4

Chemical Bonding and Molecular Structure

Trend Analysis with Important Topics & Sub-Topics

		2020		2019		2018		2017		2016	
Topic Name	**Sub-Topic**	**QNS.**	**LOD**	**QNS.**	**LOD**	**QNS.**	**LOD**	**QNS.**	**LOD**	**QNS.**	**LOD**
Dipole moment and bond polarity	dipole moment	1	A								
VSEPR theory and hybridisation	structure and hybridisation					2	A	2	A		
	VSEPR theory									2	E
Valence bond and molecular orbital theory	molecular orbital theory/bond order	1	A	1	A	1	A	1	A		
	valence bond theory			1	A						

LOD - Level of Difficulty | E - Easy | A - Average | D - Difficult | Qns - No. of Questions

Topic 1: Electrovalent, Covalent and Co-ordinate Bonding

1. Which of the following is electron - deficient? ***[NEET 2013]***
   (a) $(SiH_3)_2$ (b) $(BH_3)_2$
   (c) PH_3 (d) $(CH_3)_2$
2. The correct sequence of increasing covalent character is represented by ***[2005]***
   (a) $LiCl < NaCl < BeCl_2$
   (b) $BeCl_2 < LiCl < NaCl$
   (c) $NaCl < LiCl < BeCl_2$
   (d) $BeCl_2 < NaCl < LiCl$
3. Which of the following is the electron deficient molecule? ***[2005]***
   (a) C_2H_6 (b) B_2H_6
   (c) SiH_4 (d) PH_3
4. Cation and anion combines in a crystal to form following type of compound. ***[2000]***
   (a) ionic (b) metallic
   (c) covalent (d) dipole-dipole
5. Among the following electron deficient compound is : ***[2000]***
   (a) BCl_3 (b) CCl_4
   (c) PCl_5 (d) PCl_3
6. Which of the following compounds has a 3-centre bond? ***[1996]***
   (a) Diborane (b) Carbon dioxide
   (c) Boron trifluroide (d) Ammonia
7. Linus Pauling received the Nobel Prize for his work on ***[1994]***
   (a) atomic structure (b) photosynthesis
   (c) chemical bonds (d) thermodynamics
8. Which of the following pairs will form the most stable ionic bond ? ***[1994]***
   (a) Na and Cl (b) Mg and F
   (c) Li and F (d) Na and F
9. The weakest among the following types of bonds is ***[1994]***
   (a) ionic (b) covalent
   (c) metallic (d) H–bond.
10. Strongest bond is in between ***[1993]***
    (a) CsF (b) NaCl
    (c) Both (a) and (b) (d) None of above

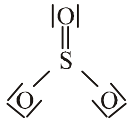
11. Among the following which compound will show the highest lattice energy ? ***[1993]***
    (a) KF (b) NaF
    (c) CsF (d) RbF

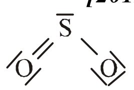
12. Among LiCl, $BeCl_2$ BCl_3 and CCl_4, the covalent bond character follows the order ***[1990]***
    (a) $LiCl < BeCl_2 > BCl_3 > CCl_4$
    (b) $BeCl_2 < BCl_3 < CCl_4 < LiCl$
    (c) $LiCl < BeCl_2 < BCl_3 < CCl_4$
    (d) $LiCl > BeCl_2 > BCl_3 > CCl_4$

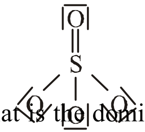
13. Which of the following does not apply to metallic bond ? ***[1989]***
    (a) Overlapping valence orbitals
    (b) Mobile valency electrons
    (c) Delocalized electrons
    (d) Highly directed bonds.

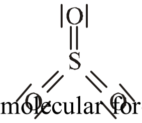
Topic 2: Octet rule, Resonance and Hydrogen Bonding

14. Which of the following structures is the most preferred and hence of lowest energy for SO_3? ***[2011 M]***

(a) 

(b) 

(c) 

(d) 

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

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

17. In X—H—Y, X and Y both are electronegative elements (a) Electron density on X will increase and on
    H will decrease ***[2001]***
    (b) In both electron density will decrease (c) In both electron density will increase (d) Electron density will decrease on X and will
    increase on H 18. Which one of the following molecules will form ***[2000]***
    (a) NH_3 (b) H_2O
    (c) HCl (d) HF

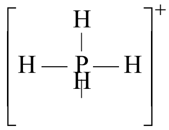
19. In PO_4^{3-} ion, the formal charge on each oxygen atom and P—O bond order respectively are ***[1998]***
    (a) –0.75, 0.6 (b) –0.75, 1.0
    (c) –0.75, 1.25 (d) –3, 1.25

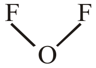
20. The low density of ice compared to water is due to ***[1997]***
    (a) hydrogen-bonding interactions (b) dipole-dipole interactions (c) dipole-induced dipole interactions (d) induced dipole-induced dipole interac
    tions 21. The boiling point of p-nitrophenol is higher than ***[1994]***
    that of o-nitrophenol because
    (a) NO_2 group at p-position behave in a different way from that at o-position.
    (b) intramolecular hydrogen bonding exists in p-nitrophenol
    (c) there is intermolecular hydrogen bonding in p-nitrophenol
    (d) p-nitrophenol has a higher molecular weight than o-nitrophenol.

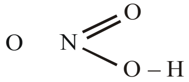
22. Which one of the following is the correct order of interactions ? ***[1993]***
    (a) Covalent < hydrogen bonding < van der Waals < dipole-dipole
    (b) van der Waals < hydrogen bonding < dipole-dipole < covalent
    (c) van der Waals < dipole-dipole < hydrogen bonding < covalent
    (d) Dipole-dipole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

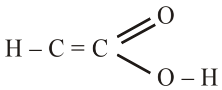
23. Strongest hydrogen bond is shown by ***[1992]***
    (a) Water
    (b) Ammonia
    (c) Hydrogen fluoride
    (d) Hydrogen sulphide.

24. Which one of the following formulae does not correctly represent the bonding capacities of the two atoms involved ? ***[1990]***

(a) 

(b) 

(c) 

(d) 

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

Topic 3: Dipole Moment and Bond Polarity

26. Which of the following set of molecules will have zero dipole moment? ***[2020]***
(a) Boron trifluoride, hydrogen fluoride, carbon dioxide, 1,3-dichlorobenzene
(b) Nitrogen trifluoride, beryllium difluoride, water, 1,3-dichlorobenzene
(c) Boron trifluoride, beryllium difluoride, carbon dioxide, 1,4-dichlorobenzene
(d) Ammonia, beryllium difluoride, water, 1,4-dichlorobenzene

27. Which of the following is the correct order of dipole moment? ***[NEET Odisha 2019]***
(a) $H_2O < NF_3 < NH_3 < BF_3$
(b) $NH_3 < BF_3 < NF_3 < H_2O$
(c) $BF_3 < NF_3 < NH_3 < H_2O$
(d) $BF_3 < NH_3 < NF_3 < H_2O$

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

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

30. The electronegativity difference between N and F is greater than that between N and H yet the dipole moment of NH_3 (1.5 D) is larger than that of NF_3 (0.2D). This is because ***[2006]***
(a) in NH_3 the atomic dipole and bond dipole are in the same direction whereas in NF_3 these are in opposite directions
(b) in NH_3 as well as NF_3 the atomic dipole and bond dipole are in opposite directions
(c) in NH_3 the atomic dipole and bond dipole are in the opposite directions whereas in NF_3 these are in the same direction
(d) in NH_3 as well as in NF_3 the atomic dipole and bond dipole are in the same direction

31. Which of the following would have a permanent dipole moment? ***[2005]***
(a) SiF_4 (b) SF_4
(c) XeF_4 (d) BF_3

32. The correct order of the O–O bond length in O_2, H_2O_2 and O_3 is ***[1995, 2005]***
(a) $O_2 > O_3 > H_2O_2$
(b) $O_3 > H_2O_2 > O_2$
(c) $O_2 > H_2O_2 > O_3$
(d) $H_2O_2 > O_3 > O_2$

33. H_2O is dipolar, whereas BeF_2 is not. It is because ***[2004]***
(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

34. The dipole moments of diatomic molecules *AB* and *CD* are 10.41D and 10.27 D, respectively while their bond distances are 2.82 and 2.67 Å, respectively. This indicates that ***[1999]***
(a) bonding is 100% ionic in both the molecules
(b) *AB* has more ionic bond character than *CD*
(c) *AB* has lesser ionic bond character than *CD* (d)
bonding is nearly covalent in
both
the
molecules

35. Which of the following bonds will be most polar? (b) Cl – F
c F (d) N – N ***[1992]***

36. H_2O has a non zero dipole moment while BeF_2 has zero dipole moment because ***[1989]***
(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

Topic 4: VSEPR Theory and Hybridisation

oxygen.

37. In the structure of ClF_3, the number of lone pair of electrons on central atom 'Cl' is ***[2018]***
(a) One (b) Two
(c) Three (d) Four

38. Which of the following molecules represents the order of hybridisation *sp*^{2}, *sp*^{2}, *sp*, *sp* from left to right atoms? ***[2018]***
(a) $HC\equiv C-C\equiv CH$ (b)
$CH_2=CH-C\equiv CH$
(c) $CH_3-CH=CH-CH_3$
(d) $CH_2=CH-CH=CH_2$

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

40. The species, having bond angles of 120° is :- ***[2017]***
(a) ClF_3 (b) NCl_3
(c) BCl_3 (d) PH_3

41. Consider the molecules CH_4, NH_3 and H_2O. Which of the given statements is false? ***[2016]***
(a) 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°
(b) The H–O–H bond angle in H_2O is larger than the H–C–H bond angle in CH_4.
(c) The H–O–H bond angle in H_2O is smaller than the H–N–H bond angle in NH_3.
(d) The H–C–H bond angle in CH_4 is larger than the H–N–H bond angle in NH_3.

42. Predict the correct order of electron repulsion among the following : ***[2016]***
(a) lone pair- lone pair > lone pair - bond pair > bond pair - bond pair
(b) lone pair - lone pair > bond pair - bond pair > lone pair - bond pair
(c) bond pair - bond pair > lone pair - bond pair > lone pair - lone pair
(d) lone pair - bond pair > bond pair - bond pair > lone pair - lone pair

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

44. Maximum bond angle at nitrogen is present in which of the following ? ***[2015]***
(a) NO_2^- (b) NO_2^+
(c) NO_3^- (d) NO_2

45. In which of the following pairs, both the species are not isostructural ? ***[2015 RS]***
(a) $SiCl_4, PCl_4^+$
(b) diamond, silicon carbide
(c) NH_3, PH_3 (d)
XeF_4, XeO_4

46. Be^{2+} is isoelectronic with which of the following ions? ***[2014]***
(a) H^+ (b) Li^+
(c) Na^+ (d) Mg^{2+}

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

48. In which of the following pair both the species have *sp*^{3} hybridization? ***[NEET Kar. 2013]***
(a) H_2S, BF_3 (b) SiF_4, BeH_2
(c) NF_3, H_2O (d) NF_3, BF_3

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

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

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

52. 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^-? **[2011]**
(a) NO_2^- and NO_3^- (b) NH_4^+ and NO_3^-
(c) SCN^- and NH_2^- (d) NO_2^- and NH_2^-

53. Considering the state of hybridization of carbon atoms, find out the molecule among the following which is linear ? **[2011]**
(a) $CH_3-CH=CH-CH_3$ (b) $CH_3-C\equiv C-CH_3$ (c) $CH_2=CH-CH_2-C\equiv CH$
(d) $CH_3-CH_2-CH_2-CH_3$

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

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

56. 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^- **[2010]**
(c) $SbCl_5^{2-}$ (d) PCl_5

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

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

59. The correct order of increasing bond angles in the following triatomic species is : **[2008]**
(a) $NO_2^- < NO_2^+ < NO_2$
(b) $NO_2^- < NO_2 < NO_2^+$
(c) $NO_2^+ < NO_2 < NO_2^-$
(d) $NO_2^+ < NO_2^- < NO$

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

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

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

63. In which of the following molecules all the bonds are not equal? **[2006]**
(a) BF_3 (b) AlF_3
(c) NF_3 (d) ClF_3

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

65. In BrF_3 molecule, the lone pairs occupy equatorial positions to minimize **[2004]**
(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

66. In an octahedral structure, the pair of d orbitals involved in d^2sp^3 hybridization is **[2004]**
(a) $d_{x^2-y^2}, d_{z^2}$ (b) $d_{xz}, d_{x^2-y^2}$
(c) d_{z^2}, d_{xz} (d) d_{xy}, d_{yz}

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

68. Which of the following has $p_\pi - d_\pi$ bonding? ***[2002]***
(a) NO_3^- (b) SO_3^{2-}
(c) BO_3^{3-} (d) CO_3^{2-}

69. Main axis of a diatomic molecule is z, molecular orbital p_x and p_y overlap to form which of the following orbital? ***[2001]***
(a) π - molecular orbital (b)
σ - molecular orbital (c)
δ - molecular orbital (d)
No bond will be formed

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

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

72. Among the following ions the pπ–dπ overlap could be present in ***[2000]***
(a) NO_2^- (b) NO_3^-
(c) PO_4^{3-} (d) CO_3^{2-}

73. Which one of the following has the pyramidal shape? ***[1999]***
(a) CO_3^{2-} (b) SO_3
(c) BF_3 (d) PF_3

74. Which of the following molecules is planar? ***[1998]***
(a) SF_4 (b) XeF_4
(c) NF_3 (d) SiF_4

75. The AsF_5 molecule is trigonal bipyramidal. The hybrid orbitals used by the As atom for bonding are ***[1997]***
(a) $d_{x^2-y^2}, d_{z^2}, s, p_x, p_y$
(b) d_{xy}, s, p_x, p_y, p_z
(c) $s, p_x, p_y, p_z, d_{z^2}$
(d) $d_{x^2-y^2}, s, p_x, p_y, p_z$

76. The cylindrical shape of an alkyne is due to the fact that it has ***[1997]***
(a) three sigma C – C bonds
(b) two sigma C – C and one 'π' C – C bond
(c) three 'π' C – C bonds
(d) one sigma C– C and two 'π' C – C bonds

77. The BCl_3 is a planar molecule whereas NCl_3 is pyramidal because ***[1995]***
(a) B-Cl bond is more polar than N-Cl bond
(b) N-Cl bond is more covalent than B-Cl bond
(c) nitrogen atom is smaller than boron atom
(d) BCl_3 has no lone pair but NCl_3 has a lone pair of electrons

78. The distance between the two adjacent carbon atoms is largest in ***[1994]***
(a) benzene (b) ethene
(c) butane (d) ethyne

79. Among the following orbital bonds, the angle is minimum between ***[1994]***
(a) sp^3 bonds (b) p_x and p_y orbitals
(c) H – O – H in water (d) sp bonds.

80. Which of the following does not have a tetrahedral structure? ***[1994]***
(a) BH_4^- (b) BH_3
(c) NH_4^+ (d) H_2O.

81. Which of the following statements is not correct ? ***[1993]***
(a) Double bond is shorter than a single bond
(b) Sigma bond is weaker than a π (pi) bond
(c) Double bond is stronger than a single bond
(d) Covalent bond is stronger than hydrogen bond.

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

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

84. In compound X, all the bond angles are exactly 109°28; X is ***[1991]***
(a) Chloromethane
(b) Carbon tetrachloride
(c) Iodoform
(d) Chloroform.

85. Which statement is NOT correct ? ***[1990]***
(a) A sigma bond is weaker than a π-bond.
(b) A sigma bond is stronger than a π-bond.
(c) A double bond is stronger than a single bond.
(d) A double bond is shorter than a single bond.

86. In which one of the following molecules the central atom said to adopt sp^2 hybridization? **[1989]**
(a) BeH_2 (c) C_2H_2 (b) BF_3 (d) NH_3

87. Which of the following molecule does not have a linear arrangement of atoms ? **[1989]**
(a) H_2S (b) C_2H_2
(c) BeH_2 (d) CO_2

88. Equilateral shape has **[1988]**
(a) *sp* hybridisation (b) sp^2 hybridisation
(c) sp^3 hybridisaiton (d) sp^3 hybridisation

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

Topic 5: Valence Bond and Molecular Orbital Theory

90. Identify a molecule which does not exist. **[2020]**
(a) Li_2 (b) C_2
(c) O_2 (d) He_2

91. Which of the following is paramagnetic? **[NEET Odisha 2019]**
(a) O_2 (b) N_2
(c) H_2 (d) Li_2

92. The manganate and permanganate ions are tetrahedral, due to: **[2019]**
(a) The π-bonding involves overlap of *p*-orbitals of oxygen with *d*-orbitals of manganese
(b) There is no π-bonding
(c) The π-bonding involves overlap of *p*-orbital of oxygen with *p*-orbitals of manganese
(d) The π- bonding involves overlap of *d*-orbital of oxygen with *d*-orbitals of manganese

93. Which of the following diatomic molecular species has only π–bonds according to Molecular Orbital Theory ? **[2019]**
(a) O_2 (b) N_2
(c) C_2 (d) Be_2

94. Consider the following species :
CN^+, CN^-, NO and CN
Which one of these will have the highest bond order? **[2018]**
(a) NO (b) CN^-
(c) CN (d) CN^+

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

96. The correct bond order in the following species is: **[2015]**
(a) $O_2^{2+} < O_2^- < O_2^+$ (b) $O_2^+ < O_2^- < O_2^{2+}$
(c) $O_2^- < O_2^+ < O_2^{2+}$ (d) $O_2^{2+} < O_2^+ < O_2^-$

97. Which of the following options represents the correct bond order ? **[2015]**
(a) $O_2^- < O_2 < O_2^+$ (b) $O_2^- > O_2 < O_2^+$
(c) $O_2^- < O_2 > O_2^+$ (d) $O_2^- > O_2 > O_2^+$

98. Which of the following species contains equal number of σ- and π-bonds : **[2015]**
(a) XeO_4 (b) $(CN)_2$
(c) $CH_2(CN)_2$ (d) HCO_3^-

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

100. The hybridization involved in complex $[Ni(CN)_4]^{2-}$. is (At. No. Ni = 28) **[2015 RS]**
(a) dsp^2 (b) sp^3
(c) d^2sp^2 (d) d^2sp^3

101. 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 **[NEET Kar. 2013]**
(a) 1 sigma (σ) and 2 pi (π) bonds
(b) 3 sigma (σ) and 2 pi (π) bonds
(c) 4 sigma (σ) and 1 pi (π) bonds
(d) 5 sigma (σ) and 1 pi (π) bonds

102. In which of the following ionisation processes the bond energy increases and the magnetic behaviour changes from paramagnetic to diamagnetic? ***[NEET Kar. 2013]***
(a) $N_2 \rightarrow N_2^+$ (b) $O_2 \rightarrow O_2^+$
(c) $C_2 \rightarrow C_2^+$ (d) $NO \rightarrow NO^+$

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

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

105. Which one of the following molecules contains no π bond? ***[NEET 2013]***
(a) H_2O (b) SO_2
(c) NO_2 (d) CO_2

106. Four diatomic species are listed below. Identify the correct order in which the bond order is increasing in them: ***[2008, 2012 M]***
(a) $NO \quad O_2^- \quad C_2^{2-} \quad He_2$
(b) $O_2^- \quad NO \quad C_2^{2-} \quad He_2$
(c) $C_2^{2-} \quad He_2^+ \quad O_2^- \quad NO$
(d) $He_2^+ \quad O_2^- \quad NO \quad C_2^{2-}$

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

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

109. Bond order of 1.5 is shown by : ***[2012]***
(a) O_2 (b) O_2^-
(c) O_2^{2-} (d) O_2

110. The pairs of species of oxygen and their magnetic behaviours are noted below. Which of the following presents the correct description ? ***[2011 M]***
(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

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

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

113. According to MO theory which of the following lists ranks the nitrogen species in terms of increasing bond order? ***[2009]***
(a) $N_2^{2-} \quad N_2^- \quad N_2$ (b) $N_2 \quad N_2^{2-} \quad N_2^-$
(c) $N_2^- \quad N_2^{2-} \quad N_2$ (d) $N_2^- \quad N_2 \quad N_2^{2-}$

114. The angular shape of ozone molecule (O_3) consists of : ***[2008]***
(a) 1 sigma and 2 pi bonds
(b) 2 sigma and 2 pi bonds
(c) 1 sigma and 1 pi bonds
(d) 2 sigma and 1 pi bonds

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

116. The number of unpaired electrons in a paramagnetic diatomic molecule of an element with atomic number 16 is ***[2006]***
(a) 3 (b) 4
(c) 1 (d) 2

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

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

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

120. The relationship between the dissociation energy of N_2 and N_2^+ is : ***[2000]***
   (a) Dissociation energy of N_2^+ > dissociation energy of N_2
   (b) Dissociation energy of N_2 = dissociation energy of N_2^+
   (c) Dissociation energy of N_2 > dissociation energy of N_2^+
   (d) Dissociation energy of N_2 can either be lower or higher than the dissociation energy of N_2^+

121. Which one of the following arrangements represents the increasing bond orders of the given species? ***[1999]***
   (a) $NO^+ < NO < NO^- < O_2^-$
   (b) $O_2^- < NO^- < NO < NO^+$
   (c) $NO^- < O_2^- < NO < NO^+$
   (d) $NO < NO^+ < O_2^- < NO^-$

122. Among the following which one is not paramagnetic? [Atomic numbers : Be = 4, Ne = 10, As = 33, Cl = 17] ***[1998]***
   (a) Cl^- (b) Be^+ (c) Ne^{+2} (d) As^+

123. 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) ***[1998]***
   (a) 5 (b) 2 (c) 3 (d) 4

124. N_2 and O_2 are converted into monoanions, N_2^- and O_2^- respectively. Which of the following statements is wrong ? ***[1997]***
   (a) In N_2, the N—N bond weakens
   (b) In O_2, the O—O bond order increases
   (c) In O_2, bond length decreases
   (d) N_2^- becomes diamagnetic

125. The correct order of N–O bond lengths in NO, NO_2^-, NO_3^- and N_2O_4 is ***[1996]***
   (a) $N_2O_4 > NO_2^- > NO_3^- > NO$
   (b) $NO > NO_3^- > N_2O_4 > NO_2^-$
   (c) $NO_3^- > NO_2^- > N_2O_4 > NO$
   (d) $NO > N_2O_4 > NO_2^- > NO_3^-$

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

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

128. Mark the incorrect statement in the following ***[1994]***
   (a) The bond order in the species O_2, O_2^+ and O_2^- decreases as $O_2^+ > O_2 > O_2^-$
   (b) The bond energy in a diatomic molecule always increases when an electron is lost
   (c) Electrons in antibonding M.O. contribute to repulsion between two atoms.
   (d) With increase in bond order, bond length decreases and bond strength increases.

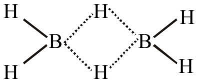
129. Linear combination of two hybridized orbitals belonging to two atoms and each having one electron leads to a ***[1990]***
   (a) Sigma bond
   (b) Double bond
   (c) Co-ordinate covalent bond
   (d) Pi bond.

ANSWER KEY

1	(b)	**14**	(d)	**27**	(c)	**40**	(c)	**53**	(b)	**66**	(a)	**79**	(b)	**92**	(a)	**105**	(a)	**118**	(c)
2	(c)	**15**	(d)	**28**	(c)	**41**	(b)	**54**	(c)	**67**	(a)	**80**	(b)	**93**	(c)	**106**	(d)	**119**	(d)
3	(b)	**16**	(b)	**29**	(a)	**42**	(a)	**55**	(b)	**68**	(b)	**81**	(b)	**94**	(b)	**107**	(a)	**120**	(c)
4	(a)	**17**	(a)	**30**	(a)	**43**	(c)	**56**	(c)	**69**	(a)	**82**	(b)	**95**	(b)	**108**	(a)	**121**	(b)
5	(a)	**18**	(d)	**31**	(b)	**44**	(b)	**57**	(b)	**70**	(c)	**83**	(c)	**96**	(c)	**109**	(b)	**122**	(a)
6	(a)	**19**	(c)	**32**	(d)	**45**	(d)	**58**	(c)	**71**	(c)	**84**	(b)	**97**	(a)	**110**	(c)	**123**	(d)
7	(c)	**20**	(a)	**33**	(d)	**46**	(b)	**59**	(b)	**72**	(c)	**85**	(a)	**98**	(a)	**111**	(a)	**124**	(b)
8	(b)	**21**	(c)	**34**	(c)	**47**	(b)	**60**	(c)	**73**	(d)	**86**	(b)	**99**	(a)	**112**	(b)	**125**	(c)
9	(d)	**22**	(b)	**35**	(c)	**48**	(c)	**61**	(d)	**74**	(b)	**87**	(a)	**100**	(a)	**113**	(a)	**126**	(d)
10	(a)	**23**	(c)	**36**	(b)	**49**	(a)	**62**	(b)	**75**	(c)	**88**	(b)	**101**	(d)	**114**	(d)	**127**	(b)
11	(b)	**24**	(d)	**37**	(b)	**50**	(d)	**63**	(d)	**76**	(d)	**89**	(a)	**102**	(d)	**115**	(c)	**128**	(b)
12	(c)	**25**	(d)	**38**	(b)	**51**	(d)	**64**	(a)	**77**	(d)	**90**	(d)	**103**	(b)	**116**	(d)	**129**	(a)
13	(d)	**26**	(c)	**39**	(b)	**52**	(a)	**65**	(c)	**78**	(c)	**91**	(a)	**104**	(a)	**117**	(a)		

Hints & Solutions

1. (b) $(BH_3)_2$ or (B_2H_6)



It contains two, 3 centre - 2 electron bonds that are present above and below the plane of molecules. Compounds which do not have sufficient number of electrons to form normal covalent bonds are called electron deficient molecules.

2. (c) As difference of electronegativity increases % ionic character increases and covalent character decreases i.e., as electronegativity difference decreases covalent character increases. Further greater the charge on the cation more will be its covalent character. Be has maximum (+2) charge.

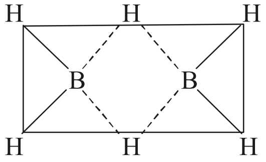
3. (b) The compound, of which central atom is octetless known as electron deficient compound. Hence B_2H_6 is electron deficient compound.

4. (a) Cation and anion form ionic bond in crystal.

NOTES: The electrostatic force that binds the oppositely charged ions which are formed by transfer of electron from one atom to another is called ionic bond.

5. (a) Boron in BCl_3 has 6 electrons in outer most shell. Hence BCl_3 is an electron pair deficient compound.

6. (a)



The bond represented by dots form the 3-centred electron pair bond.

NOTES: The idea of three centred electron pair bond B–H–B bridges is necessary because diborane does not have sufficient electrons to form normal covalent bonds. It has only 12 electrons instead of 14 that are required to give simple ethane like structure.

7. (c) Chemical bonds.

8. (b) The stability of the ionic bond depends upon the lattice energy which is expected to be more between Mg and F due to +2 charge on Mg atom.

9. (d) H-bond is the weakest.

10. (a) According to Fajan's rule, ionic character increases with increase in size of the cation and decrease in size of the anion. Thus, CsF has higher ionic character than NaCl and hence bond strength of CsF is stronger than NaCl.

11. (b) For compounds containing ions of same charge, lattice energy increases as the size the ions decrease. Thus, NaF has highest lattice energy. The size of cation is in the order $Na^+ < K^+ < Rb^+ < Cs^+$.

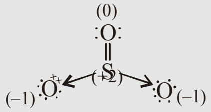
12. (c) As we move in period from Li → Be → B → C, the electronegativity (EN) increases and hence the EN difference between the element and Cl decreases and accordingly the covalent character increases. Thus $LiCl < BeCl_2 < BCl_3 < CCl_4$ is correct.

13. (d) In metallic bonds each ion is surrounded by equal no. of oppositely charged ions hence have electrostatic attraction on all sides and hence do not have directional characteristics.

14. (d) The lowest energy structure is the one with the smallest formal charges on the atoms.

Option (b) and (c) are not possible structures of SO_3.

NOTES: Option (a) :

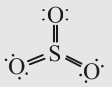


Formal charge = total no. of valence e^- in the free atom – total no. of non-bonding (lone pair) $e^- - \frac{1}{2}$ (total no. of bonding e^-).

Formal charge on S stom $= 6 - 0 - \frac{1}{2}(8) = +2$

Similarly, formal charges on coordinated bonded oxygen atom and covalently bonded oxygen atom are –1 and 0 respectively.

Option (d) :



Formal charge on S atom

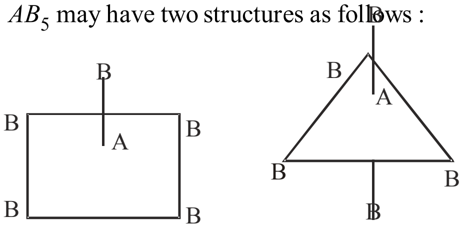
$= 6 - 0 - \frac{1}{2}(12) = 0$

Formal charge on O atom

$= 6 - 4 - \frac{1}{2}(4) = 0$

15. (d) Due to intermolecular hydrogen bonding in methanol, it exist as assosiated molecule.

16. (b) Statement (a), (c), (d) are correct. Statement (b) is incorrect statement.
AB_5 may have two structures as follows :



Square Pyramidal **Trigonal Bipyramidal**

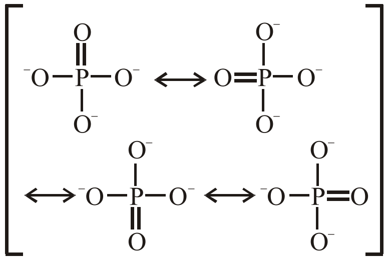
> **NOTES** Individual cannonical structures do not exist. The molecule as such has a single structure, which is the resonance hybrid of the cannonical forms.

17. (a) In X — H - - - Y, X and Y both are electronegative elements (i.e attracts the electron pair) then electron density on X will increase and on H will decrease.

18. (d) F—H-----F—H-----F—H-----F
HF form linear polymer structure due to hydrogen bonding.

19. (c) Bond order between P – O

$$= \frac{\text{no. of bonds in all possible direction}}{\text{total no. of resonating structures}} = \frac{5}{4} = 1.25$$



or Formal charge on oxygen $= -\frac{3}{4} = -0.75$

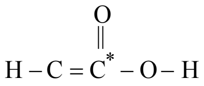
20. (a) We know that due to polar nature, water molecules are held together by intermolecular hydrogen bonds. The structure of ice is open with large number of vacant spaces, therefore the density of ice is less than water.

21. (c) The b.p. of p-nitrophenol is higher than that of o-nitrophenol because in p-nitrophenol there is intermolecular H-bonding but in o-nitrophenol it is intramolecular H-bonding.

> **NOTES** Intramolecular Hydrogen bonding in o-nitrophenol is a interaction with in the molecule whereas the intermolecular H-bonding in p-nitrophenol is a interaction between the molecules which results into higher boiling point. Intermolecular hydrogen bonding also results in a stronger driving force for cystal formation in other molecules generating higher melting temperature *e.g.* p-hydroxy benzoic acid.

22. (b) The strength of the interactions follows the order: van der Waal's < hydrogen – bonding < dipole-dipole < covalent.

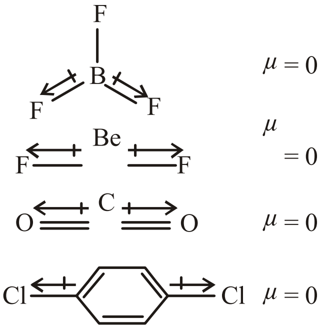
23. (c) Hydrogen fluoride shows strongest hydrogen bonding due to high electronegativity of fluorine.

24. (d)

$$\mathrm{H-C=\overset{\overset{\displaystyle O}{\|}}{C^{*}}-O-H}$$
The star marked carbon has a valency of 5 and hence this formula is not correct.

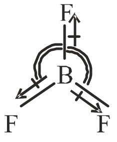
25. (d) As F is most electronegative thus HF shows maximum strength of hydrogen bond.

> **NOTES** With the increase of electronegativity and decrease in size of the atom to which hydrogen is covalently linked, the strength of hydrogen bond increases.

26. (c) BF_3, BeF_2, CO_2 and 1, 4-dichlorobenzene all are symmetrical molecules.

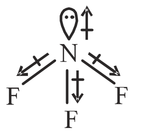


27. (c) Dipole moment of a molecule is the vector sum of dipoles of bonds. So based on molecular geometry of following molecules,

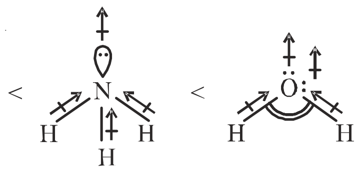


Three equal vectors at 120° has resultant dipole moment = 0, so non-polar molecule

<



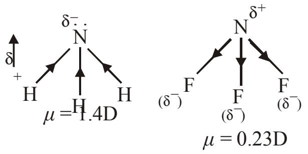
Vectors not alligned in the same direction of lone pair, so less dipole moment



Vectors alligned in same direction

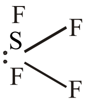
Maximum dipole moment of lone pair

28. (c) Dipole moment of $NH_3 > NF_3$



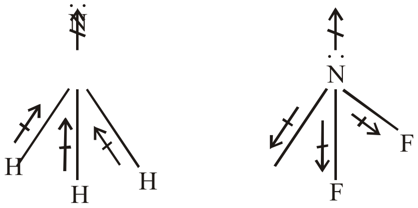
(F is more electronegative than N)

29. (a) SF_4 has 4 bond pairs and 1 lone pair of electrons, sp^3d hybridisation leads to irregular shape



and resultant $\mu \neq 0$.

30. (a) In NH_3 the atomic dipole and bond dipole are in the same direction whereas in NF_3 these are in opposite direction so in the former case they are added up whereas in the latter case net result is reduction of dipole moment. It has been shown in the following figure :



31. (b) SF_4 has permanent dipole moment.

SF_4 has sp^3d hybridization and see saw shape (irregular geometry).

$\mu \neq 0$

Whereas XeF_4 shows square planar geometry, SiF_4 has tetrahedral shape and BF_3 has Trigonal planar shape. All these are symmetric molecules. Hence $\mu = 0$.

32. (d) In H — O — O — H, the O – O bond is purely single. O_3 molecule is a resonance hybrid of two structures : O ═ O → O and O ← O ═ O. Thus, its bond length will be longer than O_2 molecule which has purely double bond (O ═ O). Hence, the correct order is:

$H_2O_2 > O_3 > O_2$ (bond length of O — O)

33. (d) In a linear symmetrical molecule like BeF_2, the bond angle between three atoms is 180°, hence the polarity due to one bond is cancelled by the equal polarity due to other bond. H_2O is angular.

34. (c) As dipole moment = electric charge × bond length

D. M. of *AB* molecules

$= 4.8\times10^{-10}\times2.82\times10^{-8} = 13.53\text{D}$

D.M. of *CD* molecules

$= 4.8\times10^{-10}\times2.67\times10^{-10} = 12.81\text{D}$

now % ionic character

$$= \frac{\text{Actual dipole moment of the bond}}{\text{Dipole moment of pure ionic compound}}$$

% ionic character in

$$AB = \frac{10.41}{13.53}\times100 = 76.94\%$$

% ionic character in

$$CD = \frac{10.27}{12.81}\times100 = 80.23\%$$

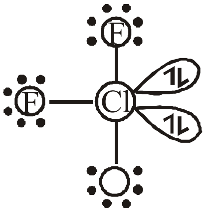
35. (c) As the electronegativity difference between N and F is maximum hence, this bond is most polar.

NOTES Polarity of the bond depends upon the electronegativity difference of the two atoms forming the bond. Greater the electronegativity difference, more is the polarity of the bond.

N – Cl	O – F	N – F	N – N
3.0–3.0	3.5–4.0	3.0–4.0	3.0–3.0

36. (b) BeF_2 is linear and hence has zero dipole moment while H_2O, being a bent molecule, has a finite or non-zero dipole moment.

37. (b) The structure of ClF_3 is



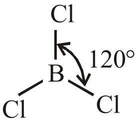
The number of lone pair of electrons on central Cl is 2.

38. (b) $\overset{sp^2}{CH_2} = \overset{sp^2}{CH} - \overset{sp}{C} \equiv \overset{sp}{CH}$

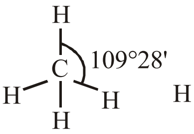
39. (b) IBr_2^-, XeF_2

Total number of valence electrons are equal in both the species and both the species exhibit linear shape.

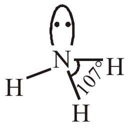
40. (c) BCl_3 is trigonal planar and hence the bond angle is 120°.



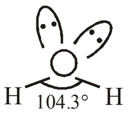
41. (b) CH_4 NH_3 H_2O



Tetrahedral;



Trigonal pyramidal



Bent

NOTES The geometry of H_2O should have been tetrahedral if there are all bond pairs. But due to presence of two lone pairs the shape is distorted tetrahedral. Hence bond angle reduced to 104.5° from 109.5°.

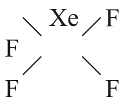
42. (a) According to VSEPR theory order of repulsion in between lp – lp, lp – bp and bp – bp is as under

lp – lp > lp – bp > bp – bp

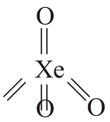
43. (c) ClO_3^- and SO_3^{-2} both have same number of electrons (42) and central atom in each being sp^3 hybridised. Both are having one lone pair on central atom hence they are pyramidal.

44. (b) NO_2^+ has sp hybridisation so it is linear with bond angle = 180°.

45. (d) XeF_4, XeO_4



(Square planar)



[Tetrahedral]

46. (b) $Be^{2+} = (4 - 2) = 2$

is isoelectronic with Li^+ $(3 - 1 = 2)$

Since both have same number of electrons in their outermost shell.

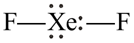
47. (b) Hybridization of $NO_3^- = \frac{1}{2}(5 \quad 0 \quad 1 - 0)$

$= \frac{6}{2} \quad 3 \quad sp^2$ hence geometry is trigonal planner.

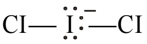
NOTES NO_2^- (nitrite ion) also has sp^2 hybridization and gives a trigonal planner geometry but because there are only two outer atoms, the molecular geometry is bent with Ð120° bond angles.

48. (c) Applying VSEPR theory, both NF_3 and H_2O are sp^3 hybridized.

49. (a)

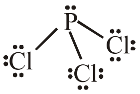


$F-\underset{\cdot\cdot}{\overset{\cdot\cdot}{Xe}}:-F$ sp^3d and Linear



$\left[Cl-\underset{\cdot\cdot}{\overset{\cdot\cdot}{I}}:-Cl\right]^-$ sp^3d and Linear

50. (d) PCl_3



51. (d) BF_4^- hybridisation sp^3, tetrahedral structure.

NH_4 hybridisation sp^3, tetrahedral structure.

52. (a)

NO_2^-, $H \quad \frac{1}{2}[5 \quad 0 \quad 1 - 0] \quad 3 \quad sp^2$

NO_3^-, $H \quad \frac{1}{2}[5 \quad 0 \quad 1 - 0] \quad 3 \quad sp^2$

NH_2^-, $H \quad \frac{1}{2}[5 \quad 2 \quad 1 \quad 0] \quad 4 \quad sp^3$

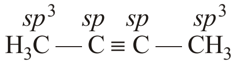
NH_4^+, $H \quad \frac{1}{2}[5 \quad 4 \quad 0 - 1] \quad 4 \quad sp^3$

SCN^-, $H = \frac{1}{2}[4 + 0 + 0 + 0] = 2 = sp$

$\therefore$ NO_2^- and NO_3^- have same hybridisation.

NOTES Hybridisation $= \frac{1}{2}$ [No. of valence electrons of central atom + no. of monovalent atoms attached to it + Negative charge if any – positive charge if any]

53. (b)

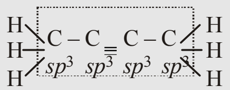


$\overset{sp^3}{H_3C}-\overset{sp}{C}\equiv\overset{sp}{C}-\overset{sp^3}{CH_3}$

linear

NOTES

It is important to note that in but-2-yne, the hydrogen atoms are not linear.



Linear part of molecule

54. (c) (a) NH_4^+ : sp^3 hybridisation
(b) CH_4: sp^3 hybridisation
(c) SF_4: sp^3 d hybridisation
(d) BF_4^- : sp^3 hybridisation

55. (b) In NO_3^- , nitrogen is in sp^2 hybridisation, thus planar in shape. In H_3O^+ , oxygen is in sp^3 hybridisation, thus trigonal pyramidal in shape.

56. (c) $SbCl_5^{2-}$: $\frac{5+5+2}{2} = 6$ means sp^3d^2 hybridisation

I_3^- , SF_4 , and PCl_5 ; all have sp^3d hybridization.

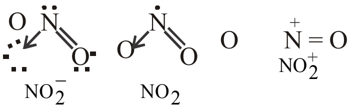
57. (b) $BF_3 : \frac{3+3}{2} = 3$ means sp^2 hybridisation

$NO_2^- : \frac{5+1}{2} = 3$ means sp^2 hybridisation

58. (c) We find that in the given molecules hybridisation is

$BF_3 \rightarrow sp^2$
$NO_2^- \rightarrow sp^2$
$NH_2 \rightarrow sp^3$
$H_2O \rightarrow sp^3$

59. (b) From the structure of three species we can determine the number of lone pair electrons on central atom (i.e. N atom) and thus the bond angle.



We know that higher the number of lone pair of electron on central atom, greater is the lp – lp repulsion between Nitrogen and oxygen atoms. Thus smaller is bond angle.

The correct order of bond angle is

$$NO_2^- \quad NO_2 \quad NO_2$$

60. (c) Hybridization of Br in BrO_3^-

$H = \frac{1}{2}\ 7+0-0\ \ 1\ \ \ 4$

hybridization = sp^3

Hybridization of Xe in XeO_3.

$H\ \ \frac{1}{2}\ 8\ \ 0-0\ \ 0\ \ \ 4$

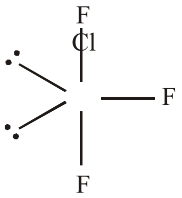
Hybridization = sp^3

In both cases, the structure is trigonal pyramidal.

61. (d) In $SiCl_4$ there is sp^3 hybridisation, so the structure is tetrahedral. In SO_4^{2-}, PO_4^{3-}, NH_4^+ the structure is tetrahedral with sp^3 hybridisation. But in SCl_4, sp^3d hybridisation is present, so its shape is different i.e., see saw.

62. (b) NO_2^+ will have linear shape as it will have sp hybridisation.

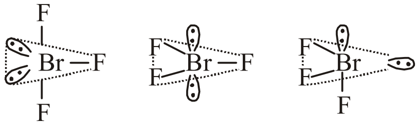
63. (d) In BF_3, AlF_3 & NF_3 all fluoride atoms are symmetrically oriented with respect to central metal atom but in ClF_3 three fluorine atoms are arranged as follows :



Here two bonds are in equatorial plane & one bond is in axial plane.

64. (a) BF_3 is sp^2 hybridised. So, it is trigonal planar. NH_3, PCl_3 has sp^3 hybridisation hence has trigonal pyramidal shape, IF_3, has sp^3d hydridization and is T-shaped.

65. (c) The possible structures are:



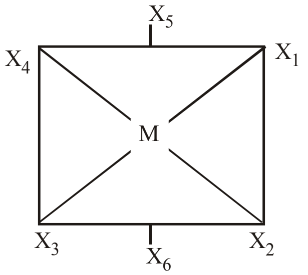
	I	II	III
90° *lp* – *lp* repulsion	0	0	1
90° *lp* – *bp* repulsion	4	6	3
90° *bp* – *bp* repulsion	2	0	2

The first structure is minimizing the *lp* – *lp* repulsion if we compare it with III. The same is minimizing the *lp* – *bp* repulsions if we compare it with II. Also it can be noted that, I structure is not minimizing the *bp* – *bp* repulsions.

66. (a) $d_{x^2-y^2}$, d_{z^2} orbitals are involved in d^2sp^3 hybridisation.

> **NOTES** Only those d orbitals whose lobes are directed along X, Y and Z directions hybridise with s and p orbitals. In other three d orbitals namely d_{xy}, d_{yz} and d_{xz}, the lobes are at an angle of 45° from both axis, hence the extent of their overlap with s and p orbitals is much lesser than $d_{x^2-y^2}$ and d_{z^2} orbitals.

67. (a)



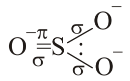
Thus here bond angles between

$X_4 - M - X_2 = 180°$

$X_1 - M - X_3 = 180°$

$X_5 - M - X_6 = 180°$

68. (b) In SO_3^{-2}



S is sp^3 hybridised, so

$${}_{16}S = 1s^2 2s^2 2p^6 \underbrace{3s^2 3p_x^1 3p_y^1 3p_z^1}_{sp^3\text{hybridisation}} \quad \underbrace{3d_{xy}^1}_{\text{unhybride}}$$

In 'S' unhybride d-orbital is present, which will involved in π bond formation with oxygen atom.

$${}_8O = 1s^2\ 2s^2\ 2p_x^2\ 2p_y^1\ 2p_z^1$$

In oxygen two unpaired p-orbital is present in these one is involved in σ bond formation while other is used in π bond formation

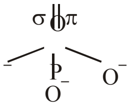
Thus in SO_3^{2-}, pπ and dπ orbitals are involved for $p\pi - d\pi$ bonding.

69. (a) For π-overlap the lobes of the atomic orbitals are perpendicular to the line joining the nuclei.

70. (c) In XeF_2 and IF^{2-}. Both XeF_2 and IF_2^- are sp^3d hybridized and have linear shape.

71. (c) In all the species, the center atom is sp^3 hybridized. But only in NH_4^+, no lone pair of electrons are present. Thus, it has maximum bond angle.

72. (c) In P–O bond, π bond is formed by the sidewise overlapping of d-orbital of P and p-orbital of oxygen. Hence it is formed by $p\pi$ and $d\pi$ overlapping.



73. (d) PF_3 has pyramidal shape Phosphorus exist in sp^3 hybridiation state hence it exist in tetrahedral geometry. But due to presence of lone pair its shape is pyramidal.

74. (b) XeF_4 hybridisation is $\frac{1}{2}(V \quad X - C \quad A)$

hence V = 8 (no. of valence e^-)

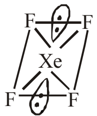
$X = 4$ (no of monovalent atom)

$$\frac{1}{2}(8 \quad 4 \quad 0 - 0) \quad 6,\ sp^3d^2$$

C = 0 charge on cation

A = 0 (charge on anion).

The shape is



Square planar shape.

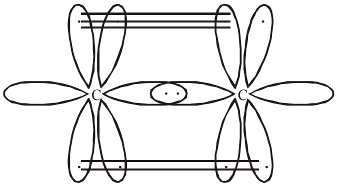
75. (c) The electronic configuration of As is

$$As = 1s^2\ 2s^2\ 2p^6 \underbrace{3s^1\ 3p_{x_3}^{\ 1}\ 3p_y^{\ 1}\ 3p_z^{\ 1}\ 3d^1}_{\downarrow sp\ \ d \text{ hybridisation}}$$

So, the hybrid orbitals used by As atom in AsF_5 molecule are s, p_x, p_y, p_z, d_z^2.

> **NOTES** In the formation of a stable trigonal pyramid, the two axial bonds above and below the equatorial xy-plane have to be equally strong. Thus, the d_z^2 orbital is used.

76. (d) In alkynes the hybridisation is *sp* i.e each carbon atom undergoes *sp* hybridisation to form two *sp*-hybrid orbitals. The two 2*p*-orbitals remain unhybridised. Hybrid orbitals form one sigma and two unhybridised orbitals form π-bonds.



Hence two π bond and one sigma bond between C — C lead to cylindrical shape.

77. (d) As there is no lone pair on boron in BCl_3 therefore no repulsion takes place. But there is a lone pair on nitrogen in NCl_3. Therefore repulsion takes place. Thus, BCl_3 is planar molecule but NCl_3 is a pyramidal molecule.

78. (c) The C–C bond distance decreases as the multiplicity of the bond increases. Thus, bond distance decreases in the order: butane (1.54 Å) > benzene (1.39 Å) > ethene (1.34) Å > ethyne
(1.20 Å). Thus in butane, C – C bond distance is the largest.

79. (b) The angle between the bonds formed by p_x and p_y orbitals is the minimum i.e. 90°.

80. (b) BH_3 has sp^2 hybridization and hence does not have tetrahedral structure while all others have tetrahedral structures.

81. (b) Sigma bond is stronger than π-bond. The electrons in the π bond are loosely held. The bond is easily broken and is more reactive than σ -bond. Energy released during sigma bond formation is always more than π bond because of greater extent of overlapping.

82. (b) CO_2 has *sp*-hybridization and is linear. SO_2 and CO_3^{2-} are planar (sp^2) while SO_4^{2-} is tetrahedral (sp^3).

83. (c) The bond length decreases in the order $sp^3 > sp^2 > sp$.
Because of the triple bond, the carbon-carbon bond distance in ethyne is shortest.

84. (b) All compounds have sp^3 hybridisation, but in CCl_4, all bonded atoms are same. Hence, the bond angle will be exactly 109°28°

85. (a) A σ − bond is stronger than a π -bond hence option (a) is not correct.

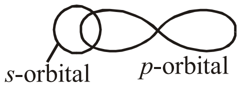
> **NOTES** Sigma (s) bonds are formed by head on overlap of unhybridised *s–s*, *p–p* or *s–p* orbitals and hybridised orbitals (*sp*, sp^2, sp^3, sp^3d and sp^3d^2) hence s bonds are strong bonds where as Pi (p)-bonds are formed by side ways overlap of unhybridised *p*- and *d*-orbitals hence p bonds are weak bonds.

86. (b) BF_3 involves sp^2-hybridization.

87. (a) For linear arrangement of atoms the hybridisation should be *sp*(linear shape, 180° angle). Only H_2S has sp^3-hybridization and hence has angular shape while C_2H_2, BeH_2 and CO_2 all involve *sp*-hybridization and hence have linear arrangement of atoms.

88. (b) Equilateral or triangular planar shape involves sp^2 hybridization.

89. (a)



The overlap between *s*- and *p*-orbitals occurs along internuclear axis and hence the angle is 180°.

90. (d) For He_2 molecule, Electronic configuration is $\sigma 1s^2, \sigma^* 1s^2$

Bond order $= \frac{1}{2}(N_b - N_a) = \frac{1}{2}(2-2) \quad 0$

Since, bond order of He_2 is zero, so it does not exist.

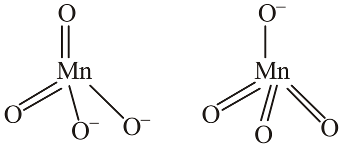
91. (a) Molecular orbital configuration of O_2 is given as :

$O_2\,(16\,e^-) : \sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \sigma 2p_z^2$

$\pi 2p_x^2 = \pi 2p_y^2 \pi^* 2p_x^1 = \pi^* 2p_y^1$

So, in O_2 molecule, there are two (2) unpaired electrons, so, it is a "paramagnetic" substance in nature.

92. (a)



Manganate ion Permanganate ion

93. (c) Only π bond is present in C_2 molecule.
$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \pi 2p_x^2 = \pi 2p_y^2$

94. (b) NO : $(\sigma 1s)^2, (\sigma^* 1s)^2, (\sigma 2s)^2, (\sigma^* 2s)^2, (\sigma 2p_z)^2,$
$(\pi 2p_x)^2 = (\pi 2p_y)^2, (\pi^* 2p_x)^1 = (\pi^* 2p_y)^0$

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

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

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

CN : $(\sigma 1s)^2, (\sigma^* 1s)^2, (\sigma 2s)^2, (\sigma^* 2s)^2,$
$(\pi 2p_x)^2 = (\pi 2p_y)^2, (\sigma 2p_z)^1$

$$\text{B.O.} = \frac{9-4}{2} = 2.5$$

CN$^+$: $(\sigma 1s)^2, (\sigma^* 1s)^2, (\sigma 2s)^2, (\sigma^* 2s)^2,$
$(\pi 2p_x)^2 = (\pi 2p_y)^2$

$$\text{B.O.} = \frac{8-4}{2} = 2$$

Hence, option (2) should be the right answer.

95. (b) CN$^-$ and CO have same no. of electrons and have same bond order equal to 3.

NOTES

Short cut trick to calculate the bond order:
N_2 has 14 electrons and its bond order is 3. We have to remember this concept that every electron added or subtracted to 14, reduces the bond order by 0.5. For example
CN$^-$ ⇒ no. of electrons = 6 + 7 + 1 = 14
∴ bond order = 3
CO ⇒ no. of electrons = 6 + 8 = 14
∴ bond order = 3
NO ⇒ no. of electrons = 7 + 8 = 15
∴ bond order = 3 – 0.5 = 2.5
NO$^+$ ⇒ no. of electrons = 7 + 8 – 1 = 14
∴ bond order = 3
O_2^- ⇒ no. of electrons = 8 + 8 + 1 = 17
∴ bond order = 3 – 1.5
Please note that this method will work for any species that have electrons between 10 and 18.

96. (c) O_2^+ ion - Total number of electrons $(16-1) = 15$.

Electronic configuration

$$\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2p_x^2 < \pi 2p_y^2 = \pi 2p_z^2 < \pi^* 2p_y^1$$

$$\text{Bond order} = \frac{N_b - N_a}{2} = \frac{10-5}{2} = \frac{5}{2} = 2\frac{1}{2}$$

O_2^- (Super oxide ion): Total number of electrons $(16+1) = 17$.

Electronic configuration

$$\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2p_x^2 < \pi 2p_y^2 = \pi 2p_z^2 < \pi^* 2p_y^2 = \pi^* 2p_z^1$$

$$\text{Bond order} = \frac{(N_b - N_a)}{2} = \frac{10-7}{2} = \frac{3}{2} = 1\frac{1}{2}$$

O_2^{+2} ion: Total number of electrons $= (16-2) = 14$ Electronic configuration
$\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2p_x{}^2 < \pi 2p_y{}^2 = \pi 2p_z{}^2$

$$\text{Bond order} = \frac{(N_b - N_a)}{2} = \frac{10-4}{2} = \frac{6}{2} = 3$$

So bond order: $O_2^- < O_2^+ < O_2^{2+}$

97. (a) Oxygen molecule (O_2) – Total number of electrons = 16 and electronic configuration is

$$\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2p_x^2 < \pi 2p_y^2 = \pi 2p_z^2 < \pi^* 2p_y^1 = \pi^* 2p_z^1$$

$$\text{Bond order} = \frac{N_b - N_a}{2} = \frac{10-6}{2} = \frac{4}{2} = 2$$

O_2^+ ion - Total number of electrons $(16-1) = 15$.
Electronic configuration

$$\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2p_x^2 < \pi 2p_y^2 = \pi 2p_z^2 < \pi^* 2p_y^1$$

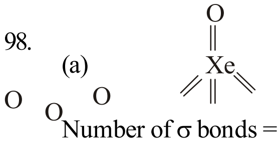
$$\text{Bond order} = \frac{N_b - N_a}{2} = \frac{10-5}{2} = \frac{5}{2} = 2\frac{1}{2}$$

O_2^- (Super oxide ion) Total number of electrons $(16+1) = 17$. Electronic configuration

$$\sigma 1\mathrm{s}^2 < \sigma^* 1\mathrm{s}^2 < \sigma 2\mathrm{s}^2 < \sigma^* 2\mathrm{s}^2 < \sigma 2\mathrm{p}_x^2 < \pi 2\mathrm{p}_y^2 = \pi 2\mathrm{p}_z^2 < \pi^* 2\mathrm{p}_y^2 = \pi^* 2\mathrm{p}_z^1$$

$$\text{Bond order} = \frac{(N_b - N_a)}{2} = \frac{10-7}{2} = \frac{3}{2} = 1\frac{1}{2}$$

98. (a)



Number of σ bonds = 4
Number of π bonds = 4

99. (a) According to molecular orbital theory as bond order decreases stability of the molecule decreases

Bond order $\frac{1}{2}(N_b - N_a)$

Bond order for $O_2^+ = \frac{1}{2}(10-5) = 2.5$

Bond order for $O_2 = \frac{1}{2}(10-6) = 2$

Bond order for $O_2^- = \frac{1}{2}(10-7) = 1.5$

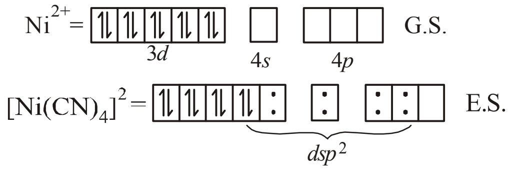
Bond order for $O_2^{2-} = \frac{1}{2}(10-8) = 1.0$

hence the correct order is

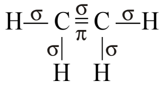
$O_2^+ > O_2 > O_2^- > O_2^{2-}$

100. (a) $Ni^{2+} = [Ar]\,3d^8, 4s^0$

In the presence of strong ligand CN^-, pairing of electrons will occur:



101. (d)



$$\underset{}{H} \overset{\sigma}{-} \underset{H}{\overset{}{C}} \overset{\sigma}{\underset{\pi}{=}} \underset{H}{C} \overset{\sigma}{-} H$$

102. (d) (a) $N_2 \longrightarrow N_2$

B.O. 3 2.5

Bond energy decreases

Magnetic behaviour changes from diamagnetic to paramagnetic

(b) $O^2 \longrightarrow O_2^+$

B.O. 2 2.5

Bond energy increases

Magnetic behaviour does not change.

(c) $C_2 \longrightarrow C_2^+$

B.O. 2 2.5

Bond energy decreases

Magnetic behaviour changes from diamagnetic to paramagnetic

(d) $NO \longrightarrow NO^+$

B.O. 2 2.5

bond energy increases

Magnetic behaviour changes from paramagnetic to diamagnetic

103. (b) No. of electrons in CO = 6 + 8 = 14

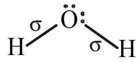
No. of electrons in NO^+ = 7 + 8 – 1 = 14

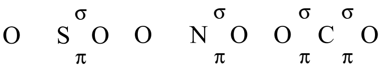
∴ CO and NO^+ are isoelectronic species. Isoelectronic species have identical bond order.

104. (a) Molecular orbital configuration of O_2^- is

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

105. (a)





$$O \quad S \overset{\sigma}{\underset{\pi}{\,}} O \quad O \qquad N \overset{\sigma}{\underset{\pi}{\,}} O \qquad O \overset{\sigma}{\underset{\pi}{\,}} C \overset{\sigma}{\underset{\pi}{\,}} O$$

106. (d) Calculating the bond order of various species.

O_2^- : $KK\sigma 2s^2\, \sigma^* 2s^2 \sigma 2p_z^2$

$\pi 2p_x^2\ \pi 2p_y^2\ \pi^* 2p_x^2\ \pi^* 2p_y^1$

$$\text{B.O.} = \frac{\text{Number of electrons in bonding} - \text{Number of electrons in non-bonding}}{2}$$

$$= \frac{8-5}{2} \text{ or } 1.5$$

$NO: KK\,\sigma 2s^2\ \sigma^* 2s^2\ \pi 2p_x^2 \approx \pi 2p_y^2\ \sigma 2p_z^2\ \pi^* 2p_x^1$

$$\text{B.O.} = \frac{N_b - N_a}{2} = \frac{8-2}{2} \text{ or } 2.5$$

$C_2^{2-} : kk\,\sigma 2s^2\ \sigma^* 2s^2\, \pi 2p_x^2\ \ \pi 2p_y^2\, \sigma 2p_z^2$

$$\text{B.O.} = \frac{N_b - N_a}{2} = \frac{8-2}{2} \text{ or } 3$$

$He_2^+ = \sigma 1s^2\, \sigma^* 1s^1$

$$\text{B. O.} = \frac{N_b - N_a}{2} = \frac{2-1}{2} \text{ or } 0.5$$

From these values we find the correct order of increasing bond order is

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

107. (a) $O_2 = KK(\sigma 2s)^2 (\sigma^* 2s)^2 (\sigma 2p_z)^2 (\pi 2p_x)^2 (\pi 2p_y)^2 (\pi^* 2p_x)^1 (\pi^* 2p_y)^1$

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

108. (a) Both O_2^{2-} and B_2 has bond order equal to 1.

$$B_2(10) = [\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \pi 2p^1{}_y \pi 2p_z{}^1]$$

$$\text{Bond order} = \frac{N_b - N_a}{2} = \frac{6-4}{2} = \frac{2}{2} = 1$$

B_2 is known to be in the gas phase.

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

$$\text{Bond order} = \frac{1}{2} \; 10 - 8 \quad 1$$

109. (b) $(O_2) = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2 \pi 2p_x^2$

$$= \pi 2p_y^2 \; \pi^* 2p_x^1 = \pi^* 2p_y^1$$

$$\text{Bond order} = \frac{N_b - N_a}{2} = \frac{10-6}{2} = \frac{4}{2} = 2$$

O_2 ion $\quad \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2$

$$\sigma 2p_z^2 \; \pi 2p_x^2 = \pi 2p_y^2 \; \pi^* 2p_x^1$$

$$\text{Bond order} = \frac{N_b - N_a}{2} = \frac{10-5}{2} = \frac{5}{2} = 2\frac{1}{2}$$

$O_2^- \quad \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2P_z^2$

$\pi 2p_x^2 = \pi 2p_y^2 \; \pi^* 2p_x^2 \; \pi^* 2p_y^1$

$$\text{Bond order} = \frac{(N_b - N_a)}{2} = \frac{10-7}{2} = \frac{3}{2} = 1\frac{1}{2}$$

$O_2^{2-} \quad \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2 \; \pi 2p_x^2$

$$= \pi 2p_y^2 \; \pi^* 2p_x^2 = \pi^* 2p_y^2$$

$$\text{Bond order} \; \frac{N_b - N_a}{2} \quad \frac{10-8}{2} \quad \frac{2}{2} \quad 1$$

110. (c) MOT configurations of O_2 and $O_2{}^+$:
$O_2^+ : (\sigma 1s)^2 (\sigma^* 1s)^2 (\sigma 2s)^2 (\sigma^* 2s)^2 (\sigma 2p_z)^2$
$(\pi 2p^2{}_x = \pi 2p^2{}_y) \; (\pi^* 2p_x{}^1 = \pi^* 2p^1{}_y)$
Number of unpaired electrons = 2, so paramagnetic.
$O_2 : (\sigma 1s)^2 (\sigma^* 1s)^2 (\sigma 2s)^2 (\sigma^* 2s)^2 (\sigma 2p_z)^2 (\pi 2p^2{}_x = \pi 2p^2{}_y) \; (\pi^* 2p_x{}^1 = \pi^* 2p^0{}_y)$
Number of unpaired electrons = 2, so paramagnetic.

111. (a) $O_2(16) : KK (\sigma 2s)^2 (\sigma * 2s)^2 (\sigma 2p_z)^2 (\pi 2p_x)^2 (\pi 2p_y)^2, (\pi^*{}_2 p_y)^1 = (\pi^*{}_2 p_x)^1$, B.O.: 2

$O_2{}^+$ (15) : Remove one electron from $\pi^* 2p_y$ from O_2, B.O.: 2.5

$O_2{}^-$ (17) : KK $(\sigma 2s)^2 (\sigma * 2s)^2 (\sigma 2p_z)^2 (\pi 2p_x)^2 (\pi 2p_y)^2, (\pi * 2p_x)^2 (\pi * 2p_y)^1$, B.O.: 1.5

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

Since, the bond length decreases as the bond order increases, hence, $O_2{}^+$ have least bond length.

112. (b) Bond order of $Be_2 = 0$, hence Be_2 cannot exist.

113. (a) Molecular orbital configuration of

2 $\quad N_{-} = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 -$

$$\begin{cases} \pi 2p_y^2 \\ \pi 2p_z^2 \end{cases} \sigma 2p_x^2 \begin{cases} \pi^* 2p_y^1 \\ \pi^* 2p_z^1 \end{cases}$$

$$\text{Bond order} = \frac{10-6}{2} \quad 2$$

$$N_2^- = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2$$

$$\begin{cases} \pi 2p_y^2 \\ \pi 2p_z^2 \end{cases} \sigma 2p_x^2 \begin{cases} \pi^* 2p_y^1 \\ \pi^* 2p_z^0 \end{cases}$$

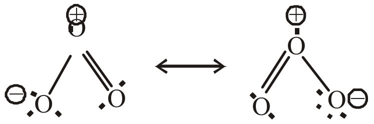
$$\text{Bond order} = \frac{10-5}{2} \quad 2.5$$

$$N_2 = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \begin{cases} \pi 2p_y^2 \\ \pi 2p_z^2 \end{cases}, \; \sigma 2p_x^2$$

$$\text{Bond order} = \frac{10-4}{2} \quad 3$$

$\therefore$ The correct order is $= N_2^{2-} \quad N_2^- \quad N_2$

114. (d) The shape of ozone molecule is

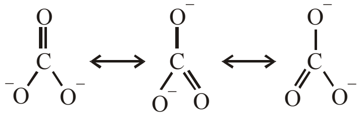


In it we find 2 σ and 1π bond, i.e., option (d) is correct.

115. (c) All these structures exhibits resonance and can be represented by the following resonating structures.

(i) $:\overline{\mathrm{C}} \equiv \mathrm{O}: \longleftrightarrow :\mathrm{C} \quad \ddot{\mathrm{O}}:$

(ii)



(iii) $:\underset{..}{\mathrm{O}} \quad \mathrm{C} \quad \underset{..}{\mathrm{O}}: \longrightarrow :\mathrm{O}-\mathrm{C}\equiv \underset{..}{\overset{..}{\overline{\mathrm{O}}}}:$

$\longleftrightarrow \; \overline{:}\underset{..}{\overset{..}{\mathrm{O}}}\equiv \mathrm{C}-\mathrm{O}:$

More is the single bond character. More will be the bond length. Hence, the corret order is :

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

116. (d) Electronic configuration of the mo-lecule

according to molecular orbital theory, is $\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2\, (\pi 2p_x^2 = \sigma 2p_y^2)$

$(\pi^* 2p_x^2 = \pi 2p_y^2)\, \sigma^* 2p_z^2 \sigma 3s^2 \sigma^* 3s^2 \sigma 3p_z^2$

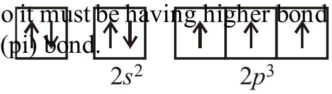
$(\pi 3p_x^2 = \pi 3p_y^2)\, (\pi^* 3p_x^1 = 3p_y^1)$

Last two electrons are unpaired. So no. of unpaired electron is 2.

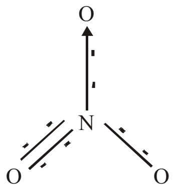
117. (a) SiF_4 has symmetrical tetrahedral shape which is due to sp^3 hybridisation of silicon atom in its excited state while SF_4 has distorted tetrahedral or sea-saw geometry which arises due to sp^3d hybridisation of sulphur atom and one lone pair of e^-s in one of the equatorial hybrid orbital.

118. (c) As sigma bond is stronger than the π (pi) bond, so it must be having higher bond energy than π (pi) bond.

119. (d) N :



To form NO_3^-, nitrogen uses one *p*-electron for π-bond formation and two *p*-electrons for σ-bond formation. 2*s* electrons are used for coordinate bond formation. Thus there is no lone pair on nitrogen and four bond pairs are present.



120. (c) Dissociation energy of any molecules depends upon bond order. Bond order in N_2 molecule is 3 while bond order in N_2^+ is 2.5. Further we know that more the Bond order, more is the stability and more is the BDE.

121. (b) $NO^+ = \sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2 \sigma^* 2s^2\ \sigma 2p_x^{\ 2}$

$\pi 2p_y^{\ 2} = \pi 2p_z^{\ 2}$

Bond order of $NO^+ = \frac{1}{2}(N_b - N_a)$

$= \frac{1}{2}(10-4) = \frac{1}{2}\times 6 \quad 3$

Similarly, Bond order of $NO = \frac{1}{2}(10 \quad 5)$

$= \frac{1}{2}(5) = 2.5$

Bond order of NO^- $\quad \frac{1}{2}(10 \quad 6) = \frac{1}{2}(4) = 2$

Bond order of $O_2^- = \frac{1}{2}(10-7) = \frac{1}{2}(3) = 1.5$

By above calculation, we get

Decreasing bond order

$$NO^+ > NO > NO^- > O_2^-$$

122. (a) Paramagnetic character is based upon presence of unpaired electron

$Cl^- = 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p_x^2\, 3p_y^2\, 3p_z^2$

$Be^+ = 1s^2\, 2s^1$

$$Ne^{2+} = 1s^2\,2s^2\,2p_x^2\,2p_y^1\,2p_z^1$$

$$As^{+} = 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}$$

$$4s^2\,4p_x^1\,4p_y^1\,4p_z^1$$

Hence only Cl^- do not have unpaired electrons.

123. (d) Total no. of electrons in $O_2^{2-} = 16 + 2 = 18$

Distribution of electrons in molecular orbital

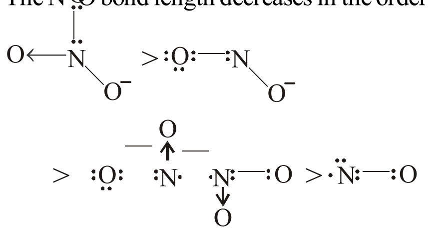
$$\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_x^2, \pi 2p_y^2$$

$$\pi 2p_z^2, \pi^* 2p_x^2\, \pi^* 2p_y^2$$

Anti bonding electron = 8 (4 pairs)

124. (b) We know that in O_2 bond, the order is 2 and in O_2^- bond, the order is 1.5. Therefore, the wrong statements is (b).

125. (c) The N–O bond length decreases in the order



126. (d) In this configuration, there are four completely filled bonding molecular orbitals and one completely filled antibonding molecular orbital. So that $N_b = 8$ and $N_a = 2$.

$$\therefore \quad \text{Bond order} = \frac{1}{2}(N_b - N_a) = \frac{1}{2}(8-2) = 3.$$

127. (b) The structure of NO:

In NO, the presence of unpaired electron is clear. Therefore, it is paramagnetic.

128. (b) The removal of an electron from a diatomic molecule may increase or decrease the bond order.

> Removal of an electron from bonding orbital results in decrease of bond order, hence reduces bond strength while removal of an electron from antibonding orbital results into increase in bond order hence increases the bond strength.

129. (a) Linear combination of two hybridized orbitals leads to the formation of sigma bond.