Chapter 4. Chemical Bonding and Molecular Structure

1. Which of the following pairs of compounds is isoelectronic and isostructural?
(a) TeI_2, XeF_2 (b) IBr_2^-, XeF_2
(c) IF_3, XeF_2 (d) $BeCl_2$, XeF_2
(NEET 2017)

2. The species, having bond angles of 120° is
(a) ClF_3 (b) NCl_3 (c) BCl_3 (d) PH_3
(NEET 2017)

3. Which one of the following pairs of species have the same bond order?
(a) O_2, NO^+ (b) CN^-, CO
(c) N_2, O_2^- (d) CO, NO
(NEET 2017)

4. Which one of the following compounds shows the presence of intramolecular hydrogen bond?
(a) H_2O_2 (b) HCN
(c) Cellulose
(d) Concentrated acetic acid
(NEET-II 2016)

5. The hybridizations of atomic orbitals of nitrogen in NO_2^+, NO_3^- and NH_4^+ respectively are
(a) sp, sp^3 and sp^2 (b) sp^2, sp^3 and sp
(c) sp, sp^2 and sp^3 (d) sp^2, sp and sp^3
(NEET-II 2016)

6. Which of the following pairs of ions is isoelectronic and isostructural?
(a) CO_3^{2-}, NO_3^- (b) ClO_3^-, CO_3^{2-}
(c) SO_3^{2-}, NO_3^- (d) ClO_3^-, SO_3^{2-}
(NEET-II 2016)

7. The correct geometry and hybridization for XeF_4 are
(a) octahedral, sp^3d^2
(b) trigonal bipyramidal, sp^3d
(c) planar triangle, sp^3d^3
(d) square planar, sp^3d^2. *(NEET-II 2016)*

8. Among the following, which one is a wrong statement?
(a) PH_5 and $BiCl_5$ do not exist.
(b) $p\pi$-$d\pi$ bonds are present in SO_2.
(c) SeF_4 and CH_4 have same shape.
(d) I_3^+ has bent geometry. *(NEET-II 2016)*

9. Consider the molecules CH_4, NH_3 and H_2O. Which of the given statements is false?
(a) The H — O — H bond angle in H_2O is smaller than the H — N — H bond angle in NH_3.
(b) The H — C — H bond angle in CH_4 is larger than the H — N — H bond angle in NH_3.
(c) The H — C — H bond angle in CH_4, the H — N — H bond angle in NH_3, and the H — O — H bond angle in H_2O are all greater than 90°.
(d) The H — O — H bond angle in H_2O is larger than the H — C — H bond angle in CH_4.
(NEET-I 2016)

10. Predict the correct order among the following :
(a) bond pair - bond pair > lone pair - bond pair > lone pair - lone pair
(b) lone pair - bond pair > bond pair - bond pair > lone pair - lone pair
(c) lone pair - lone pair > lone pair - bond pair > bond pair - bond pair
(d) lone pair - lone pair > bond pair - bond pair > lone pair - bond pair
(NEET-I 2016)

11. In which of the following pairs, both the species are not isostructural?
(a) Diamond, Silicon carbide
(b) NH_3, PH_3
(c) XeF_4, XeO_4
(d) $SiCl_4$, PCl_4^+ *(2015)*

12. Decreasing order of stability of O_2, O_2^-, O_2^+ and O_2^{2-} is
(a) $O_2^{2-} > O_2^- > O_2 > O_2^+$
(b) $O_2 > O_2^+ > O_2^{2-} > O_2^-$
(c) $O_2^- > O_2^{2-} > O_2^+ > O_2$
(d) $O_2^+ > O_2 > O_2^- > O_2^{2-}$ *(2015)*

13. Which of the following pairs of ions are isoelectronic and isostructural?
(a) SO_3^{2-}, NO_3^- (b) ClO_3^-, SO_3^{2-}
(c) CO_3^{2-}, SO_3^{2-} (d) ClO_3^-, CO_3^{2-}
(2015, Cancelled)

14. The correct bond order in the following species is
(a) $O_2^+ < O_2^- < O_2^{2+}$ (b) $O_2^- < O_2^+ < O_2^{2+}$
(c) $O_2^{2+} < O_2^+ < O_2^-$ (d) $O_2^{2+} < O_2^- < O_2^+$
(2015, Cancelled)

15. Which of the following options represents the correct bond order?
(a) $O_2^- > O_2 < O_2^+$ (b) $O_2^- < O_2 > O_2^+$
(c) $O_2^- > O_2 > O_2^+$ (d) $O_2^- < O_2 < O_2^+$
(2015, Cancelled)

16. Maximum bond angle at nitrogen is present in which of the following?
(a) NO_2^+ (b) NO_3^- (c) NO_2 (d) NO_2^-
(2015, Cancelled)

17. Which of the following molecules has the maximum dipole moment?
(a) CO_2 (b) CH_4 (c) NH_3 (d) NF_3
(2014)

18. Which one of the following species has plane triangular shape?
(a) N_3 (b) NO_3^- (c) NO_2^- (d) CO_2
(2014)

19. Which of the following is electron-deficient?
(a) $(BH_3)_2$ (b) PH_3
(c) $(CH_3)_2$ (d) $(SiH_3)_2$
(NEET 2013)

20. XeF_2 is isostructural with
(a) $SbCl_3$ (b) $BaCl_2$ (c) TeF_2 (d) ICl_2^-
(NEET 2013)

21. Which of the following is a polar molecule?
(a) SiF_4 (b) XeF_4 (c) BF_3 (d) SF_4
(NEET 2013)

22. Which of the following is paramagnetic?
(a) CN^- (b) NO^+ (c) CO (d) O_2^-
(NEET 2013)

23. Dipole-induced dipole interactions are present in which of the following pairs
(a) HCl and He atoms
(b) SiF_4 and He atoms
(c) H_2O and alcohol
(d) Cl_2 and CCl_4 *(NEET 2013)*

24. The pair of species that has the same bond order in the following is
(a) CO, NO^+ (b) NO^-, CN^-
(c) O_2, N_2 (d) O_2, B_2
(Karnataka NEET 2013)

25. The outer orbitals of C in ethene molecule can be considered to be hybridized to give three equivalent sp^2 orbitals. The total number of sigma (σ) and pi (π) bonds in ethene molecule is
(a) 3 sigma (σ) and 2 pi (π) bonds
(b) 4 sigma (σ) and 1 pi (π) bonds
(c) 5 sigma (σ) and 1 pi (π) bonds
(d) 1 sigma (σ) and 2 pi (π) bonds.
(Karnataka NEET 2013)

26. In which of the following pair both the species have sp^3 hybridization?
(a) SiF_4, BeH_2 (b) NF_3, H_2O
(c) NF_3, BF_3 (d) H_2S, BF_3
(Karnataka NEET 2013)

27. In which of the following ionization processes the bond energy increases and the magnetic behaviour changes from paramagnetic to diamagnetic.
(a) $O_2 \rightarrow O_2^+$ (b) $C_2 \rightarrow C_2^+$
(c) $NO \rightarrow NO^+$ (d) $N_2 \rightarrow N_2^+$
(Karnataka NEET 2013)

28. Which one of the following pairs is isostructural (*i.e.*, having the same shape and hybridization)?
(a) [BCl_3 and $BrCl_3$] (b) [NH_3 and NO_3^-]
(c) [NF_3 and BF_3] (d) [BF_4^- and NH_4^+]
(2012)

29. Bond order of 1.5 is shown by
(a) O_2^+ (b) O_2^- (c) O_2^{2-} (d) O_2
(2012)

30. Which of the following species contains three bond pairs and one lone pair around the central atom?
(a) H_2O (b) BF_3 (c) NH_2^- (d) PCl_3
(2012)

31. The pair of species with the same bond order is
(a) O_2^{2-}, B_2 (b) O_2^+, NO^+
(c) NO, CO (d) N_2, O_2
(2012)

32. During change of O_2 to O_2^- ion, the electron adds on which one of the following orbitals?
(a) π^* orbital (b) π orbital
(c) σ^* orbital (d) σ orbital
(Mains 2012)

33. Four diatomic species are listed below. Identify the correct order in which the bond order is increasing in them

(a) $NO < O_2^- < C_2^{2-} < He_2^+$

(b) $O_2^- < NO < C_2^{2-} < He_2^+$

(c) $C_2^{2-} < He_2^+ < O_2^- < NO$

(d) $He_2^+ < O_2^- < NO < C_2^{2-}$

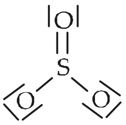
(Mains 2012, 2008)

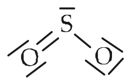
34. Which of the following has the minimum bond length?
(a) O_2^+ (b) O_2^- (c) O_2^{2-} (d) O_2
(2011)

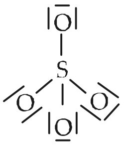
35. Which of the two ions from the list given below that have the geometry that is explained by the same hybridization of orbitals, NO_2^-, NO_3^-, NH_2^-, NH_4^+, SCN^- ?
(a) NO_2^- and NO_3^- (b) NH_4^+ and NO_3^-
(c) SCN^- and NH_2^- (d) NO_2^- and NH_2^-
(2011)

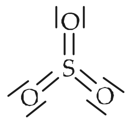
36. The correct order of increasing bond length of C – H, C – O, C – C and C=C is
(a) C – H < C=C < C – O < C – C
(b) C – C < C=C < C – O < C – H
(c) C – O < C – H < C – C < C=C
(d) C – H < C – O < C – C < C=C *(2011)*

37. Which of the following structures is the most preferred and hence of lowest energy for SO_3?

(a)


(b)


(c)


(d)


(Mains 2011)

38. The pairs of species of oxygen and their magnetic behaviour are noted below. Which of the following presents the correct description?
(a) O_2^-, O_2^{2-} - Both diamagnetic
(b) O^+, O_2^{2-} - Both paramagnetic
(c) O_2^+, O_2 - Both paramagnetic
(d) O, O_2^{2-} - Both paramagnetic *(2011)*

39. In which of the following pairs of molecules/ions, the central atoms have sp^2 hybridisation?
(a) NO_2^- and NH_3 (b) BF_3 and NO_2^-
(c) NH_2^- and H_2O (d) BF_3 and NH_2^-
(2010)

40. Which one of the following species does not exist under normal conditions?
(a) Be_2^+ (b) Be_2 (c) B_2 (d) Li_2
(2010)

41. In which one of the following species the central atom has the type of hybridization which is not the same as that present in the other three?
(a) SF_4 (b) I_3^-
(c) $SbCl_5^{2-}$ (d) PCl_5 *(2010)*

42. In which of the following molecules the central atom does not have sp^3 hybridization?
(a) CH_4 (b) SF_4 (c) BF_4^- (d) NH_4^+
(Mains 2010)

43. Some of the properties of the two species, NO_3^- and H_3O^+ are described below. Which one of them is correct?
(a) Dissimilar in hybridization for the central atom with different structures.
(b) Isostructural with same hybridization for the central atom.
(c) Isostructural with different hybridization for the central atom.
(d) Similar in hybridization for the central atom with different structures. *(Mains 2010)*

44. What is the dominant intermolecular force or bond that must be overcome in converting liquid CH_3OH to a gas?
(a) Dipole-dipole interaction
(b) Covalent bonds
(c) London dispersion force
(d) Hydrogen bonding *(2009)*

45. According to MO theory which of the lists ranks the nitrogen species in terms of increasing bond order?
(a) $N_2^{2-} < N_2^- < N_2$ (b) $N_2 < N_2^{2-} < N_2^-$
(c) $N_2^- < N_2^{2-} < N_2$ (d) $N_2^- < N_2 < N_2^{2-}$
(2009)

46. In which of the following molecules/ions BF_3, NO_2^-, NH_2^- and H_2O, the central atom is sp^2 hybridised?
(a) NH_2^- and H_2O (b) NO_2^- and H_2O
(c) BF_3 and NO_2^- (d) NO_2^- and NH_2^-
(2009)

47. The correct order of increasing bond angles in the following triatomic species is
(a) $NO_2^+ < NO_2 < NO_2^-$

(b) $NO_2^+ < NO_2^- < NO_2$
(c) $NO_2^- < NO_2^+ < NO_2$
(d) $NO_2^- < NO_2 < NO_2^+$ *(2008)*

48. In which of the following pairs, the two species are isostructural?
(a) SO_3^{2-} and NO_3^- (b) BF_3 and NF_3
(c) BrO_3^- and XeO_3 (d) SF_4 and XeF_4
(2007)

49. The correct order of C – O bond length among CO, CO_3^{2-}, CO_2 is
(a) $CO < CO_3^{2-} < CO_2$
(b) $CO_3^{2-} < CO_2 < CO$
(c) $CO < CO_2 < CO_3^{2-}$
(d) $CO_2 < CO_3^{2-} < CO$ *(2007)*

50. Which of the following is not a correct statement?
(a) Multiple bonds are always shorter than corresponding single bonds.
(b) The electron-deficient molecules can act as Lewis acids.
(c) The canonical structures have no real existence.
(d) Every AB_5 molecule does in fact have square pyramid structure. *(2006)*

51. Which of the following species has a linear shape?
(a) O_3 (b) NO_2^- (c) SO_2 (d) NO_2^+
(2006)

52. Which of the following is not isostructural with $SiCl_4$?
(a) NH_4^+ (b) SCl_4 (c) SO_4^{2-} (d) PO_4^{3-}
(2006)

53. Which of the following molecules has trigonal planar geometry?
(a) BF_3 (b) NH_3 (c) PCl_3 (d) IF_3
(2005)

54. The correct order in which the O – O bond length increases in the following is
(a) $O_2 < H_2O_2 < O_3$ (b) $O_3 < H_2O_2 < O_2$
(c) $H_2O_2 < O_2 < O_3$ (d) $O_2 < O_3 < H_2O_2$
(2005)

55. The surface tension of which of the following liquid is maximum?
(a) C_2H_5OH (b) CH_3OH
(c) H_2O (d) C_6H_6 *(2005)*

56. Among the following, the pair in which the two species are not isostructural is
(a) SiF_4 and SF_4 (b) IO_3^- and XeO_3
(c) BH_4^- and NH_4^+ (d) PF_6^- and SF_6.
(2004)

57. In a regular octahedral molecule, MX_6 the number of $X - M - X$ bonds at 180° is
(a) three (b) two (c) six (d) four.
(2004)

58. H_2O is dipolar, whereas BeF_2 is not. It is because
(a) the electronegativity of F is greater than that of O
(b) H_2O involves hydrogen bonding whereas BeF_2 is a discrete molecule
(c) H_2O is linear and BeF_2 is angular
(d) H_2O is angular and BeF_2 is linear.
(2004)

59. In BrF_3 molecule, the lone pairs occupy equatorial positions 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.
(2004)

60. Which one of the following statements is not correct for sigma- and pi- bonds formed between two carbon atoms?
(a) Sigma-bond is stronger than a pi-bond.
(b) Bond energies of sigma- and pi-bonds are of the order of 264 kJ/mol and 347 kJ/mol, respectively.
(c) Free rotation of atoms about a sigma-bond is allowed but not in case of a pi-bond.
(d) Sigma-bond determines the direction between carbon atoms but a pi-bond has no primary effect in this regard. *(2003)*

61. 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-}
(2002)

62. In NO_3^- ion number of bond pair and lone pair of electrons on nitrogen atom are
(a) 2, 2 (b) 3, 1 (c) 1, 3 (d) 4, 0.
(2002)

63. Which of the following is isoelectronic?
(a) CO_2, NO_2 (b) NO_2^-, CO_2
(c) CN^-, CO (d) SO_2, CO_2
(2002)

64. Which of the following two are isostructural?
(a) XeF_2, IF_2^- (b) NH_3, BF_3
(c) CO_3^{2-}, SO_3^{2-} (d) PCl_5, ICl_5
(2001)

65. In which of the following bond angle is maximum?
(a) NH_3 (b) NH_4^+ (c) PCl_3 (d) SCl_2
(2001)

66. Nitrogen forms N_2, but phosphorus does not form P_2, however, it converts P_4, reason is
(a) triple bond present between phosphorus atom
(b) $p\pi - p\pi$ bonding is weak
(c) $p\pi - p\pi$ bonding is strong
(d) multiple bonds form easily. *(2001)*

67. In $X - H - - - Y$, X and Y both are electronegative elements. Then
(a) electron density on X will increase and on H will decrease
(b) in both electron density will increase
(c) in both electron density will decrease
(d) on X electron density will decrease and on H increases. *(2001)*

68. $d\pi - p\pi$ bond present in
(a) CO_3^{2-} (b) PO_4^{3-} (c) NO_3^- (d) NO_2^-
(2000)

69. Right order of dissociation energy N_2 and N_2^+ is
(a) $N_2 > N_2^+$ (b) $N_2 = N_2^+$
(c) $N_2^+ > N_2$ (d) none. *(2000)*

70. Which species does not exhibit paramagnetism?
(a) N_2^+ (b) O_2^- (c) CO (d) NO
(2000)

71. The number of anti-bonding electron pairs in O_2^{2-} molecular ion on the basis of molecular orbital theory is (Atomic number of O is 8)
(a) 3 (b) 2 (c) 5 (d) 4
(1998)

72. In PO_4^{3-} ion, the formal charge on each oxygen atom and P—O bond order respectively are
(a) –0.75, 1.25 (b) –0.75, 1.0
(c) –0.75, 0.6 (d) –3, 1.25 *(1998)*

73. N_2 and O_2 are converted into monocations, N_2^+ and O_2^+ respectively. Which is wrong?
(a) In O_2 paramagnetism decreases.
(b) N_2^+ becomes diamagnetic.
(c) In N_2, the N–N bond weakens.
(d) In O_2, the O–O bond order increases.
(1997)

74. N_2 and O_2 are converted into monoanions N_2^- and O_2^- respectively, which of the following statements is wrong?
(a) In O_2, bond length increases.
(b) N_2^- becomes diamagnetic.
(c) In N_2, then N–N bond weakens.
(d) In O_2, the O–O bond order increases.
(1997)

75. The bond length between hybridised carbon atom and other carbon atom is minimum in
(a) propene (b) propyne
(c) propane (d) butane. *(1996)*

76. Which of the following has sp^2-hybridisation?
(a) $BeCl_2$ (b) C_2H_2 (c) C_2H_6 (d) C_2H_4
(1996)

77. Which of the following species is paramagnetic?
(a) CO (b) CN^- (c) O_2^{2-} (d) NO
(1995)

78. The correct order of the O–O bond length in O_2, H_2O_2 and O_3 is
(a) $O_2 > H_2O_2 > O_3$ (b) $H_2O_2 > O_3 > O_2$
(c) $O_2 > O_3 > H_2O_2$ (d) $O_3 > H_2O_2 > O_2$
(1995)

79. The ground state electronic configuration of valence shell electrons in nitrogen molecule (N_2) is written as $KK, \sigma 2s^2, \sigma^* 2s^2, \pi 2p_x^2 = \pi 2p_y^2 \sigma 2p_z^2$. Hence the bond order in nitrogen molecule is
(a) 2 (b) 3 (c) 0 (d) 1
(1995)

80. Which of the following molecules has the highest bond order?
(a) O_2^- (b) O_2 (c) O_2^+ (d) O_2^{2-}
(1994)

81. Which of the following molecule does not possess a permanent dipole moment?
(a) CS_2 (b) SO_3 (c) H_2S (d) SO_2
(1994)

82. The table shown below gives the bond dissociation energies (E_{diss}) for single covalent bonds of carbon (C) atoms with element A, *B*, *C* and *D*. Which element has the smallest atoms?

Bond	E_{diss} (kJ mol^{-1})
C-*A*	240
C-*B*	328
C-*C*	276
C-*D*	485

(a) *C* (b) *D* (c) *A* (d) *B* *(1994)*

83. Among the following which compound will show the highest lattice energy?
(a) KF (b) NaF (c) CsF (d) RbF *(1993)*

84. Which one of the following is the correct order of interactions?
(a) Covalent < hydrogen bonding < van der Waals' < dipole-dipole
(b) van der Waals' < hydrogen bonding < dipole < covalent
(c) van der Waals' < dipole-dipole < hydrogen bonding < covalent
(d) Dipole-dipole < van der Waals' < hydrogen bonding < covalent. *(1993)*

85. Which one of the following has the shortest carbon carbon bond length?
(a) Benzene (b) Ethene
(c) Ethyne (d) Ethane *(1992)*

86. Which structure is linear?
(a) SO_2 (b) CO_2 (c) CO_3^{2-} (d) SO_4^{2-} *(1992)*

87. Strongest hydrogen bond is shown by
(a) water
(b) ammonia
(c) hydrogen fluoride
(d) hydrogen sulphide. *(1992)*

88. In compound *X*, all the bond angles are exactly 109°28′, *X* is
(a) chloromethane
(b) carbon tetrachloride
(c) iodoform
(d) chloroform. *(1991)*

89. Among LiCl, $BeCl_2$, BCl_3 and CCl_4, the covalent bond character follows the order
(a) $BeCl_2 > BCl_3 > CCl_4 < LiCl$
(b) $BeCl_2 < BCl_3 < CCl_4 < LiCl$
(c) $LiCl < BeCl_2 < BCl_3 < CCl_4$
(d) $LiCl > BeCl_2 > BCl_3 > CCl_4$ *(1990)*

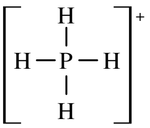
90. The complex ion $[Co(NH_3)_6]^{3+}$ is formed by sp^3d^2 hybridisation. Hence the ion should possess
(a) octahedral geometry
(b) tetrahedral geometry
(c) square planar geometry
(d) tetragonal geometry. *(1990)*

91. Which statement is NOT correct?
(a) A sigma bond is weaker than a pi bond.
(b) A sigma bond is stronger than a pi bond.
(c) A double bond is stronger than a single bond.
(d) A double bond is shorter than a single bond. *(1990)*

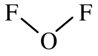
92. Which one shows maximum hydrogen bonding?
(a) H_2O (b) H_2Se (c) H_2S (d) HF *(1990)*

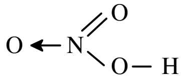
93. Linear combination of two hybridized orbitals belonging to two atoms and each having one electron leads to the formation of
(a) sigma bond
(b) double bond
(c) co-ordinate covalent bond
(d) pi bond. *(1990)*

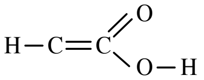
94. Which one of the following formulae does not correctly represent the bonding capacities of the two atoms involved?

(a) 

$\left[H-\overset{H}{\underset{H}{P}}-H\right]^+$

(b) 

(c) 

(d)  *(1990)*

95. Which of the following molecule does not have a linear arrangement of atoms?
(a) H_2S (b) C_2H_2 (c) Be_2 (d) CO_2 *(1989)*

96. Which of the following does not apply to metallic bond?
(a) Overlapping valence orbitals
(b) Mobile valence electrons

(c) Delocalized electrons
(d) Highly directed bonds *(1989)*

97. In which one of the following molecules the central atom can be said to adopt sp^2 hybridization?
(a) BeF_2 (b) BF_3 (c) C_2H_2 (d) NH_3
(1989)

98. H_2O has a net dipole moment while BeF_2 has zero dipole moment because
(a) H_2O molecule is linear while BeF_2 is bent
(b) BeF_2 molecule is linear while H_2O is bent
(c) fluorine has more electronegativity than oxygen
(d) beryllium has more electronegativity than oxygen. *(1989)*

99. The angle between the overlapping of one *s*-orbital and one *p*-orbital is
(a) 180° (b) 120°
(c) 109°28′ (d) 120°, 60°
(1988)

100. Equilateral shape has
(a) *sp* hybridisation
(b) sp^2 hybridisation
(c) sp^3 hybridisation
(d) dsp^3 hybridisation. *(1988)*

Answer Key

1.	(None)			**2.**	(c)	**3.**	(b)	**4.**	(c)	**5.**	(c)	**6.**	(a,d)	**7.**	(a)	**8.**	(c)	**9.**	(d)
10.	(c)	**11.**	(c)	**12.**	(d)	**13.**	(b)	**14.**	(b)	**15.**	(d)	**16.**	(a)	**17.**	(c)	**18.**	(b)	**19.**	(a)
20.	(d)	**21.**	(d)	**22.**	(d)	**23.**	(a)	**24.**	(a)	**25.**	(c)	**26.**	(b)	**27.**	(c)	**28.**	(d)	**29.**	(b)
30.	(d)	**31.**	(a)	**32.**	(a)	**33.**	(d)	**34.**	(a)	**35.**	(a)	**36.**	(a)	**37.**	(d)	**38.**	(c)	**39.**	(b)
40.	(b)	**41.**	(c)	**42.**	(b)	**43.**	(a)	**44.**	(d)	**45.**	(a)	**46.**	(c)	**47.**	(d)	**48.**	(c)	**49.**	(c)
50.	(d)	**51.**	(d)	**52.**	(b)	**53.**	(a)	**54.**	(d)	**55.**	(c)	**56.**	(a)	**57.**	(a)	**58.**	(d)	**59.**	(d)
60.	(b)	**61.**	(b)	**62.**	(d)	**63.**	(c)	**64.**	(a)	**65.**	(b)	**66.**	(b)	**67.**	(a)	**68.**	(b)	**69.**	(a)
70.	(c)	**71.**	(d)	**72.**	(a)	**73.**	(b)	**74.**	(d)	**75.**	(b)	**76.**	(d)	**77.**	(d)	**78.**	(b)	**79.**	(b)
80.	(c)	**81.**	(a)	**82.**	(b)	**83.**	(b)	**84.**	(b)	**85.**	(c)	**86.**	(b)	**87.**	(c)	**88.**	(b)	**89.**	(c)
90.	(a)	**91.**	(a)	**92.**	(a)	**93.**	(a)	**94.**	(d)	**95.**	(a)	**96.**	(d)	**97.**	(b)	**98.**	(b)	**99.**	(a)
100.	(b)																		

EXPLANATIONS

1. **(None)**

Species	No. of electrons	Structure
TeI_2	158	Bent
XeF_2	72	Linear
IBr_2^-	124	Linear
XeF_2	72	Linear
IF_3	80	T-shaped
XeF_2	72	Linear
$BeCl_2$	38	Linear
XeF_2	72	Linear

Note : In this question, in place of isoelectronic there should be same number of valence electrons.

2. **(c) :** BCl_3-Trigonal planar, sp^2-hybridised, 120° angle.

3. **(b) :** Molecular orbital electronic configurations and bond order values are :

$O_2 : \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^{\,2}, \pi 2p_x^{\,2} = \pi 2p_y^{\,2}, \pi^* 2p_x^1 = \pi^* 2p_y^1$

$$\text{B.O.} = \frac{1}{2}(N_b - N_a) = \frac{1}{2}(10-6) = 2$$

$NO^+ : \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^{\,2}, \pi 2p_x^{\,2} = \pi 2p_y^{\,2}$

$$\text{B.O.} = \frac{1}{2}(10-4) = 3$$

$CN^- : \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \pi 2p_x^{\,2} = \pi 2p_y^{\,2}, \sigma 2p_z^{\,2}$

$$\text{B.O.} = \frac{1}{2}(10-4) = 3$$

$CO : \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \pi 2p_x^{\,2} = \pi 2p_y^{\,2}, \sigma 2p_z^{\,2}$

$$\text{B.O.} = \frac{1}{2}(10-4) = 3$$

$N_2 : \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \pi 2p_x^{\,2} = \pi 2p_y^{\,2}, \sigma 2p_z^{\,2}$

$$\text{B.O.} = \frac{1}{2}(10-4) = 3$$

$O_2^- = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^{\,2}, \pi 2p_x^{\,2} = \pi 2p_y^{\,2}, \pi^* 2p_x^{\,2} = \pi^* 2p_y^{\,1}$

$$\text{B.O.} = \frac{1}{2}(10-7) = 1.5$$

$NO : \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^{\,2}, \pi 2p_x^{\,2} = \pi 2p_y^{\,2}, \pi^* 2p_x^{\,1}$

$$\text{B.O.} = \frac{1}{2}(10-5) = 2.5$$

4. **(c) :** H_2O_2, HCN and conc. CH_3COOH form intermolecular hydrogen bonding while cellulose has intramolecular hydrogen bonding.

5. **(c) :** $X = \frac{1}{2}(VE + MA - c + a)$

For NO_2^+, $X = \frac{1}{2}(5 + 0 - 1) = 2$ *i.e.*, *sp* hybridisation

For NO_3^-, $X = \frac{1}{2}(5 + 0 + 1) = 3$ *i.e.*, sp^2 hybridisation

For NH_4^+, $X = \frac{1}{2}(5 + 4 - 1) = 4$ *i.e.*, sp^3 hybridisation

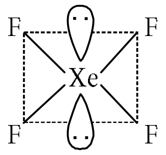
6. **(a, d) :** (a) CO_3^{2-} : 6 + 24 + 2 = 32; sp^2; trigonal planar
NO_3^- : 7 + 24 + 1 = 32; sp^2; trigonal planar
Hence, these are isoelectronic as well as isostructural.

(b) ClO_3^- : 17 + 24 + 1 = 42; sp^3, trigonal pyramidal
CO_3^{2-} : 6 + 24 + 2 = 32; sp^2, trigonal planar
Hence, these are neither isoelectronic nor isostructural.

(c) SO_3^{2-} : 16 + 24 + 2 = 42; sp^3, trigonal pyramidal
NO_3^- : 7 + 24 + 1 = 32; sp^2, trigonal planar
These are neither isoelectronic nor isostructural

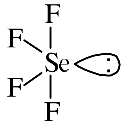
(d) ClO_3^- : 17 + 24 + 1 = 42; sp^3, trigonal pyramidal
SO_3^{2-} : 16 + 24 + 2 = 42; sp^3, trigonal pyramidal

7. **(a) :**

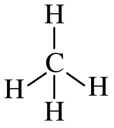


sp^3d^2 hybridisation
(octahedral geometry, square planar shape)

8. **(c) :**

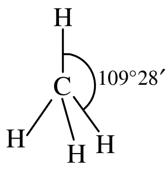


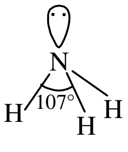
sp^3d hybridisation
(see-saw shape)

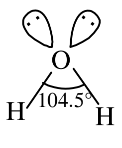


sp^3 hybridisation
(tetrahedral)

9. **(d) :**

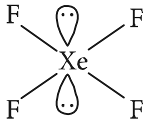


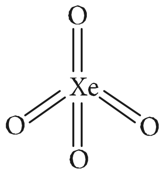




10. (c) : According to VSEPR theory, the repulsive forces between lone pair and lone pair are greater than between lone pair and bond pair which are further greater than bond pair and bond pair.

11. (c) : In diamond and silicon carbide, central atom is sp^3 hybridised and hence, both are isostructural. NH_3 and PH_3, both are pyramidal and central atom in both cases is sp^3 hybridised.


XeF_4


XeO_4

$SiCl_4$ and PCl_4^+, both are tetrahedral and central atom in both cases is sp^3 hybridised.
In XeF_4, Xe is sp^3d^2 hybridised and structure is square planar while in XeO_4, Xe is sp^3 hybridised and structure is tetrahedral.

12. (d) : $O_2(16) : KK\, \sigma 2s^2\, \sigma^* 2s^2\, \sigma 2p_z^2\, \pi 2p_x^2 = \pi 2p_y^2\, \pi^* 2p_x^1 = \pi^* 2p_y^1$

$$\text{Bond order} = \frac{1}{2}(8-4) = 2$$

$O_2^{2-}(18) : KK\, \sigma 2s^2\, \sigma^* 2s^2\, \sigma 2p_z^2\, \pi 2p_x^2 = \pi 2p_y^2\, \pi^* 2p_x^2 = \pi^* 2p_y^2$

$$\text{Bond order} = \frac{1}{2}(8-6) = 1$$

$O_2^-(17) : KK\, \sigma 2s^2\, \sigma^* 2s^2\, \sigma 2p_z^2\, \pi 2p_x^2 = \pi 2p_y^2\, \pi^* 2p_x^2 = \pi^* 2p_y^1$

$$\text{Bond order} = \frac{1}{2}(8-5) = 1.5$$

$O_2^+(15) : KK\, \sigma 2s^2\, \sigma^* 2s^2\, \sigma 2p_z^2\, \pi 2p_x^2 = \pi 2p_y^2\, \pi^* 2p_x^1$

$$\text{Bond order} = \frac{1}{2}(8-3) = 2.5$$

As, bond order ∝ stability
The decreasing order of stability is

$$O_2^+ > O_2 > O_2^- > O_2^{2-}$$

13. (b) :

Species	Hybridisation	Shape	No. of e^-s
SO_3^{2-}	sp^3	Pyramidal	42
ClO_3^-	sp^3	Pyramidal	42
CO_3^{2-}	sp^2	Triangular planar	32
NO_3^-	sp^2	Triangular planar	32

14. (b):

	O_2^-	O_2	O_2^+	O_2^{2+}
B.O. :	1.5	2.0	2.5	3.0

15. (d):

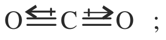
	O_2^-	<	O_2	<	O_2^+
B.O. :	1.5		2.0		2.5

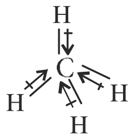
16. (a) :

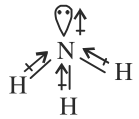
Species	NO_3^-	NO_2	NO_2^-	NO_2^+
Hybridisation	sp^2	sp^2	sp^2	sp(linear)
Bond angle	120°	134°	115°	180°

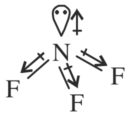
So, NO_2^+ has maximum bond angle.

17. (c) :


(μ = 0, symmetrical)

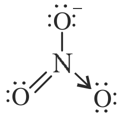

(μ = 0, symmetrical)


(μ ≠ 0, pyramidal)


(μ ≠ 0, pyramidal)

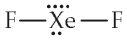
In NH_3, H is less electronegative than N and hence dipole moment of each N—H bond is towards N and create high net dipole moment whereas in NF_3, F is more electronegative than N, the dipole moment of each N—F bond is opposite to that of lone pair, hence reducing the net dipole moment.

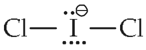
18. (b):

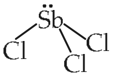

(sp^2-hybridised, trigonal planar)

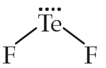
19. (a): Boron hydrides are electron deficient compounds.

20. (d):

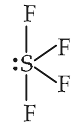

sp^3d, Linear


sp^3d, Linear


sp^3, Pyramidal


sp^3, V-shaped

21. (d): SF_4 has sp^3d-hybridisation and see-saw shape with (4 *bp* + 1*lp*)


and resultant μ ≠ 0.

22. (d): $O_2^-(17)$ superoxide has one unpaired electron.

$$\sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \sigma 2p_z^{\,2}\ \pi 2p_x^{\,2} = \pi 2p_y^{\,2}\ \ \pi^* 2p_x^{\,2} = \pi^* 2p_y^{1}$$

23. (a) : HCl is polar ($\mu \neq 0$) and He is non-polar ($\mu = 0$) gives dipole-induced dipole interaction.

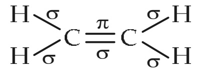
24. (a) : $CO = 6 + 8 = 14$ electrons

$NO^+ = 7 + 8 - 1 = 14$ electrons

Both have electronic configuration :

$\sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \sigma 2p_z^{\,2}\ \pi 2p_x^{\,2}\ \pi 2p_y^{\,2}$

So both have bond order $= \dfrac{10-4}{2} = 3$

25. (c) : 

5 σ-bond and 1 π-bond

26. (b) : NF_3 and H_2O are sp^3-hybridisation.

27. (c) : Molecular orbital configuration of

$O_2 \Rightarrow \sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \sigma 2p_z^{\,2}\ \pi 2p_x^{\,2}\ \pi 2p_y^{\,2}\ \pi^* 2p_x^{\,1}\ \pi^* 2p_y^{\,1}$

$\Rightarrow$ Paramagnetic

Bond order $= \dfrac{10-6}{2} = 2$

$O_2^{\,+} \Rightarrow \sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \sigma 2p_z^{\,2}\ \pi 2p_x^{\,2}\ \pi 2p_y^{\,2}\ \pi^* 2p_x^{\,1}$

$\Rightarrow$ Paramagnetic

Bond order $= \dfrac{10-5}{2} = 2.5$

$C_2 \Rightarrow \sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \pi 2p_x^{\,2}\ \pi 2p_y^{\,2}$

$\Rightarrow$ Diamagnetic

Bond order $= \dfrac{8-4}{2} = 2$

$C_2^{\,+} \Rightarrow \sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \pi 2p_x^{\,2}\ \pi 2p_y^{\,1}$

$\Rightarrow$ Paramagnetic

Bond order $= \dfrac{7-4}{2} = 1.5$

$NO \Rightarrow \sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \sigma 2p_z^{\,2}\ \pi 2p_x^{\,2}\ \pi 2p_y^{\,2}\ \pi^* 2p_x^{\,1}$

$\Rightarrow$ Paramagnetic

Bond order $= \dfrac{10-5}{2} = 2.5$

$NO^+ \Rightarrow \sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \sigma 2p_z^{\,2}\ \pi 2p_x^{\,2}\ \pi 2p_y^{\,2}$

$\Rightarrow$ Diamagnetic.

Bond order $= \dfrac{10-4}{2} = 3$

$N_2 \Rightarrow \sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \pi 2p_x^{\,2}\ \pi 2p_y^{\,2}\ \sigma 2p_z^{\,2}$

$\Rightarrow$ Paramagnetic

Bond order $= \dfrac{10-4}{2} = 3$

$N_2^{\,+} \Rightarrow \sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \pi 2p_x^{\,2}\ \pi 2p_y^{\,2}\ \sigma 2p_z^{\,1}$

$\Rightarrow$ Paramagnetic

Bond order $= \dfrac{9-4}{2} = 2.5$

28. (d) : $BCl_3 \Rightarrow sp^2$, trigonal planar
$BrCl_3 \Rightarrow sp^3d$, T-shaped
$NH_3 \Rightarrow sp^3$, pyramidal
$NO_3^- \Rightarrow sp^2$, trigonal planar
$NF_3 \Rightarrow sp^3$, pyramidal
$BF_3 \Rightarrow sp^2$, trigonal planar
$BF_4^- \Rightarrow sp^3$, tetrahedral
$NH_4^+ \Rightarrow sp^3$, tetrahedral

29. (b) : Configuration of O_2

$\sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \sigma 2p_z^{\,2}\ \pi 2p_x^{\,2}\ \pi 2p_y^{\,2}\ \pi^* 2p_x^{\,1}\ \pi^* 2p_y^{\,1}$

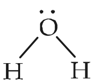
$$\text{Bond order} = \frac{\begin{array}{c}\text{No. of } e^- \text{ in} \\ \text{bonding M.O.}\end{array} - \begin{array}{c}\text{No. of } e^- \text{ in} \\ \text{antibonding M.O.}\end{array}}{2}$$

Bond order of $O_2^{\,+} = \dfrac{10-5}{2} = 2.5$

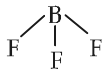
Bond order of $O_2^{\,-} = \dfrac{10-7}{2} = 1.5$

Bond order of $O_2^{\,2-} = \dfrac{10-8}{2} = 1.0$

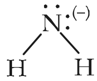
Bond order of $O_2 = \dfrac{10-6}{2} = 2$

30. (d) : 

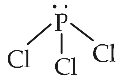
2 bond pairs, 1 lone pair



3 bond pairs, 0 lone pair



2 bond pairs, 2 lone pairs



3 bond pairs, 1 lone pair

31. (a) : $O_2^{\,2-} \rightarrow 1$
$O_2^{\,+} \rightarrow 2.5$
$NO \rightarrow 2.5$
$N_2 \rightarrow 3$
$B_2 \rightarrow 1$
$NO^+ \rightarrow 3$
$CO \rightarrow 3$
$O_2 \rightarrow 2.0$

32. (a) : Electronic configuration of O_2

$\sigma(1s)^2\ \sigma^*(1s)^2\ \sigma(2s)^2\ \sigma^*(2s)^2\ \sigma(2p_z)^2\ \pi(2p_x)^2\ \pi(2p_y)^2\ \pi^*(2p_x)^1\ \pi^*(2p_y)^1$

Thus the incoming electron will enter in $\pi^* 2p_x$ to form $O_2^{\,-}$.

33. (d) :

Diatomic species	Bond order
NO	2.5
$O_2^{\,-}$	1.5
$C_2^{\,2-}$	3.0
$He_2^{\,+}$	0.5

Thus increasing order : $He_2^+ < O_2^- < NO < C_2^{2-}$

34. (a) : Electronic configuration

$O_2 : KK(\sigma 2s)^2 (\sigma^* 2s)^2 (\sigma 2p_x)^2 (\pi 2p_y)^2 (\pi 2p_z)^2 (\pi^* 2p_y)^1 (\pi^* 2p_z)^1$

Bond order $= \frac{1}{2}(8-4) = 2$

O_2^+ : Bond order $= \frac{1}{2}(8-3) = 2\frac{1}{2}$

O_2^- : Bond order $= \frac{1}{2}(8-5) = 1\frac{1}{2}$

O_2^{2-} : Bond order $= \frac{1}{2}(8-6) = 1$

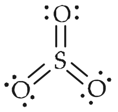
As bond order increases, bond length decreases.

35. (a) :

Ions	Hybridisation
NO_2^-	sp^2
NO_3^-	sp^2
NH_2^-	sp^3
NH_4^+	sp^3
SCN^-	sp

36. (a) : Increasing order of bond length is

$$\underset{107\text{ pm}}{C—H} < \underset{134\text{ pm}}{C{=}C} < \underset{141\text{ pm}}{C—O} < \underset{154\text{ pm}}{C—C}$$

37. (d) :  has maximum number of covalent bonds.

38. (c) : O_2^+ and O_2 are paramagnetic in nature as they contain one and two unpaired electrons respectively.

39. (b) : The hybridisation of the central atom can be calculated as

$$H = \frac{1}{2}\left[\begin{pmatrix}\text{No. of electrons}\\ \text{in valence shell}\\ \text{of atom}\end{pmatrix} + \begin{pmatrix}\text{No. of monovalent}\\ \text{atoms around}\\ \text{central atom}\end{pmatrix} - \begin{pmatrix}\text{Charge on}\\ \text{cation}\end{pmatrix} + \begin{pmatrix}\text{Charge on}\\ \text{anion}\end{pmatrix}\right]$$

$\therefore$ For BF_3, $H = \frac{1}{2}[(3)+(3)-(0)+(0)]$
$= 3 \Rightarrow sp^2$ hybridisation.

For NO_2^-, $H = \frac{1}{2}[(5)+(0)-(0)+(1)]$
$= 3 \Rightarrow sp^2$ hybridisation.

40. (b) : Be_2 does not exist.

Be_2 has an electronic configuration of :
$\sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2$

$\therefore$ Bond order $= \frac{4-4}{2} = 0$

Thus, Be_2 does not exist.

41. (c) : Hybridisation of the central atom can be calculated as:

$$H = \frac{1}{2}\left[\begin{pmatrix}\text{No. of valence}\\ \text{electrons in the}\\ \text{central atom}\end{pmatrix} + \begin{pmatrix}\text{No. of monovalent}\\ \text{atoms around}\\ \text{central atom}\end{pmatrix} - \begin{pmatrix}\text{Charge on}\\ \text{cation}\end{pmatrix} + \begin{pmatrix}\text{Charge on}\\ \text{anion}\end{pmatrix}\right]$$

Applying this formula we find that all the given species except $[SbCl_5]^{2-}$ have central atom with sp^3d (corresponding to H = 5) hybridization. In $[SbCl_5]^{2-}$, Sb is sp^3d^2 hybridized.

42. (b) : For neutral molecules,

No. of electron pairs = No. of atoms bonded to it + 1/2[Gp. no. of central atom – Valency of central atom]

$\therefore$ For CH_4, no. of e^- pairs $= 4 + \frac{1}{2}[4-4]$
$= 4$ (sp^3 hybridisation)

For SF_4, no. of e^- pairs $= 4 + \frac{1}{2}[6-4]$
$= 5$ (sp^3d hybridisation)

For ions,

No. of electron pairs = No. of atoms bonded to it + 1/2[Gp. no. of central atom – Valency of central atom ± No. of electrons]

$\therefore$ For BF_4^-, no. of e^- pairs $= 4 + \frac{1}{2}[3-4+1]$
$= 4$ (sp^3 hybridisation)

For NH_4^+, no. of e^- pairs $= 4 + \frac{1}{2}[5-4-1]$
$= 4$ (sp^3 hybridisation)

43. (a) : No. of electron pairs at the central atom = No. of atoms bonded to it + 1/2[Group number of central atom – Valency of the central atom ± no. of electrons]

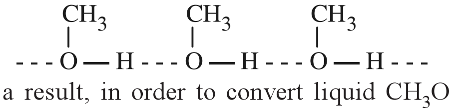
No. of electron pairs at the central atom in NO_3^-

$= 3 + \frac{1}{2}[5-6+1] = 3$ (sp^2 hybridisation).

No. of electron pairs at the central atom in

$H_3O^+ = 3 + \frac{1}{2}[6-3-1] = 4$ (sp^3 hybridisation).

44. (d) : Methanol can undergo intermolecular association through H-bonding as the – OH group in alcohols is highly polarised.



$$\text{---}\overset{\displaystyle CH_3}{\overset{|}{O}}\text{—}H\text{---}\overset{\displaystyle CH_3}{\overset{|}{O}}\text{—}H\text{---}\overset{\displaystyle CH_3}{\overset{|}{O}}\text{—}H\text{---}$$

As a result, in order to convert liquid CH_3OH to gaseous state, the strong hydrogen bonds must be broken.

45. (a) : According to MOT, the molecular orbital electronic configuration of

$N_2 : (\sigma 1s)^2 (\sigma^* 1s)^2 (\sigma 2s)^2 (\sigma^* 2s)^2 (\pi 2p_x)^2 (\pi 2p_y)^2 (\sigma 2p_z)^2$

$$\therefore \quad \text{B.O} = \frac{10-4}{2} = 3$$

$N_2^- : (\sigma 1s)^2 (\sigma^* 1s)^2 (\sigma 2s)^2 (\sigma^* 2s)^2 (\pi 2p_x)^2 (\pi p_y)^2 (\sigma 2p_z)^2 (\pi^* 2p_x)^1$

$$\therefore \quad \text{B.O} = \frac{10-5}{2} = 2.5$$

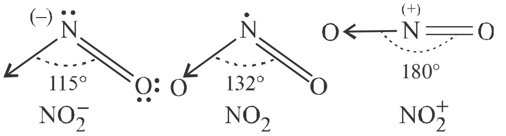
$N_2^{2-} : (\sigma 1s)^2 (\sigma^* 1s)^2 (\sigma 2s)^2 (\sigma^* 2s)^2 (\pi 2p_x)^2 (\pi 2p_y)^2 (\sigma 2p_z)^2 (\pi^* 2p_x)^1 (\pi^* 2p_y)^1$

$$\therefore \quad \text{B.O.} = \frac{10-6}{2} = 2.$$

Hence the order : $N_2^{2-} < N_2^- < N_2$

46. (c) : $BF_3 \rightarrow sp^2$, $NO_2^- \rightarrow sp^2$, $NH_2^- \rightarrow sp^3$, $H_2O \rightarrow sp^3$

47. (d) : Structures of NO_2^-, NO_2 and NO_2^+ is given as



The correct order of increasing bond angles in the following triatomic species is

$NO_2^- < NO_2 > NO_2^+$

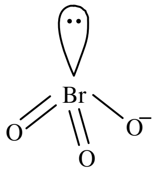
48. (c) : Hybridisation of Br in BrO_3^- :

$H = 1/2(7+0-0+1) = 4$ *i.e.* sp^3 hybridisation

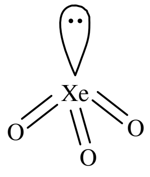
Hybridisation of Xe in XeO_3 :

$H = \frac{1}{2}(8+0-0+0) = 4$ *i.e.* sp^3 hybridisation

In both BrO_3^- and XeO_3, the central atom is sp^3 hybridised and contains one lone pair of electrons, hence in both the cases, the structure is trigonal pyramidal.



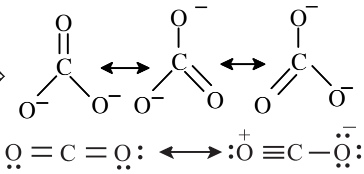
BrO_3^-



XeO_3

49. (c) : $CO \Rightarrow :\overset{-}{C} \equiv \overset{+}{O}: \longleftrightarrow :C = \ddot{O}:$

$CO_3^{2-} \Rightarrow$



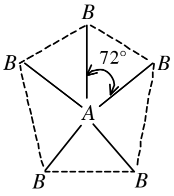
$CO_2 \Rightarrow :\ddot{O} = C = \ddot{O}: \longleftrightarrow :\overset{+}{O} \equiv C - \overset{-}{\ddot{O}}:$

$\longleftrightarrow :\overset{-}{\ddot{O}} - C \equiv \overset{+}{O}:$

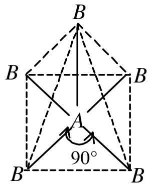
More single bond character in resonance hybrid, more is the bond length. Hence the increasing bond length is

$CO < CO_2 < CO_3^{2-}$

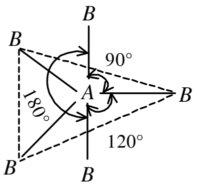
50. (d) : For AB_5 molecules, there are three possible geometries *i.e.* planar pentagonal, square pyramidal and trigonal bipyramidal.



planar pentagonal



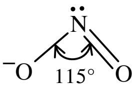
square pyramidal



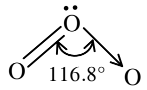
trigonal bipyramidal

Out of these three geometries, it is only trigonal pyramidal shape in which bond pair-bond pair repulsions are minimum and hence this geometry is the most probable geometry of AB_5 molecule.

51. (d) : NO_2^- : Due to sp^2 hybridisation of N-atom and the presence of one lone pair on it, NO_2^- has angular shape.

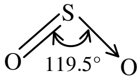


O_3 :



V-shaped

SO_2 : Due to the presence of one lone pair of electros in one of the three sp^2-hybrid orbitals and sp^2 hybridisation of S or S^+ atom, SO_2 molecule has angular (V-shaped) structure.

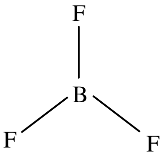


NO_2^+ : Due to sp hybridisation of N^+, NO_2^+ ion has linear shape.

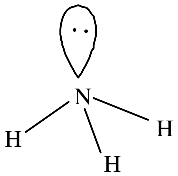
$:\ddot{O} = \overset{+}{N} = \ddot{O}:$

52. (b) : $SiCl_4$, NH_4^+, SO_4^{2-} and PO_4^{3-} ions are the examples of molecules/ions which are of AB_4 type and have tetrahedral structure. SCl_4 is AB_4(lone pair) types species. Although the arrangement of five sp^3d hybrid orbitals in space is trigonal bipyramidal, due to the presence of one lone pair of electron in the basal hybrid orbital, the shape of AB_4 (lone pair) species gets distorted and becomes distorted tetrahedral or see-saw.

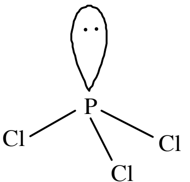
53. (a) :



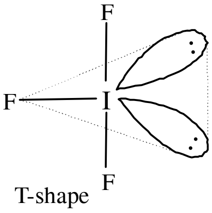
trigonal planar



pyramidal



pyramidal



T-shape

54. (d) : Bond lengths of O – O in O_2 is 1.21Å, in H_2O_2 is 1.48Å and in O_3 is 1.28Å. Therefore, correct order of the O – O bond length is $H_2O_2 > O_3 > O_2$.

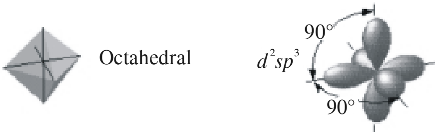
55. (c) : Hydrogen bonding in $H_2O > C_2H_5OH > CH_3OH$

Hence, H_2O has maximum surface tension.

56. (a) : SiF_4 has symmetrical tetrahedral shape which is due to sp^3 hybridisation of the central silicon atom in its excited state configuration.

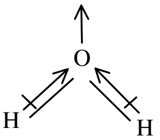
SF_4 has distorted tetrahedral or sea-saw geometry which arises due to sp^3d hybridisation of central sulphur atom and due to the presence of one lone pair of electrons in one of the equatorial hybrid orbital.

57. (a) : In octahedral molecule six hybrid orbitals directed towards the corners of a regular octahedron with a bond angle of 90°.

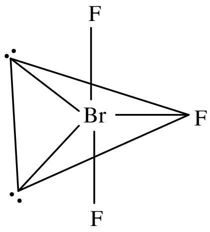


According to this geometry, the number of $X-M-X$ bonds at 180° must be three.

58. (d) : The overall value of the dipole moment of a polar molecule depends on its geometry and shape, *i.e.* vectorial addition of dipole moment of the constituent bonds. Water has angular structure with bond angle 105° as it has dipole moment. However BeF_2 is a linear molecule since dipole moment summation of all the bonds present in the molecule cancel each other.



59. (d) :

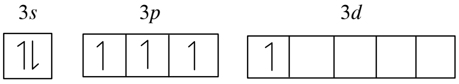


Bent T-shaped geometry in which both lone pairs occupy the equatorial positions of the trigonal bipyramid. Here (*lp* - *lp*) repulsion = 0, (*lp* - *bp*) repulsion = 4 and (*bp* - *bp*) repulsion = 2.

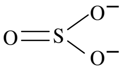
60. (b) : We know C – C = 347 kJ/mol
C ═ C = 619 kJ/mol

61. (b) : In sulphite ion the central atom sulphur is sp^3 hybridised.

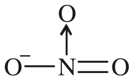
Electronic structure of S atom in excited state



The three *p* electrons form σ bonds with three oxygen atoms - with one position (of the tetrahedron) being occupied by a lone pair. The *d* electron (excluded from hybridisation) forms π bond with one oxygen atom. *i.e.* *p*π - *d*π bonding occurs.



62. (d) :



$\overset{\overset{\displaystyle O}{\uparrow}}{\overset{-}{O}-N=O}$

In NO_3^- ion, nitrogen has 4 bond pair of electrons and no lone pair of electrons.

63. (c) : In CO, the number of electrons
= 6 + 8 = 14 [Z of C = 6 and O = 8]

Electronic configuration of molecular orbital of CO :
$(\sigma 1s)^2(\sigma^*1s)^2(\sigma 2s)^2(\sigma^*2s)^2(\pi 2p_x)^2(\pi 2p_y)^2(\sigma 2p_z)^2$

CN^- have also get (6 + 7 + 1) 14 electrons and the configuration is similar to that of CO.

CN^- and CO are isoelectronic.

64. (a) : Compounds having same shape with same hybridisation are known as isostructural.

XeF_2, IF_2^- → both are sp^3d hybridised linear molecules.

65. (b) : Bond angle is maximum in NH_4^+ tetrahedral molecule with bond angle 109°.

66. (b) : For strong π-bonding, *p*π - *p*π bonding should be strong. In case of P, due to larger size as compared to N-atom, *p*π - *p*π bonding is not so strong.

67. (a)

68. (b) : In PO_4^{3-}, P atom has vacant *d*-orbitals, thus it can form *p*π-*d*π bond. 'N' and 'C' have no vacant '*d*' orbital in their valence shell, so they cannot form such bond.

69. (a) : $N_2(14) \rightarrow (\sigma 1s)^2, (\sigma^*1s)^2, (\sigma 2s)^2, (\sigma^*2s)^2$
$(\sigma^*2s)^2, (\pi 2p_x)^2, (\pi 2p_y)^2, (\sigma 2p_z)^2$

In N_2, bond order = $\frac{N_b - N_a}{2} = \frac{10-4}{2} = 3$

In N_2^+, bond order = $\frac{9-4}{2} = 2 \cdot 5$

As the bond order in N_2 is more than N_2^+ so the dissociation energy of N_2 is higher than N_2^+.

70. (c) : In 'CO' (14 electrons), there is no unpaired electron in its molecular orbital. Therefore this does not exhibit paramagnetism.

71. (d) : $O_2^{2-}(18) \rightarrow (\sigma 1s)^2, (\sigma^* 1s)^2 (\sigma 2s)^2, (\sigma^* 2s)^2$
$(\sigma 2p_x)^2, (\pi 2p_y)^2, (\pi 2p_z)^2, (\pi^* 2p_y)^2, (\pi^* 2p_z)^2$
$\rightarrow$ represents antibonding molecular orbitals.

Thus the no. of antibonding electrons in O_2^{2-} ion is = 8(4 pairs)

72. (a) : The total charge = –3
So the average formal charge on each 'O' atom is –3/4 = –0.75
Again total no. of electrons in the valence shell of PO_4^{3-} ion = 5 + 8 = 13
No. of electrons involved in bond formation in PO_4^{3-} ion = 13 – 3 = 10

No. of bonds in $PO_4^{3-} = \frac{10}{2} = 5$

$\Rightarrow$ Average P—O bond order = $\frac{5}{4}$ = 1.25

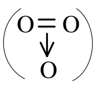
73. (b) : Diamagnetism is caused due to the absence of unpaired electrons. But in N^{2+}, there is unpaired electron. So, it is paramagnetic.

74. (d) : In O_2 bond, the order is 2 and in O_2^- bond, the order is 1.5.

75. (b) : The C–C bond length = 1.54 Å, C=C bond length = 1.34 Å and C≡C bond length = 1.20 Å. Since propyne has a triple bond, therefore it has minimum bond length.

76. (d) : $BeCl_2$ and C_2H_2 have *sp*-hybridisation and C_2H_6 has sp^3-hybridisation.

77. (d) : Paramagnetism is caused by the presence of atoms, ions or molecules with unpaired electrons, *i.e* $:\dot{N}=\ddot{O}:$

78. (b) : Bond length of O – O in O_2 is 1.21 Å (O = O); in H_2O_2 is 1.48 Å (HO – HO) and in O_3 is 1.28 Å  $\left(\begin{array}{c} O=O \\ \downarrow \\ O \end{array}\right)$.

79. (b) : Number of electrons in bonding orbitals N_b = 10 and number of electrons in antibonding orbitals N_a = 4.
Therefore bond order = $1/2(N_b - N_a) = 1/2(10 - 4) = 3$

80. (c) : The bond order of O_2^+ = 2.5, O_2^{2-} = 1, O_2^- = 1.5 and that of O_2 = 2.

81. (a) : The structure of CS_2 is linear and therefore it does not have permanent dipole moment. It is represented as S=C=S.

82. (b) : Smaller the atom, stronger is the bond and greater the bond dissociation energy. Therefore the bond C-*D* has the greatest energy or smallest atoms.

83. (b) : For compounds containing ions of same charge, lattice energy increases as the size of ions decreases. Thus, NaF has highest lattice energy.

84. (b) : The strength of interaction follow the order van der Waals' < hydrogen-bond < dipole-dipole < covalent. It is so because bond length of H-bond is larger than that of a covalent bond.
And also covalent bond is strongest because, the greater the extent of overlapping, the stronger is the bond formed.

85. (c) : There is a triple bond in ethyne molecule $(H-C\equiv C-H)$ and due to this triple bond, carbon-carbon bond distance is shortest in ethyne.

86. (b) : CO_2 molecule is *sp*-hybridised and thus it is linear, while CO_3^{2-} is planar (sp^2 -hybridised), SO_2 is an angular molecule with sp^2 hybridisation
SO_4^{2-} is tetrahedral (sp^3-hybridised).

87. (c) : H – F shows strongest H-bonds because fluorine is most electronegative.

88. (b) : As all C – Cl bonds are directed towards the corner of a regular tetrahedron.

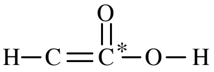
89. (c) : Along the period, electronegativity (*EN*) increases and hence as we move from Li → Be → B → C, the electronegativity increases and hence the *EN* difference between the element and Cl decreases and accordingly the covalent character increases.
Thus $LiCl < BeCl_2 < BCl_3 < CCl_4$ is correct.

90. (a) : According to VSEPR theory, a molecule with 6 bond pairs must be octahedral.

91. (a) : A σ-bond is stronger than a π-bond.

92. (a) : H_2O shows maximum H-bonding because each H_2O molecule is linked to four H_2O molecules through H-bonds.

93. (a)

94. (d) : 

$$H-C=\overset{\overset{O}{\|}}{C^{*}}-O-H$$

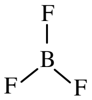
The asterick (*) marked carbon has a valency of 5 and hence this formula is not correct because carbon has a maximum valency of 4.

95. (a) : For linear arrangement of atoms the hybridisation is *sp*. (bond angle = 180°).

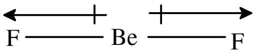
Only H_2S has sp^3-hybridisation and hence it has angular shape while C_2H_2, BeH_2 and CO_2 all involve *sp*-hybridisation and hence has linear arrangement of atoms.

96. (d) : Metallic bonds have electrostatic attraction on all sides and hence do not have directional characteristics.

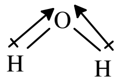
97. (b) : BF_3 involves sp^2-hybridisation



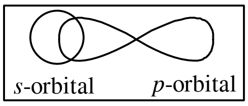
98. (b) : BeF_2 is linear and hence it has zero dipole moment.



while H_2O is a bent molecule and hence it has a non-zero dipole moment



99. (a) : The type of overlap between *s*- and *p*-orbitals occurs along internuclear axis and hence the angle is 180°.



s-*p* overlapping

100. (b) : Equilateral or triangular planar shape involves sp^2 hybridisation. *e.g.* – BCl_3.