CH_4$ (b) $BF_3$

(c) $PF_3$ (d) $NH_3$

**75.** Two lone pairs of electrons and two bond pairs are present in:

(a) $NH_3$ (b) $BF_3$

(c) $CO_3^{2-}$ (d) $NH_2^-$

**76.** When the hybridization state of carbon atom changes from $sp^3$ to $sp^2$ and finally to *sp*, the angle between the hybridized orbitals:

(a) Decreases gradually (b) Decreases considerably

(c) Is not affected (d) Increases progressively

**77.** Which of the following is expected to have a linear structure?

(a) $SO_2$ (b) $CO_2$

(c) $CO_3^{2-}$ (d) $SO_4^{2-}$

**78.** Which of the following phenomenon will occur when two atoms of same spin will react?

(a) Bonding will not occur

(b) Orbital overlap will not occur

(c) Both (a) and (b)

(d) None of these

**79.** Which is not linear?

(a) $CO_2$ (b) HCN

(c) $C_2H_2$ (d) $H_2O$

**80.** Among $NH_3$, $BeCl_2$, $CO_2$, and $H_2O$, the nonlinear molecules are:

(a) $BeCl_2$ and $H_2O$ (b) $BeCl_2$ and $CO_2$

(c) $NH_3$ and $H_2O$ (d) $NH_3$ and $CO_2$

**81.** Dipole moment is highest for:

(a) $CHCl_3$ (b) $CH_4$

(c) $CHF_3$ (d) $CCl_4$

**82.** Consider the following iodides:

| $PI_3$ | $AsI_3$ | $SbI_3$ |
|---|---|---|
| 102° | 100.2° | 99° |

The bond angle is maximum in $PI_3$ which is:

(a) Due to small size of phosphorus

(b) Due to more bond pair–bond pair repulsion in $PI_3$

(c) Due to less electronegativity of P

(d) None of these

**83.** Which of the following is the largest ion?

(a) $Na^+$ (b) $Mg^{2+}$

(c) $O^{2-}$ (d) $F^-$

**84.** The ionization potential order for which set is correct:

(a) Li > K < Cs (b) B > Li > K

(c) Cs > Li > B (d) Cs > Li < K

**85.** For the type of interactions: (I) covalent bond, (II) van der Waals' forces, and (III) hydrogen bonding, which represents the correct order of increasing stability?

(a) (I) < (III) < (II) (b) (II) < (III) < (I)

(c) (II) > (III) > (I) (d) (II) = (III) = (I)

**86.** Which of the moelcule/species has $d^2s$-hybridization?

(a) $CrO_2Cl_2$ (b) $PCl_4^+$

(c) $NH_4^+$ (d) $ClO_3^-$

**87.** Identify the least stable ion amongst the following:

(a) $Li^-$ (b) $Be^-$

(c) $B^-$ (d) $C^-$

**88.** Identity the pair in which the two species are isostructural:

(a) $SiF_4$ and $SF_4$ (b) $IO_3^+$ and $XeO_3$

(c) $BH_4^-$ and $NH_4^+$ (d) $PF_6^-$ and $SF_6$

**89.** The total right-angles ∠ClPCl present in $PCl_5$, $PCl_4^+$, $PCl_6^-$ are _ , _ , _, respectively.

(a) 0, 1, 4 (b) 6, 0, 4

(c) 2, 4, 0 (d) 6, 0, 12

**90.** Which molecule has a trigonal planar geometry?

(a) $IF_3$ (b) $PCl_3$

(c) $NH_3$ (d) $BF_3$

**91.** The molecule having permanent dipole moment is:

(a) $SF_4$ (b) $XeF_4$

(c) $SiF_4$ (d) $BF_3$

**92.** What is the formal charge on the chlorine atom in the oxyacid $HOClO_2$ if it contains single bonds?

(a) 2– (b) 1–

(c) 1+ (d) 2+

**93.** The hybridization of P in phosphate ion ( $PO_4^{3-}$ ) is the same as in:

(a) I in $ICl_4^-$ (b) S in $SO_3$

(c) N in $NO_3^-$ (d) S in $SO_3^{2-}$

**94.** The electronegativity difference between N and F is greater than N and H, yet the dipole moment of $NH_3$ (1.5 D) is greater than that of $NF_3$ (0.2 D). This is because:

(a) In $NH_3$ as well as $NF_3$, the atomic dipole and bond dipole are in the opposite direction

(b) In $NH_3$, the atomic dipole and bond dipole are in the opposite direction, whereas in $NF_3$ these are in the same direction

(c) In $NH_3$ as well as in $NF_3$ the atomic dipole and bond dipole are in the same direction

(d) In $NH_3$, the atomic dipole and bond dipole are in the same direction, whereas in $NF_3$ these are in the opposite direction

**95.** Which of the following species have undistorted octahedral structures?

1. $SF_6$ 2. $PF_6^-$

3. $SiF_6^{2-}$ 4. $XeF_6$

Select the correct answer using the codes given below:

(a) 2, 3, and 4 (b) 1, 3, and 4

(c) 2 and 3 (d) 1, 2, and 3

**96.** In the anion $HCOO^-$, the carbon–oxygen bonds are found to be of equal length. This is because:

(a) The anion $HCOO^-$ has two resonating structures

(b) The anion is obtained by the removal of a proton from the acid molecule

(c) Electronic orbitals of carbon are hybridized

(d) The C = O bond is weaker than the C — O bond

**97.** On analysis, a certain compound was found to contain 254 g of *X* and 80 g of *Y*. If the atomic weight of *X* is 127 and that of *Y* is 16, then the formula of the compound containing *X* and *Y* is:

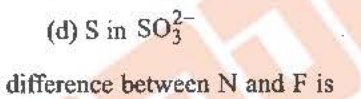
(a) *XY* (b) $X_2Y$

(c) $X_5Y_2$ (d) $X_2Y_5$

**98.** How many bonding pairs and lone pairs surround the central atom in the $I_3^-$ ion?

| | Bonding pairs | Lone pairs |
|---|---|---|
| (a) | 2 | 2 |
| (b) | 2 | 3 |
| (c) | 3 | 2 |
| (d) | 4 | 3 |

**99.** What hybrid orbitals are employed by carbon atoms 1, 2, and 3, respectively, as labeled in the compound shown?



(a) $sp^3$, $sp$, $sp$ (b) $sp^2$, $sp^2$, $sp$

(c) $sp^3$, $sp^2$, $sp$ (d) $sp^3$, $sp^2$, $sp^2$

**100.** Which reaction involves a change in the electron pair geometry for the underlined atom?

(a) $\underline{B}F_3 + F \rightarrow \underline{B}F_4^-$ (b) $\underline{N}H_3 + H^+ \rightarrow \underline{N}H_4^+$

(c) $2\underline{S}O_2 + O_2 \rightarrow 2\underline{S}O_3$ (d) $H_2\underline{O} + H^+ \rightarrow H_3\underline{O}^+$

## Multiple Correct Answers Type

**1.** In V.B.T., the idea of hybridization was required to explain which of the following facts:

(a) The equivalence of the bonds in most of the compounds

(b) The stereochemistry of the molecules

(c) The better overlapping of the orbitals

(d) None of these

**2.** Which of the following molecule has/have structure similar to $NH_3$?

(a) $PH_3$ (b) $H_3O^+$

(c) $SeF_3^+$ (d) $\bar{C}H_3$

**3.** Which of the following properties of water is related to the hydrogen bonding?

(a) High boiling point (b) High heat of vaporization
(c) Low density of ice compared to water
(d) None of these

4. $NH_3$ is isoelectronic with:
(a) $H_2O$ (b) $CH_4$
(c) HF (d) None of these

5. Which of the following molecule(s) is/are planar?
(a) $ICl_2^-$ (b) $IF_2^+$
(c) $SnI_2$ (d) $CdBr_2$

6. Which of the following molecules are nonplanar and have a dipole moment?
(a) $CH_2Cl_2$ (b) $C_2H_2Cl_2$ (*cis*)
(c) $ICl_2^-$ (d) $NH_3$

7. Which of the following molecules are planar and have an angular geometry?
(a) $ClO_3^+$ (b) $Cl_2O^+$
(c) $H_3O^+$ (d) $BF_2^-$

8. Which of the following molecule(s) have a bent shape?
(a) $ClF_2^+$ (b) $ClF_2^-$
(c) $BF_2^-$ (d) None of these

9. Which of the following molecule(s) is/are having a square planar geometry?
(a) $ICl_4^-$ (b) $BrF_4^-$
(c) $XeF_4$ (d) $SF_4$

10. Which of the following molecule(s) is/are having a linear geometry?
(a) $XeF_2$ (b) $ICl_2^-$
(c) $I_3^-$ (d) $CO_2$

11. Which of the following molecule(s) is/are having a see-saw geometry?
(a) $TeBr_4$ (b) $TeCl_4$
(c) $XeO_2F_2$ (d) $SF_4$

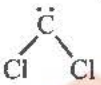
12. Which of the following sets of molcule(s) is/are having a V-shape but different hybridization?
(a) $SnCl_2$ and $H_2O$ (b) $SO_2$ and $NO_2^+$
(c) $BF_2^-$ and $SCl_2$ (d) $OF_2$ and $SCl_2$

13. $sp^2$-Hybridization is not shown by:
(a) $BeCl_2$ (b) $BF_3$
(c) $NH_3$ (d) $XeF_2$

14. Which statement(s) is/are correct?
(a) A double bond is shorter than a single bond
(b) A sigma bond is weaker than a π-bond
(c) A double bond is stronger than a sigma bond
(d) A covalent bond is stronger than a hydrogen bond

15. Which of the following molecule(s) is/are triangular pyramidal in shape?
(a) $NH_3$ (b) $NCl_3$
(c) $PF_3$ (d) $BCl_3$

16. Which oxide(s) of nitrogen is/are not isoelectronic with $CO_2$?
(a) $NO_2$ (b) $N_2O$
(c) NO (d) $N_2O_2$

17. Which of the following species are deficient?
(a)  (b) $Br^-$
(c) $BF_3$ (d) $NH_4^+$

18. Which compound contains double bond or triple bond?
(a) $C_2H_4$ (b) $H_2O$
(c) $N_2$ (d) HCN

19. Which of the following molecule has/have structure similar to $IF_5$?
(a) $PCl_5$ (b) $BrF_5$
(c) $SF_5^-$ (d) $PF_5$

20. Which of the following oxide(s) is/are amphoteric?
(a) $CO_2$ (b) $SO_2$
(c) $SnO_2$ (d) $PbO_2$

21. Which of the following acid(s) is/are monobasic?
(a) $HPO_3$ (b) $H_3PO_3$
(c) $H_4P_2O_7$ (d) $H_3PO_2$

22. Select the reaction in which coordinate bond is formed in product side:
(a) $BF_3 + F^- \longrightarrow BF_4^-$
(b) $CO + BF_3 \longrightarrow OCBF_3$
(c) $H_2O + H^+ \longrightarrow H_3O^+$
(d) $AlCl_3 + Cl^- \longrightarrow AlCl_4^-$

23. Which of the following molecules are planar and have a dipole moment?
(a) $H_2S$ (b) $I_3^-$
(c) $ClF_3$ (d) $H_2O$

24. Which of the following molecule(s) is/are having two different types of bond lengths?
(a) $PF_5$ (b) $PCl_5$
(c) $IF_7$ (d) $SF_6$