CHAPTER

04

CHEMICAL BONDING & MOLECULAR STRUCTURE

Exercise 1: NCERT Based Topic-wise MCQs

4.0 INTRDUCTION

1. The evolution of various theories of valence and the interpretation of the nature of chemical bonds have closely been related to the developments in the understanding of NCERT Page-100 / N-100
(a) structure of atom
(b) electronic configuration of elements
(c) periodic table
(d) All of the above

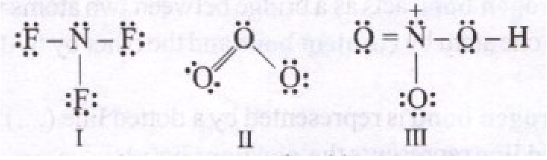
4.1 KOSSEL-LEWIS APPROACH TO CHEMICAL BONDING

2. Who provide explanation of valence based on intertness of noble gases ? NCERT Page-101 / N-101
(a) Lewis
(b) Kössel-Lewis
(c) Langmuir
(d) Sidgwick & Powell

3. The bond formed as a result of the electrostatic attraction between the positive and negative ions is termed as ... NCERT Page-101 / N-101
(a) Chemical bond
(b) Electrovalent bond
(c) Co-ordinate bond
(d) Covalent bond

4. When a metal atom combines with non-metal atom, the non-metal atom will NCERT Page-101 / N-101
(a) lose electrons and decrease in size
(b) lose electrons and increase in size
(c) gain electrons and decrease in size
(d) gain electrons and increase in size

5. Which of the following Lewis representation of the molecules NF_3, O_3 and HNO_3 is correct?



Choose the correct option(s).
(a) Only I
(b) Only II
(c) Only III
(d) I, II and III

6. The lowest energy structure is the one with the formal charges on the atoms. NCERT Page-105/ N-105
(a) smallest
(b) highest
(c) zero
(d) negative

7. Which of the following pair of molecules contain odd electron molecule and an expanded octet molecule? NCERT Page-105 / N-105
(a) BCl_3 and SF_6
(b) NO and H_2SO_4
(c) SF_6 and H_2SO_4
(d) BCl_3 and NO

8. Which of the following compounds does not follow the octet rule for electron distribution? NCERT Page-102
(a) PCl_5
(c) H_2O
(b) PCl_3
(d) PH_3

9. Which of the following is the electron deficient molecule? NCERT Page-105 / N-105
(a) C_2H_6
(c) SiH_4
(b) B_2H_6
(d) PH_3

10. A pair of compound which have odd electrons in the group $NO, CO, ClO_2, N_2O_5, SO_2$ and O_3 are NCERT Page-105/N-105
(a) NO and ClO_2
(c) ClO_2 and CO
(b) CO and SO_2
(d) SO_2 and O_3

4.2 IONIC OR ELECTROVALENT BOND

11. Energy required to completely separate one mole of a solid ionic compound into gaseous constituent ions is called NCERT Page-107 / N-107
(a) Ionisation enthalpy
(b) Electron gain enthalpy
(c) Bond dissociation enthalpy
(d) Lattice enthalpy

12. Which of the following combination will form an electrovalent bond? NCERTage-106 / N-106

(a) P and Cl
(b) NH_3 and BF_3
(c) H and Ca
(d) H and S

13. Complete the following statement by choosing the appropriate option. NCERT Page-106 / N-106
Ionic bonds will be formed more easily between elements with comparatively **A** and elements with comparatively high negative value of **B**.

(a) A = low electronegativity; B = ionization enthalpy
(b) A = low ionization enthalpy; B = electron gain enthalpy
(c) A = high ionization enthalpy; B = electron gain enthalpy
(d) A = high electronegativity; B = ionization enthalpy

14. Which of the following pairs will form the most stable ionic bond? NCERT Page-106 / N-106

(a) Na and Cl
(b) Mg and F
(c) Li and F
(d) Na and F

15. Among the following which compound will show the highest lattice energy? NCERT Page-107 / N-107

(a) KF
(b) NaF
(c) CsF
(d) RbF

4.3 BOND PARAMETERS

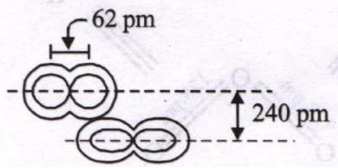
16. ______is measured as the radius of an atom's core which is in contact with the core of an adjacent atom in a bonded situation. NCERT Page-107 /. N-107

(a) van der Waal's radius
(b) Bond length
(c) Covalent radius
(d) Ionic radius

17. Which of the following methods is used for measuring bond length ? NCERT Page-107 / N-107

(a) X-ray diffraction
(b) Electron-diffraction
(c) Spectroscopic techniques
(d) All of these

18. From the given figure the van der Waal radius and covalent radius of the hydrogen atom respectively are NCERT Page-107 / N-107



(a) 151,31

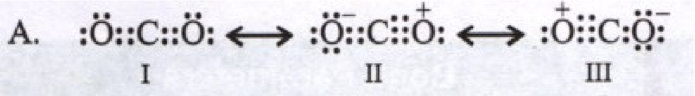
(b) 120,31
(c) 31,100
(d) 30,120

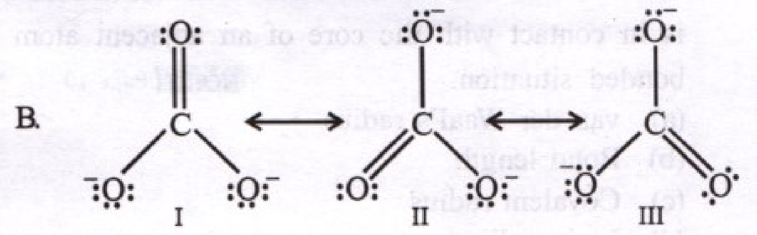
19. The covalent bond length is the shortest in which one of the following bonds? NCERT Page-108 / N-108
(a) $C - O$
(b) $C - C$
(c) $C \equiv N$
(d) $O - H$

20. Which of the following statement is correct? NCERT Page-108 / N-108
a) Amount of energy required to break one mole of bonds of a particular type between two atoms in a gaseous state is called bond enthalpy.
b) The unit of bond enthalpy is $\mathrm{kJmol^{-1}}$.
c) Larger the bond dissociation enthalpy, stronger will be the bond in the molecule.
d) All of these

21. Resonance is due to NCERT Page-109 / N-109
(a) delocalization of sigma electrons
(b) delocalization of pi electrons
(c) migration of protons
(d) Both (a) and (b)

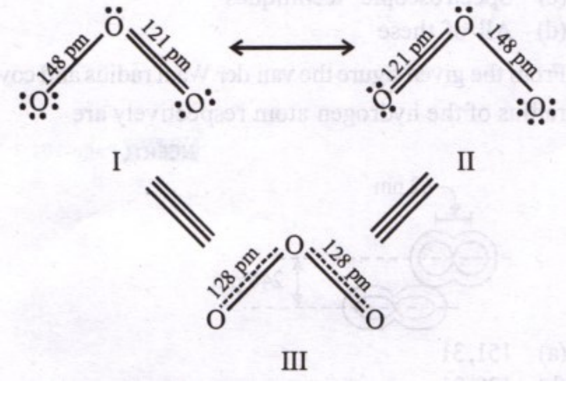
22. Which of the following is correct representation of resonance? NCERT PageN-110





Choose the correct option.
(a) Only A
(b) OnlyB
(c) Both A and B
(d) None of these

23. Which of the following structure represents structure of O_3 more accurately? NCERT Page-109 / N-109



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

24. Hydrogen chloride molecule contains NCERT Page N-111
(a) polar covalent bond
(b) double bond
(c) co-ordinate bond
(d) electrovalent bond

25. The most polar bond is NCERT Page N-111
(a) $C-F$
(b) $C-O$
(c) $C-Br$
(d) $C-S$

26. The molecule which has zero dipole moment is NCERT Page-111 / N-111
(a) CH_3Cl
(b) NF_3
(c) BF_3
(d) ClO_2

27. Among the following, the molecule of high dipole moment is NCERT Page-111 / N-111
(a) CCl_4
(c) H_2O
(b) NH_3
(d) $CHCl_3$

28. Which one of the following molecules is expected to have zero dipole moment? NCERT Page-111 / N-111
(a) H_2O
(b) CO_2
(c) SO_2
(d) CaF_2

29. Which one of the following pairs of molecules will have permanent dipole moments for both members?
(a) NO_2 and CO_2 NCERT Page-111 / N-111
(c) SiF_4 and CO_2
(b) NO_2 and O_3
(d) SiF_4 and NO_2

30. According to Fajan's rule, covalent bond is favoured by
(a) Large cation and small anion NCERT Page-112 / N-112
(b) Large cation and large anion
(c) Small cation and large anion
(d) Small cation and small anion

31. Polarisibility of halide ions increases in the order
(a) F^-, I^-, Br^-, Cl^-
(b) Cl^-, Br^-, I^-, F^-
(c) I^-, Br^-, Cl^-, F^-
(d) $F^-, Cl^-, Br^-, 1^-$

32. Which of the following substances has the least covalent character?
(a) Cl_2O
(b) NCl_3
(c) $PbCl_2$
(d) $BaCl_2$

33. The correct sequence of increasing covalent character is represented by NCERT Page-112 / N-112
(a) $LiCl < NaCl < BeCl_2$
(b) $BeCl_2 < LiCl < NaCl$
(c) $NaCl < LiCl < BeCl_2$
(d) $BeCl_2 < NaCl < LiCl$

34. Which of the following salt shows maximum covalent character? NCERT Page N-112
(a) $AlCl_3$
(b) $MgCl_2$
(c) $CsCl$
(d) $LaCl_3$

35. Arrange the following in increasing order of covalent character (i) NaCl, (ii) RbCl, (iii) $MgCl_2$, (iv) $AlCl_3$?
(a) (i), (ii), (iii), (iv) NCERT Page N-112
(b) (iv), (ii), (i), (iii)
(c) (ii), (i), (iii), (iv)
(d) (iii), (i), (ii), (iv)

36. Arrange the following in the decreasing order of their covalent character : NCERT Page N-112
(A) LiCl
(B) NaCl
(C) KCl
(D) CsCl

Choose the most appropriate answer from the options given below :
(a) (A) > (C) > (B) > (D)
(b) (B) > (A) > (C) > (D)
(c) (A) > (B) > (C) > (D)
(d) (A) > (B) > (D) > (C)

4.4 THE VALENCE SHELL ELECTRON PAIR REPULSION (VSEPR THEORY)

37. Which of the following is the correct increasing order of lone pair of electrons on the central atom?
(a) $IF_7 < IF_5 < ClF_3 < XeF_2$ NCERT Page-115 / N-115
(b) $IF_7 < XeF_2 < ClF_2 < IF_5$
(c) $IF_7 < ClF_3 < XeF_2 < IF_5$

(d) $IF_7 < XeF_2 < IF_5 < ClF_3$

38. The number of lone pair and bond pair of electrons on the sulphur atom in sulphur dioxide molecule are respectively
    (a) 1 and 3 NCERT Page-115 / N-115
    (b) 4 and 1
    (c) 3 and 1
    (d) 1 and 4

39. A molecule has two lone pairs and two bond pairs around the central atom. The molecule shape is expected to be
    (a) V-shaped NCERT Page N-115
    (b) triangular
    (c) linear
    (d) tetrahedral

40. Which of the following molecules has trigonal planar geometry? NCERT Page N-115
    (a) BF_3
    (b) NH_3
    (c) PCl_3
    (d) IF_3

41. The shape of stannous chloride molecule is NCERT Page N-115
    (a) see-saw
    (c) trigonal pyramidal
    (b) square planar
    (d) bent

42. Consider the species CH_4, NH_4^+ and BH_4^-. Choose the correct option with respect to the there species:
    (a) They are isoelectronic and only two have tetrahedral structures NCERT Page- N-115
    (b) They are isoelectronic and all have tetrahedral structures
    (c) Only two are isoelectronic and all have tetrahedral structures
    (d) Only two are isoelectronic and only two have tetrahedral structures

43. The geometry of ClO_3^- ion according to Valence Shell Electron Pair Repulsion (VSEPR) theory will be
    (a) planar triangular NCERT Page N-115
    (b) pyramidal
    (c) tetrahedral
    (d) square planar

44. Using VSEPR theory, predict the species which has square pyramidal shape NCERT Page N-115
    (a) $SnCl_2$
    (b) CCl_4
    (c) SO_3
    (d) BrF_5

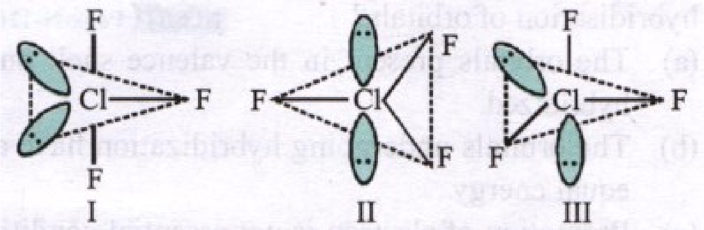
45. Among the following molecules: SO_2, SF_4, ClF_3, BrF_5 and XeF_4, which of the following shapes does not describe any of the molecules mentioned? NCERT PageN-115
    (a) Bent
    (b) Trigonal bipyramidal
    (c) See-saw
    (d) T-shape

46. A σ-bonded molecule MX_3 is T-shaped. The number of non-bonding pairs of electron is NCERT Page N-115
(a) 0
(b) 2
(c) 1
(d) can be predicted only if atomic number of M is known.

47. Which of the following molecules is planar? NCERT Page N-115
(a) SF_4
(b) XeF_4
(c) NF_3
(d) SiF_4

48. 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

49. Which of the following structure is most stable? NCERT Page-115/ N-115



Choose the correct option.
(a) Only I
(b) Only II
(c) Only III
(d) All three have same stability

50. In the structure of SF_4, the lone pair of electrons on S is in. NCERT Page-116 / N-116
(a) equatorial position and there are two lone pair-bond pair repulsions at 90°
(b) equatorial position and there are three lone pair-bond pair repulsions at 90°
(c) axial position and there are three lone pair-bond pair repulsion at 90°
(d) axial position and there are two lone pair-bond pair repulsion at 90°

4.5 VALENCE BOND THEORY

51. Which of the following statements is false ?
(a) H_2 molecule has one sigma bond
(b) HCl molecule has one sigma bond
(c) Water molecule has two sigma bonds and two lone pairs
(d) Acetylene molecule has three pi bonds and three sigma bonds

52. The number of sigma (σ) and pi (π) bonds present in 1,3,5,7 octatetraene respectively are
(a) 14 and 3
(b) 17 and 4

(c) 16 and 5
(d) 15 and 4

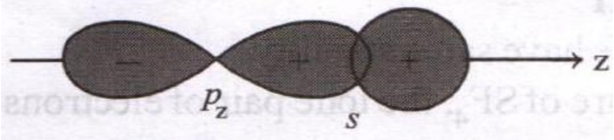
53. Allyl cyanide molecule contains
(a) 9 sigma bonds, 4 pi bonds and no lone pair
(b) 9 sigma bonds, 3 pi bonds and one lone pair
(c) 8 sigma bonds, 5 pi bonds and one lone pair
(d) 8 sigma bonds, 3 pi bonds and two lone pairs

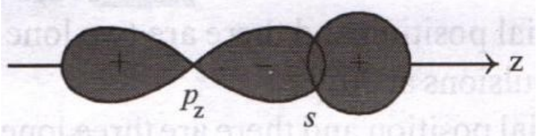
54. In hexa-1,3-diene-5-yne thenumber of $\mathrm{C-C}\sigma, \mathrm{C-C}\pi$ and $\mathrm{C-H}\sigma$ bonds, respectively are NCERT Page N-122
(a) 5,4 and 6
(b) 6,3 and 5
(c) 5,3 and 6
(d) 6,4 and 5

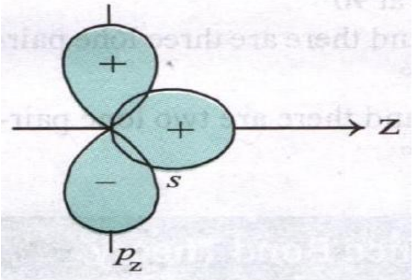
55. Linear combination of two hybridized orbitals belonging to two atoms and each having one electron leads to a
NCERT Page-126 / N-126
(a) sigma bond
(b) double bond
(c) co-ordinate covalent bond
(d) pi bond.

56. Which of the following statements is not correct? NCERT Page-N-120
(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

57. The enolic form of a acetone contains
(a) 9 sigma bonds, 1 pi bond and 2 lone pairs
(b) 8 sigma bonds, 2 pi bonds and 2 lone pairs
(c) 10 sigma bonds, 1 pi bond and 1 lone pair
(d) 9 sigma bonds, 2 pi bonds and 1 lone pair

58. Which of the following represents zero overlap of atomic orbitals. NCERT Page-119 / N-119
(a)


(b)


(c)


(d) All of these

59. The strength of bonds formed by $s-s$ and $p-p, s-p$ overlap in the order of NCERT Page-N-120
(a) $s-p > s-s > p-p$
(b) $p-p > s-s > s-p$

(c) $s-s>p-p>s-p$
(d) $s-s>s-p>p-p$

4.6 HYBRIDISATION

60. As the s-character of hybridised orbital increases, the bond angle NCERT Page- N-121
(a) increase
(b) decrease
(c) becomes zero
(d) does not change

61. The nature of hybridisation in the ammonia molecule is
(a) sp^2
(b) dp^2
(c) sp
(d) sp^3

62. The shape of sulphate ion is
(a) square planar
(b) triagonal
(c) trigonal planar
(d) tetrahedral

63. Which of the following will have sp^3d^3 hybridisation?
(a) BrF_5
(b) PCl_5
(c) XeF_6
(d) SF_6

64. Which of the following molecule does not have a linear arrangement of atoms ?
(a) H_2S
(b) C_2H_2
(c) BeH_2
(d) CO_2

65. In which one of the following molecules the central atom said to adopt sp^2 hybridisation? NCERT Page-123
(a) BeF_2
(b) BF_3
(c) C_2H_2
(d) NH_3

66. Considering the state of hybridisation of carbon atoms, find out the molecule among the following which is linear ? NCERT Page-N-124
(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) $CH_3-CH_2-CH_2-CH_3$

67. Equilateral shape has
(a) sp hybridisation
(b) sp^2 hybridisation
(c) sp^3 hybridisation
(d) None of these

68. In which of the following species is the underlined carbon having sp^3 - hybridisation ?
(a) CH_3-COOH
(b) CH_3CH_2OH
(c) CH_3COCH_3
(d) $CH_2=CH-CH_3$

69. An sp^3-hybrid orbital contains NCERT Page-122/N-122
(a) $25\% s$-character
(b) $75\% s$-character
(c) $50\% s$-character
(d) $25\% p$-character

70. All carbon atoms are sp^2 hybridised in NCERT Page-123 / N-123
(a) 1,3-butadiene
(b) $CH_2=C=CH_2$
(c) cyclohexane
(d) 2-butene

71. Hybridisation present in ClF_3 is NCERT Page-N-124
(a) sp^2
(b) sp^3
(c) dsp^2
(d) sp^3d

72. Hybridisation states of C in CH_3^+ and CH_4 are NCERT Page-121 & 122 / N-121 & 122
(a) $sp^2 \& sp^3$
(b) $sp^3 \& sp^2$
(c) $sp^2 \& sp^2$
(d) $sp^3 \& sp^3$

73. In which of the following species, all the three types of hybrid carbons are present?
(a) $CH_2=C=CH_2$
(c) $CH_3-C\equiv C-CH_2^+$
(b) $CH_3-CH=CH-CH_2^+$
(d) $CH_3-CH=CH-CH_2$

74. The trigonal bipyramidal geometry is obtained from the hybridization NCERT Page-124 / N-124
(a) dsp^3 or sp^3d
(b) dsp^2 or sp^2d
(c) d^2sp^3 or sp^3d^2
(d) None of these

75. The types of hybridisation of the five carbon atoms from left to right in the molecule NCERT Page-N-121 & 122
$\mathrm{CH_3 - CH = C = CH - CH_3}$ are
(a) $sp^3, sp^2, sp^2, sp^2, sp^3$
(b) $sp^3, sp, sp^2, sp^2, sp^3$
(c) $sp^3, sp^2, sp, sp^2, sp^3$
(d) $sp^3, sp^2, sp^2, sp, sp^3$

76. Pick out the incorrect statement from the following NCERT Page-124 & 125 / N-124 & 125
(a) sp hybrid orbitals are equivalent and are at an angle of $180°$ with each other
(b) sp^2 hybrid orbitals are equivalent and bond angle between any two of them is $120°$
(c) sp^3d^2 hybrid orbitals are equivalent and are oriented towards corners of a regular octahedron
(d) sp^3d^3 hybrid orbitals are not equivalent

77. Hybridisation and structure of $\mathrm{I_3^-}$ are NCERT Page-N-124
(a) sp^2 and trigonal planar
(b) sp^3d^2 and linear
(c) sp^3d and linear
(d) sp^3 and T-shape

78. Which one of the following is not correct in respect of hybridisation of orbitals? NCERT Page-N-120 & 121
(a) The orbitals present in the valence shell only are hybridized.
(b) The orbitals undergoing hybridization have almost equal energy.
(c) Promotion of electron is not essential condition for hybridisation.
(d) Pure atomic orbitals are more effective in forming stable bonds than hybrid orbitals.

79. What is the correct mode of hybridisation of the central atom in the following compounds? NCERT Page-124

	$\mathrm{NO_2^-}$	$\mathrm{SF_4}$	$\mathrm{PF_6}$
(a)	sp	sp^2	sp^3
(b)	sp^2	sp^3d	sp^3d^2
(c)	sp^2	sp^3	d^2sp^3
(d)	sp^3	sp^3	sp^3d^2

80. The type of hybridisation in xenon atom and the number of lone pairs present on xenon atom in xenon hexafluoride molecule are respectively
(a) sp^3d^3, one
(c) sp^3d^3, two
(b) sp^3d^3, two
(d) sp^3d^2, zero

81. In an octahedral structure, the pair of d orbitals involved in d^2sp^3 hybridisation is
(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}

82. In which of the following combination hybridisation of central atom (⬚*) does not change?
(a) $H_2O + \overset{*}{C}O_2$
(b) $H_3\overset{*}{B}O_3 + OH^-$
(c) $BF_3 + \overset{*}{N}H_3$
(d) None of these

4.7 MOLECULAR ORBITAL THEORY

83. Molecular orbital theory was given by NCERT Page-125/N-125
(a) Kössel
(c) Mulliken
(b) Mosley
(d) Wern

84. With increasing bond order, stability of bond NCERT Page- N-129
(a) Remain unaltered
(b) Decreases
(c) Increases
(d) None of these

85. If N_x is the number of bonding orbitals of an atom and N_y is the number of antibonding orbitals, then the molecule/atom will be stable if NCERT Page- N-1
(a) $N_x > N_y$
(b) $N_x = N_y$
(c) $N_x < N_y$
(d) $N_x \leq N_y$

86. When two atomic orbitals combine, they form NCERT Page- N-126
(a) one molecular orbital
(b) two molecular orbital
(c) three molecular orbital
(d) four molecular orbital

87. Consider the ions/molecule $O_2^+, O_2, O_2^-, O_2^{2-}$ For increasing bond order the correct option is : NCERT Page N-126
(a) $O_2^{2-} < O_2^- < O_2 < O_2^+$
(b) $O_2^- < O_2^{2-} < O_2 < O_2^+$
(c) $O_2^- < O_2^{2-} < O_2^+ < O_2$
(d) $O_2^- < O_2^+ < O_2^{2-} <$

O_2

88. Which contains atleast one e^-in $\sigma 2p$ bonding MO? NCERT Page-128 & 129 / N-128 & 129
(a) O_2
(b) B_2
(c) C_2
(d) Li_2

89. Bonding in which of the following diatomic molecule(s) become(s) stronger, on the basis of MO Theory, by removal of an electron? NCERT Page N-129

(A) NO
(B) N_2
(C) O_2
(D) C_2
(E) B_2 Choose the most appropriate answer from the options given below:
(a) (A), (B), (C) only (b) (B), (C), (E) only (c) (A), (C) only (d) (D) only

90. In an anti-bonding molecular orbital, electron density is minimum NCERT Page- N-127

(a) around one atom of the molecule
(b) between the two nuclei of the molecule
(c) at the region away from the nuclei of the molecule
(d) at no place

91. Atomic orbital is monocentric while a molecular orbital is polycentric. What is the meaning of above statement?

a) Electron density in atomic orbital is given by the electron distribution around a nucleus in an atom. While in molecular orbital it is given by the electron distribution around group of nuclei in a molecule.
b) While an electron in an atomic orbital is influenced by one nucleus, in a molecular orbital it is influenced by two or more nuclei depending upon the number of atoms in the molecule. NCERT Page-126 / N-126
c) The electron in an atomic orbital is present in one nucleus while in molecular orbital electrons are present on more than one nuclei depending upon the number of atoms in the molecule.
d) All of these

92. The difference in energy between the molecular orbital formed and the combining atomic orbitals is called

(a) bond energy
(b) activation energy
(c) stabilization energy
(d) destabilization energy

93. The compound which cannot be formed is NCERT Page-N-129

(a) He
(b) He^+
(c) He_2
(d) He^{+2}

4.8 BONDING IN SOME HOMONUCLEAR DIATOMIC MOLECULES

94. Which molecule has the highest bond order? NCERT Page-129 / N-129

(a) N_2
(b) Li_2
(c) He_2
(d) O_2

95. Which of the following molecule exist? NCERT Page N-129

(a) He_2
(b) Be_2
(c) Li_2
(d) Both (a) and (b)

96. 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 NCERT Page N-129
(a) 0
(b) 1
(c) 2
(d) 3

97. The bond order in $N_2⬚^+$is NCERT Page-129 / N-129
(a) 1.5
(b) 3.0
(c) 2.5
(d) 2.0

98. Which one of the following molecules is expected to exhibit diamagnetic behaviour ? NCERT Page- N-129
(a) C_2
(b) N_2^+
(c) O_2
(d) S_2

99. According to molecular orbital theory, which of the following statement about the magnetic character and bond order is correct regarding O_2^+ NCERT Page-N-129 & 130
(a) Paramagnetic and Bond order $< O_2$
(b) Paramagnetic and Bond order $> O_2$
(c) Diamagnetic and Bond order $< O_2$
(d) Diamagnetic and Bond order $> O_2$

100. Arrange the following in increasing order of bond length NCERT Page- $N - 129$
(i) N_2
(iii) N_2^{2+}
(a) (ii),(i) and (iii)
(b) (ii), (iii) and (i)
(c) (iii),(ii) and (i)
(d) (i), (ii) and (iii)
(ii) N_2^+

101. Which of the following is not correct with respect to bond length of the species? NCERT Page-N-129
(a) $C_2 > C_2^{2-}$
(c) $Li_2^+ > Li_2$
(b) $B_2^+ > B_2$
(d) $O_2 > O_2^-$

102. In O_2^-, O_2 and O_2^{2-} molecular species, the total number of antibonding electrons respectively are
(a) 7,6,8 NCERT Page-129&130 / N-129 & 130
(b) 1,0,2
(c) 6,6,6
(d) 8,6,8

103. According to MO theory which of the following lists ranks the nitrogen species in terms of increasing bond order?

(a) $N_2^{2-} < N_2^- < N_2$ NCERT Page- N-129
(b) $N_2 < N_2{}^{2-} < N_2^-$
(c) $N_2^- < N_2^{2-} < N_2$
(d) $N_2^- < N_2 < N_2^{2-}$

104. The correct statement with regard to H_2^+ and H_2^- is NCERT Page-N-129

(a) both H_2^+ and H_2^- are equally stable
(b) both H_2^+ and H_2^- do not exist
(c) H_2^- is more stable than H_2^+
(d) H_2^+ is more stable than H_2^-

105. Mark the incorrect statement in the following NCERT Page-129 &130 / N-129 & 30

(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.

106. Bond order normally gives idea of stability of a molecular species. All the molecules viz. H_2, Li_2 and B_2 have the same bond order yet they are not equally stable. Their stability order is NCERT Page-N-129 & 130

(a) $H_2 > B_2 > Li_2$
(b) $H_2 > Li_2 > B_2$
(c) $Li_2 > B_2 > H_2$
(d) $B_2 > H_2 > Li_2$

4.9 HYDROGEN BONDING

107. The correct order of increasing intermolecular hydrogen bond strength is NCERT Page-N-131

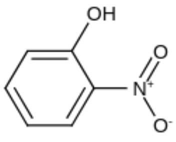
(a) $HCN < H_2O < NH_3$
(b) $HCN < CH_4 < NH_3$
(c) $CH_4 < HCN < NH_3$
(d) $CH_4 < NH_3 < HCN$

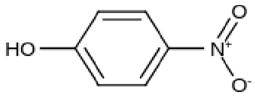
108. The boiling points at atmospheric pressure of HF, H_2S, NH_3 can be arranged in the following order:

(a) $HF > NH_3 > H_2S$
(b) $HF > H_2S > NH_3$
(c) $HF < H_2S < NH_3$
(d) $HF < NH_3 < H_2S$

109. The hydrogen bond is shortest in NCERT Page N-131

(a) $S - H - - S$
(b) $N - H - - O$
(c) $S - H - - O$
(d) $F - H — F$

110. The vapour pressure of 

is higher than 

due to NCERT Page N-132

(a) dipole moment
(b) dipole-dipole interaction
(c) H-bonding
(d) lattice structure

111. The low density of ice compared to water is due to NCERT Page-131 / N-131

(a) induced dipole-induced dipole interactions
(b) dipole-induced dipole interactions
(c) hydrogen bonding interactions
(d) dipole-dipole interactions

112. Which one of the following is the correct order of interactions?

(a) Covalent < hydrogen bonding < van der Waals < dipole-dipole. NCERT Page- N-131
(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.

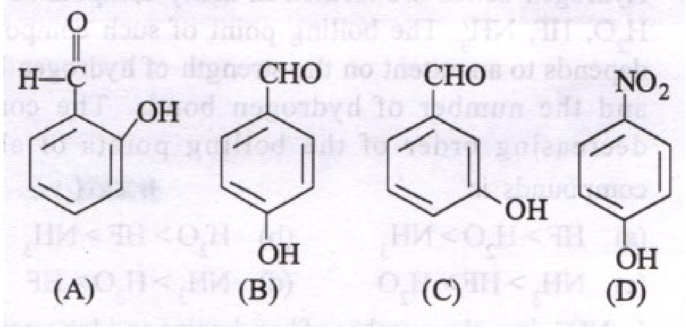
113. Acetic acid exists as dimer in benzene due to

(a) condensation reaction
(b) hydrogen bonding
(c) presence of carboxyl group
(d) presence of hydrogen atom at α-carbon

114. Maximum number of H-bonds that can be formed by a water molecule is

(a) 2
(b) 3
(c) 4
(d) 6

115. Which among the following can form intermolecular H − bonding ? NCERT Page-132 / N-132



(a) A
(b) B and D
(c) B, C and D
(d) A and C

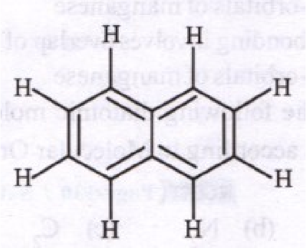
Exercise 2: NCERT Exemplar & Years NEET

NCERT EXEMPLAR QUESTIONS

1. Polarity in a molecule and hence the dipole moment depends primarily on electronegativity of the constituent atoms and shape of a molecule. Which of the following has the highest dipole moment? NCERT Page-N-111
(a) CO_2
(b) HI
(c) H_2O
(d) SO_2

2. In PO_4^{3-} ion the formal charge on the oxygen atom of $P-O$ bond is NCERT Page-104 / N-104
(a) +1
(b) -1
(c) -0.75
(d) +0.75

3. Which of the following species has tetrahedral geometry? NCERT Page-N-115
(a) BH_4^-
(b) NH_2^-
(c) CO_3^{2-}
(d) H_3O^+

4. Number of π bonds and σ bonds in the following structure is NCERT Page-N-120


(a) 6,19
(b) 4,20
(c) 5,19
(d) 5,20

5. In which of the following substances will hydrogen bond be strongest? NCERT Page-N-131
(a) HCl
(b) H_2O
(c) HI
(d) H_2S

6. If the electronic configuration of an element is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$, the four electrons involved in chemical bond formation will be
(a) $3p^6$
(c) $3p^6, 3d^2$

(b) $3p^6, 4s^2$
(d) $3d^2, 4s^2$

7. Which of the following angle corresponds to sp^2 hybridization? NCERT Page-122 / N-122
(a) 90°
(b) 120°
(c) 180°
(d) 109°

DIRECTION (Q. No. 8-11) The electronic configurations of the elements A, B and C are given below. Answer the questions from 14 to 17 on the basis of these configurations.
A $1s^2\ 2s^2\ 2p^6$
B $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$
C $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

8. Stable form of A may be represented by the formula
(a) A
(b) A_2
(c) A_3
(d) A_4

9. Stable form of C may be represented by the formula
(a) C
(b) C_2
(c) C_3
(d) C_4

10. The molecular formula of the compound formed from B and C will be
(a) BC
(b) B_2C
(c) BC_2
(d) BC_3

11. The bond between B and C will be
(a) ionic
(b) covalent
(c) hydrogen
(d) coordinate

12. The electronic configuration of the outer most shell of the most electronegative element is
(a) $2s^2 2p^5$
(b) $3s^2 3p^5$
(c) $4s^2 4p^5$
(d) $5s^2 5p^5$

13. Isostructural species are those which have the same shape and hybridisation. Among the given species identify the isostructural pairs. NCERT Page- N-115
(a) $[NF_3 \text{ and } BF_3]$
(b) $[BF_4^- \text{ and } NH_4^+]$

(c) $[BCl_3$ and $BrCl_3]$
(d) $[NH_3$ and $NO_3^-]$

14. The types of hybrid orbitals of nitrogen in NO_2^+, NO_3^- and NH_4^+ respectively are expected to be
(a) sp, sp^3 and sp^2
(b) sp, sp^2 and sp^3
(c) sp^2, sp and sp^3
(d) sp^2, sp^3 and sp

15. Hydrogen bonds are formed in many compounds e.g., H_2O, HF, NH_3. The boiling point of such compounds depends to an extent on the strength of hydrogen bond and the number of hydrogen bonds. The correct decreasing order of the boiling points of above compounds is NCERT Page-N-131
(a) $HF > H_2O > NH_3$
(b) $H_2O > HF > NH_3$
(c) $NH_3 > HF > H_2O$
(d) $NH_3 > H_2O > HF$

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

17. Which molecule/ion out of the following does not contain unpaired electrons? NCERT Page- N-129
(a) N_2^+
(b) O_2
(c) $O_2{}^{2-}$
(d) B_2

18. In which of the following molecule/ion all the bonds are not equal?
(a) XeF_4
(b) BF_4^-
(c) C_2H_4
(d) SiF_4

19. Which of the following options represents the correct bond order? NCERT Page-N-129 & 130
(a) $O_2^- > O_2 > O_2^+$
(b) $O_2^- < O_2 < O_2^+$
(c) $O_2^- > O_2 < O_2^+$
(d) $O_2^- < O_2 > O_2^+$

NEET

20 *. Amongst the following the total number of species NOT having eight electrons around central atom in its outermost shell, is $NH_3, AlCl_3, BeCl_2, CCl_4, PCl_5$: NCERT Page-105/ N-105
(a) 3
(b) 2

(c) 4
(d) 1

21. The correct order of energies of molecular orbitals of N_2 molecule, is NCERT Page-129 / N-129
(a) $\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < (\pi 2p_x = \pi 2p_y) < \sigma 2p_z < (\pi^* 2p_x = \pi^* 2p_y) < \sigma^* 2p_z$
(b) $\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < \sigma 2p_z < (\pi 2p_x = \pi 2p_y) < (\pi^* 2p_x = \pi^* 2p_y) < \sigma^* 2p_z$
(c) $\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < \sigma 2p_z < \sigma^* 2p_z < (\pi 2p_x = \pi 2p_y) < (\pi^* 2p_x = \pi^* 2p_y)$
(d) $\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < (\pi 2p_x = \pi 2p_y) < (\pi^* 2p_x = \pi^* 2p_y) < \sigma 2p_z < \sigma^* 2p_z$

22. Amongst the following which one will have maximum 'lone pair-lone pair' electron repulsions?
(a) IF_5 NCERT Page-115 / N-115 |
(c) XeF_2
(b) SF_4
(d) ClF_3

23. Which amongst following is incorrect statement? NCERT Page-129 / N-129 |
(a) C_2 molecule has four electrons in its two degenerate π molecular orbitals.
(b) H_2^+ ion has one electron.
(c) O_2^+ ion has diamagnetic.
(d) The bond orders of O_2^+, O_2, O_2^- and O_2^{2-} are 2.5, 2, 1.5 and 1 , respectively.

24. BF_3 is planar and electron deficient compound. Hybridization and number of electrons around the central atom, respectively are : NCERT Page-114 / N-114 |
(a) sp^2 and 8
(b) sp^3 and 4
(c) sp^3 and 6
(d) sp^2 and 6

25. Which of the following set of molecules will have zero dipole moment?
NCERT Page-111 & 112 / N-111 & 112 |
(a) Boron trifluoride, hydrogen fluoride, carbon dioxide, 1,3-dichlorobenzene
(b) Nitrogen trifluoride, beryllium difluoride, water, 1,3dichlorobenzene
(c) Boron trifluoride, beryllium difluoride, carbon dioxide, 1,4-dichlorobenzene
(d) Ammonia, beryllium difluoride, water, 1,4dichlorobenzene

26. Identify a molecule which does not exist. NCERT Page-130 / N-129
(a) Li_2
(b) C_2
(c) O_2
(d) He_2

27. The manganate and permanganate ions are tetrahedral, due to:
(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

28. Which of the following diatomic molecular species has only bonds according to Molecular Orbital Theory?
(a) O_2 NCERT Page-130

(b) N_2
(c) C_2
(d) Be_2

29. In the structure of ClF_3, the number of lone pair of electrons on central atom ' Cl ' is
(a) One NCERT Page-117 / N-117
(b) Two
(c) Three
(d) Four

30. Consider the following species :
CN^+, CN^-, NO and CN
Which one of these will have the highest bond order? NCERT Page N-129
(a) NO
(b) CN^-
(c) CN
(d) CN^+

31. Which of the following pairs of species have the same bond order? CERT Page N-129 | NEE
(a) O_2, NO^+
(b) CN^-, CO
(c) N_2, O_2^-
(d) CO, NO

32. 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) $BeCl_2, XeF_2$

33. Consider the molecules CH_4, NH_3 and H_2O. Which of the given statements is false?
NCERT Page-122
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.

ANSWER KEYS

Exercise - 1 : (NCERT Based Topic-wise MCQs)

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

Exercise - 2 : (NCERT Exemplar & Years NEET)

1	(c)	5	(b)	9	(b)	13	(b)	17.	(c)	21	(a)	25	(c)	29	(b)	33	(b)		
2	(c)	6	(d)	10	(d)	14	(b)	18	(c)	22	(a)	26	(d)	30	(b)				
3	(a)	7	(b)	11	(b)	15	(b)	19	(b)	23	(c)	27	(a)	31	(b)				
4	(c)	8	(a)	12	(a)	16	(d)	20	(a)	24	(d)	28	(c)	32	(b)				

HINTS AND SOLUTIONS

EXERCISE - 1

1. (d) The evolution of various theories of valence and the interpretation of the nature of chemical bonds have closely been related to the developments in the understanding of structure of atom, electronic configuration of elements and Periodic Table.
2. (b) Kossel and Lewis provide some logical explanation of valence which was based on the intertness of noble gases.
3. (b) Electrovalent bond is formed as a result of electrostatic attraction between the positive and negative ions.
4. (d) When a metal for example Na combines with a non metal e.g., Cl_2. Following reaction occurs

$$2Na + Cl_2 \longrightarrow 2NaCl$$

In this process Na loses one electron to form $Na^+$and Cl accepts one electron to form Cl^-

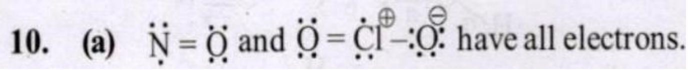
$$Na \longrightarrow Na^+ + e^-$$

$$Cl + e^- \longrightarrow Cl^-$$

Therefore, in this process Cl gains electron and hence, its size increases.

5. (a) Only (I) is correct.

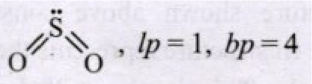
6. (a) The lowest energy structure is the one with the smallest formal charges on the atoms.
7. (b) $NO \rightarrow$ Odd Electron molecule $H_2SO_4 \rightarrow$ Expanded octet of S
8. (a) PCl_5 does not follow octet rule, it has 10 electrons in its valence shell.
9. (b) The compounds in which octet of central atom is incomplete are known as electron deficient compounds. Hence, B_2H_6 is an electron deficient compound.



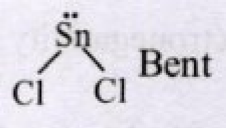
10. (a) $\dot{\ddot{N}} = \ddot{\underset{\cdot\cdot}{O}}$ and $\ddot{O} = \overset{\cdot\oplus}{\underset{\cdot\cdot}{Cl}} - :\overset{\ominus}{\ddot{O}}:$ have all electrons.

11. (d) Lattice enthalpy is required to completely separate one mole of a solid ionic compound into gaseous constituent ions.
12. (c) Higher the difference in electronegativity between the two atoms, more will be electrovalent character of the bond. Among given choices, calcium and hydrogen have maximum difference in their electronegativities.
13. (b) Ionic bonds will be formed more easily between elements with comparatively low ionization enthalpies and elements with comparatively high negative value of electron gain enthalpy.
14. (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.
15. (b) For compounds containing cations of same charge, lattice energy increases as the size of the cation decrease. Thus, NaF has highest lattice energy. The size of cations is in the order $Na^+ < K^+ < Rb^+ < Cs^+$
16. (c) The covalent radius is measured approximately as the radius of an atom's core which is in contact with the core of an adjacent atom in a bonded situation.
17. (d) Bond lengths are measured by spectroscopic, X-ray diffraction and electron diffraction techniques.
18. (b) Covalent radius is half of the distance between atoms in bonding state, while van der Waal radius is half of the distance between atoms in its non bonding state.
19. (d) The electronegativity difference is maximum in $O - H$ bond hence $O - H$ bond length is the smallest among the given set.
20. (d) All of the given statements are correct.
21. (b) Sigma electrons are not mobile e^-.
22. (c) Both representation of resonating structures in molecules of CO_2 and $CO_3{}^{2-}$ are correct.
23. (c) I and II structure shown above constitute the cannonical structure. III structure represents the structure of O_3 more accurately. This is also called resonance hybrid.
24. (a)
25. (a) $C - F$
    Because difference between electronegativity of carbon and flourine is highest.
26. (c) The dipole moment of symmetrical molecules is zero.
27. (c) CCl_4 being symmetrical has zero dipole moment. H_2O, $CHCl_3$ and NH_3 have dipole moments of $1.84D, 1.01D$ and 1.46 D respectively. Thus, among the given molecules H_2O has highest dipole moment.
28. (b) $O \leftrightarrows C \leftrightarrows O$
29. (b) Both NO_2 and O_3 have angular shape and hence will have net dipole moment.
30. (c) Ionic bond with small cation and large anion has covalent character.
31. (d) In case of anions having same charge as the size of anion increases, polarisibility of anion also increases.
32. (d) According to Fajan's rule:
    Covalent character $\propto \frac{1}{\text{size of cation}} \propto$ size of anion
    Among the given species order of size of cations
    $N^{3+} < O^{2+} < Pb^{2+} < Ba^{2+}$
    order of size of anions $O^{2-} > Cl^-$.
    Hence the order of covalent character is
    $NCl_3 > Cl_2O > PbCl_2 > BaCl_2$
    $BaCl_2$ is least covalent in nature.
33. (c) As difference of electronegativity increases % ionic character increases and covalent character decreases i.e., electronegativity difference decreases, covalent character increases.

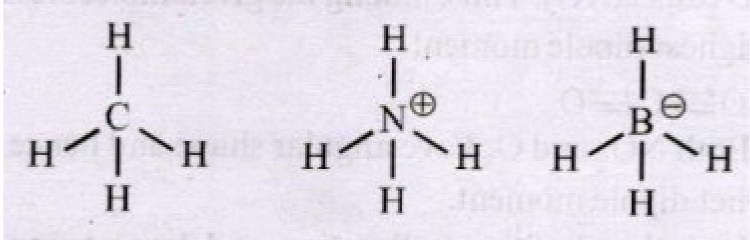
Further, greater the charge on the cation and smaller the size, more will be its polarising power. Hence, covalent character increases.

34. (a) According to Fajan's rule, as the charge on the cation increases, and size decreases, its tendency to polarise the anion increases. This brings more and more covalent nature to electrovalent compounds. Hence $\mathrm{AlCl_3}$ shows maximum covalent character.
35. (c) According to Fajan's rule, smaller size and greater charge on cation favour the formation of partial covalent character in ionic bonds.
36. (c) According to Fajan's rule, small size cation and large size anion will have high cavalent character. So the order is: $\mathrm{LiCl} > NaCl > KCl > CsCl$
37. (a)
38. (d) 

39. (a) V-shaped $\mathrm{H_2O}$ like structure.
40. (a) $\mathrm{BF_3}$ is sp^2 hybridised. So, it is trigonal planner. $\mathrm{NH_3}$, $\mathrm{PCl_3}$ has sp^3 hybridisation hence has trigonal pyramidal shape, $\mathrm{IF_3}$, has sp^3d hydridization and has T shape.
41. (d)

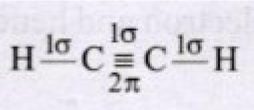


42. (b) Isoelectronic species have same number of electrons valence



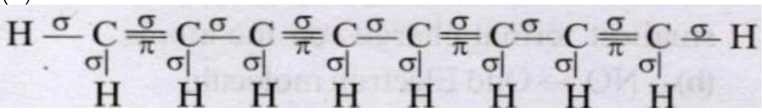
all have steric number is 4 so
All are tetrahedral and each have 10 electrons.

43. (b) According to VSEPR theory, the molecule is of $\mathrm{AB_3E}$ type in which arrangement of electron pairs are in tetrahedral shape. But due to a lone pair of electrons, the actual shape is trigonal pyramidal.
44. (d) In $\mathrm{BrF_5}$ molecule, there are 5 bond pair and one lone pair of electrons with the central atom.
45. (b) $\mathrm{SO_2}$ - bent
$\mathrm{SF_4}$ - see-saw
$\mathrm{ClF_3}$ - T-shape
$\mathrm{BrF_5}$ - square pyramidal
$\mathrm{XeF_4}$ - square planar.
46. (b) Number of lone pair $= 2$
47. (b) $\mathrm{XeF_4}$ hybridisation is $= \frac{1}{2}(V + X - C + A)$
hence $V = 8$ (no. of valence $\mathrm{e^-}$)
$X = 4$ (no. of monovalent atom)
$\mathrm{H} = \frac{1}{2}(8 + 4 + 0 - 0) = 6, sp^3d^2$, square planar shape.
48. (a) It is to minimize lone pair - bond pair repulsions only.
49. (a) I is the most stable geometry because both the lone pairs are present at equatorial position. Due to which, repulsion is minimum in molecule as compared to the repulsion in other molecules where lone pair is in axial position.
50. (a) Hybridization $= sp^3d$, shape - see-saw
Fluorine being more electronegative preferentially occupy the axial position.
51. (d) Structure of acetylene molecule


$H\overset{1\sigma}{-}C\underset{2\pi}{\overset{1\sigma}{\equiv}}C\overset{1\sigma}{-}H$

Thus, acetylene molecule has 3σ bonds and 2π bonds.

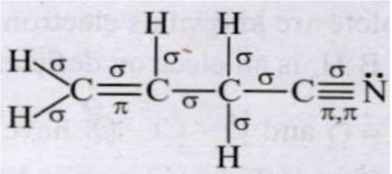
52. (b)


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

1,3,5,7 - octatetraene

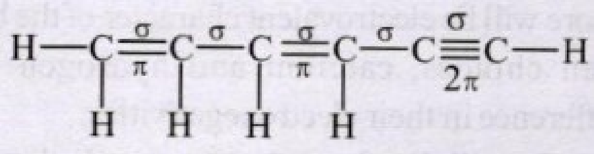
17σ and 4π

53. (b) Allyl cyanide is :



∴ It contains 9 sigma bonds, 3 pi bonds and 1 lone pair of electrons.

54. (a) The given molecule is

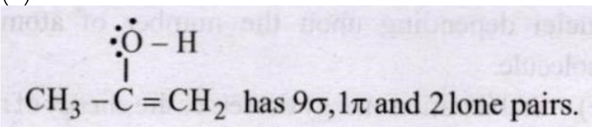

$H-CH\underset{\pi}{\overset{\sigma}{=}}CH\overset{\sigma}{-}CH\underset{\pi}{\overset{\sigma}{=}}CH\overset{\sigma}{-}C\underset{2\pi}{\overset{\sigma}{\equiv}}C-H$

The number of $\mathrm{C}-\mathrm{C}$ ' σ ' bonds $=5$

The number of $\mathrm{C}-\mathrm{C}$ ' π ' bonds $=4$

The number of $\mathrm{C}-\mathrm{H}'\sigma\sigma$ ' bonds $=6$

55. (a) Linear combination of two hybridized orbitals leads to the formation of sigma bond.
56. (b) The minimum in the energy curve corresponds to the most stable state of H_2.
57. (a)


$CH_3-\underset{}{\overset{\ddot{O}-H}{C}}=CH_2$ has $9\sigma, 1\pi$ and 2 lone pairs.

58. (c) Due to different orientation of direction of approach, there is zero overlap between orbitals.
59. (d) The strength of a bond depends upon the extent of overlapping. $s-s$ and $s-p$ overlapping results in the formation of σ bond but extent of overlapping along internuclear axis is more in case of $s-s$ overlapping than in $s-p. p-p$ overlapping may result in σ bond if overlapping takes place along internuclear axis or may result in π-bond if sideways overlapping takes place. In any case, the extent of overlapping is lesser in $p-p$ than that of the other two, $s-s$ and $s-p$. Hence, the correct order is

$$s-s>s-p>p-p$$

60. (a) Bond angle increases with increase in s-character of hybridised orbital.
61. (d) The hybridisation in a molecule is given by

$\mathrm{H}=\frac{1}{2}[V+M-C+A]$

where $V=$ no. of valence e^{-}in central atom

$M=$ no. of monovalent atoms around central atom

$C=$ charge on cation, $A=$ charge on anion

For $\mathrm{NH}_3; V=5, M=3, C=0, A=0$

Putting these values in (i), we get

$\mathrm{H}=\frac{1}{2}[5+3-0+0]=4$

For $\mathrm{H}=4$, the hybridisation in molecule is sp^3.

62. (d) Hybridisaiton of $SO_4{}^{2-}$ ion is given by

$H = \frac{1}{2}[V + M + A - C]$

For $SO^{2-}{}_4$; $V = 6, M = 0, A = 2, C = 0$

$\therefore H = \frac{1}{2}[6 + 0 + 2 - 0] = 4$

i.e., sp^3 hybridisation and tetrahedral shape.

63. (c) In case of Xenon compounds

Hybridization $= \frac{1}{2}(V + M + A - C)$

In $XeF_6 = \frac{1}{2}[8 + 6 - 0 + 0] = 7$ i.e. sp^3d^β hybridisation.

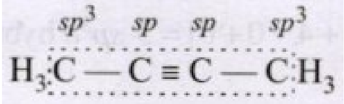
In case of SF_6, Sulphur is sp^3d^2 hybridised.

In case of BrF_5, Bromine atom is sp^3d^2 hybridised.

In PCl_5, P is sp^3d hybridised.

64. (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.

65. (b) BF_3 involves sp^2-hybridisation.

66. (b) 

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

linear part of molecule

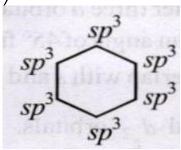
67. (b) Equilateral or triangular planar shape involves sp^2 hybridisation.

68. (b) In CH_3CH_2OH underlined C is forming 4σ bonds, hence sp^3 hybridisation. In others, it is sp^2 hybridised (due to 3σ bonds).

69. (a) Each sp^3-hybrid orbital has $25\% s$-character and $75\% p$-character.

70. (a) (b) $\overset{sp^2}{CH_2} = \overset{sp}{C} = \overset{sp^2}{CH_2}$

(c)



(d) $\overset{sp^3}{CH_3} - \overset{sp^2}{C}H = \overset{sp^2}{C}H - \overset{sp^3}{C}H_3$

(a) $\overset{sp^2}{CH_2} = \overset{sp^2}{C} - \overset{sp^2}{C}H = \overset{sp^2}{C}H_2$

1, 3-butadiene

71. (d) Hybridisation $= \frac{1}{2}(V + M - C + A)$

So, Hybridisation (in ClF_3) $= \frac{1}{2}[7 + 3 - 0 + 0] = 5 = sp^3d$.

$\Rightarrow sp^3d$ Hybridisation.

72. (a) Number of sigma bonds in C^+H_3 are 3, thus, hybridisation is sp^2.

Number of sigma bonds in CH_4 are 4, thus, hybridisation is sp^3.

73. (c) $\overset{sp^3}{CH_3} - \overset{sp}{C} \equiv \overset{sp}{C} - \overset{sp^2}{CH_2^+}$

74. (a) According to VSEPR theory, trigonal bipyramidal geometry results from sp^3d or dsp^3 hybridisation. dsp^2 hybridisation results in square planar geometry, while d^2sp^3 leads to octahedral shape.

75. (c) $\overset{sp^3}{H_3C} - \overset{sp^2}{CH} = \overset{sp}{C} = \overset{sp^2}{CH} - \overset{sp^3}{CH_3}$

76. (d) All the hybrid orbitals are equivalent.

77. (c) I_3^- has sp^3d hybridisation and has linear structure.
78. (d) Statement (d) is incorrect.
79. (b) Hybridisation of the central atom in compound is given by

$$H = \frac{1}{2}[V + M - C + A]$$

- For $NO_2^-, H = \frac{1}{2}[5 + 0 - 0 + 1] = 3 sp^2$ hybridisation
- For$_4, H = \frac{1}{2}[6 + 4 - 0 + 0] = 5 sp^3d$ hybridisation
- For $PF_6^-, H = \frac{1}{2}[5 + 6 - 0 + 1] = 6$
  sp^3d^2 hybridisation.

80. (a) XeF_6 having one lone pair of electron, show distorted pentagonal bipyramidal shape and sp^3d^3 hybridisation.
81. (a) 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.
82. (c) Hybridisation of N in NH_3 is sp^3 and in $F_3B \leftarrow NH_3$ also the hybridisation is sp^3.
83. (c) Molecular orbital theory was given by Mulliken.
84. (c) Triple bond is stronger than double bond and which is stronger than single bond.
85. (a) Bonding influence is stranger if $N_x > N_y$.
86. (b) One bonding M.O. and one anti-bonding M.O.
87. (a)

ion / molecule	Number of e^- in BMO	Number of e^- in ABMO	Bond order
O_2^+	10	5	2.5
O_2	10	6	2
O_2^-	10	7	1.5
O_2^{2-}	10	8	1

Bond order: $O_2^{2-} < O_2^- < O_2 < O_2^+$

88. (a) Oxygen molucules (O_2) :

$$O_2: \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2 (\pi 2p_x^2 = \pi 2p^2)(\pi^* 2p^1{}_x^1 = \pi^* 2p^1{}_y)$$

89. (c) Bond strength ∝ Bond order Removal of electron from antibonding MO increases B.O. NO and O_2 have valence e^-in π^* orbital.
90. (b) There is a nodal plane between two nuclei.
91. (b) Atomic orbital is monocentric because an electron in it, is influenced by one nucleus. While molecular orbital is polycentric as it is influenced by two or more nuclei depending upon the number of atoms in the molecule.
92. (c) Stabilization energy decreases the energy of molecular orbital formed.
93. (c) $He_2 = \sigma 1s^2, \sigma^* 1s^2$

    B.O. $= \frac{1}{2}[N_b - N_a] = 0$; cannot exist
94. (a) N_2 has triple bond between the atoms.
95. (c) According to molecular orbital theory, bond order of Li_2 is 1 , while in all other cases bond order is 0 , so they do not exist. Li_2 molecules are known to exist in the vapour phase.
96. (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 $N_a = 2$.

    ∴ Bond order $= \frac{1}{2}(N_b - N_a) = \frac{1}{2}(8 - 2) = 3$.
97. (c) $N_2^+ = 7 + 7 - 1 = 13$ electrons

    Configuration is

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

Bond order $= \frac{1}{2}(n_B - n_{\text{Anti } B}) = \frac{1}{2}(9-4) = \frac{1}{2} \times 5 = 2.5$

98. (a) The molecular orbital structures of C_2 and N_2 are

$\text{C}_2 = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \pi 2py^2 \pi 2P_z^2$

C_2 have paired electrons, hence they are diamagnetic.

99. (b) $\text{O}_2 : \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2 \begin{cases} \pi 2p_x^2 \\ \pi 2p_y^2 \end{cases} \begin{cases} \pi^* 2p_x^1 \\ \pi^* 2p_y^1 \end{cases}$

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

(two unpaired electrons in antibonding molecular orbital)

$\text{O}_2^+ : \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2 \begin{cases} \pi 2p_x^2 \\ \pi 2p_y^2 \end{cases} \begin{cases} \pi^* 2p_x^1 \\ \pi^* 2p_y^0 \end{cases}$

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

(One unpaired electron in antibonding molecular orbital)

Hence, O_2 as well as O_2^+both are paramagnetic, and bond order of $\text{O}_2^+$is greater than that of O_2.

100. (d) As the bond order decreases, bond length increases

Bond order $= \frac{1}{2}(\text{n}_\text{B} - \text{n}_{\text{Anti B}})$

For N_2, electronic configuration is

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

(i) Bond order of $\text{N}_2 = \frac{10-4}{2} = 3$

(ii) Bond order of $\text{N}_2^+ = \frac{9-4}{2} = 2.5$

(iii) Bond order of $\text{N}_2^{2+} = \frac{8-4}{2} = 2$

Hence, order of Bond length will be,

$\text{N}_2 < \text{N}_2^+ < \text{N}_2^{2+}$

101. (d) On calculating bond order of species given in question

$\text{C}_2 = 2, \text{C}_2^{2-} = 3; \text{B}_2^+ = 0.5, \text{B}_2 = 1$

$\text{Li}_2^+ = 0.5, \text{Li}_2 = 1; \text{O}_2 = 2.0, \text{O}_2^- = 1.5$

Bond length $\propto \frac{1}{\text{Bond order}} \therefore \text{O}_2^- > \text{O}_2$

102. (a) Molecular orbital electronic configuration of these species are :

$$\text{O}_2^-(17e^-) = \sigma 1s^2 \sigma * 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2$$
$$\pi 2\text{p}_\text{x}^2 = \pi 2\text{p}_\text{y}^2 \pi * 2\text{p}_\lambda^2 = \pi * 2\text{p}_\text{y}^1$$
$$\text{O}_2(16e^-) = \sigma 1s^2 \sigma^2 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2$$
$$\pi 2p_x^2 = \pi 2p_y^2 \pi * 2p_x^1 = \pi * 2p_y^1$$
$$\text{O}_2^{2-}(18e^-) = \sigma 1s^2 \sigma * 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2$$
$$\pi 2p_x^2 = \pi 2p_y^2 \pi * 2p_x^2 = \pi * 2p_y^2$$

Hence, number of antibonding electrons are 7, 6 and 8 respectively.

103. (a) Molecular orbital configuration of

$$\text{N}_2^{2-} = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma * 2s^2 \begin{cases} \pi 2p_x^2 \\ \pi 2p_y^2 \end{cases} \text{o2 } p_z^2 \begin{cases} \pi * 2p_x^1 \\ \pi * 2p_y^1 \end{cases}$$

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

$$\text{N}_2^- = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma * 2s^2 \begin{cases} \pi 2p_x^2 \\ \pi 2p_y^2 \end{cases} \sigma 2p_z^2 \begin{cases} \pi * 2p_x^1 \\ \pi * 2p_y^0 \end{cases}$$

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

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

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

∴ ⬚ The correct order is $= N_2^{2-} < N_2^- < N_2$

104. (d) $H_2^+ : (\sigma 1s^1)$; Bond order $= \frac{1}{2}(1-0) = \frac{1}{2}$

$H_2^- : (\sigma 1s^2)(\sigma^* 1s^1)$; Bond order $= \frac{1}{2}(2-1) = \frac{1}{2}$

The bond order of H_2^+ and H_2^- are same but H_2^+ is more stable than H_2^-. In H_2^- the antibonding orbital is filled with 1 electron so this causes instability.

105. (b) The removal of an electron from a diatomic molecule may increase the bond order as in the conversion $O_2(2) \longrightarrow O_2^+(2.5)$ or decrease the bond order as in the conversion, $N_2(3.0) \longrightarrow N_2^+(2.5)$. As a result, the bond energy may increase or decrease. Thus, statement (b) is incorrect.

106. (b) The molecular orbital configuration of the given molecules is

$H_2 = \sigma 1s^2$ (no anti-bonding electron)

$Li_2 = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2$ (two anti-bonding electrons)

$B_2 = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \{\pi 2p_y^1 = \pi 2p_z^1\}$

(4 anti-bonding electrons)

Though the bond order of all the species are same $(B.O = 1)$ but stability is different. This is due to difference in the presence of no. of anti-bonding electrons.

Higher the no. of anti-bonding electron, lower is the stability, hence the correct order is $H_2 > Li_2 > B_2$

107. (c) The strength of H-bonding depends upon two factors:

(1) Electronegativity difference between the hydrogen and Halogen element.

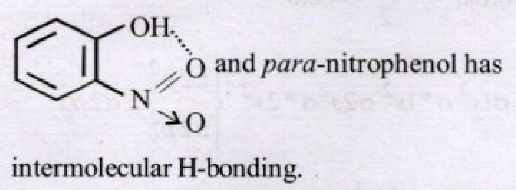
(2) Number of H-bonding interaction.

So the order of H-bonding is $CH_4 < HCN < NH_3$.

108. (a) Due to strong hydrogen bonding in HF and than NH_3.

109. (d) $F - H - - - F$ bond is shortest, because with the increase of electronegativity and decrease in size of the atom to which hydrogen is linked, the strength of the hydrogen bond increases.

110. (c) ortho-Nitrophenol has intramolecular H-bonding



and *para*-nitrophenol has intermolecular H-bonding.

111. (c) Ice has many hydrogen bonds which give rise to cage like structure of water molecules. This structure possess larger volume and thus makes the density of ice low.

112. (c) The strength of the interactions follows the order van der Waal's < dipole-dipole < hydrogen - bonding < covalent.

113. (b) It forms intermolecular hydrogen bonding with itself.

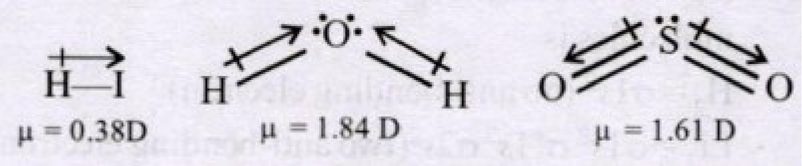
114. (c) Each H_2O molecule can form two H-bonds through H-atoms and two H-bonds through two lp of e^{-s} on O-atom.

115. (c) B, C and D form intermolecular hydrogen bonding while A form intramolecular hydrogen bonding due to proximity of oxygen and hydrogen.

EXERCISE - 2

1. (c) CO_2 being symmetrical has zero dipole moment.

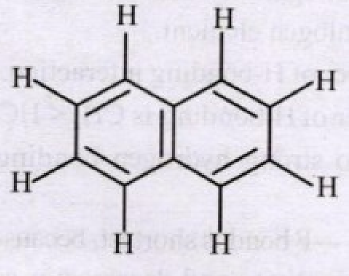
Amongst HI, SO_2 and H_2O; H_2O exhibit the highest dipole moment as the central atom in H_2O contains 2 lone pairs.



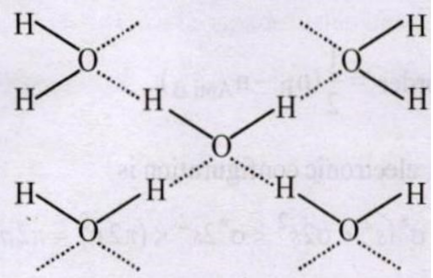
2. (c) In PO_4^{3-} ion, formal charge on each O-atom of $P-O$

$$\text{bond } = \frac{\text{Total charge}}{\text{Number of } O \text{ atom}} = -\frac{3}{4} = -0.75$$

3. (a) $BH_4^- \Rightarrow 4$ bond pairs and 0 lone pair → sp^3 hybridised.
∴ Tetrahedral geometry.
4. (c) The correct structure of the given compound will be as follows :



Now, there are 5π-bonds and 19σ-bonds present in the above molecule.
5. (b) HCl, HI and H_2S do not from H-bonds. Only H_2O forms hydrogen bonds and each H_2O molecule is linked with four H_2O molecules.



6. (d) The given electronic configuration shows that the element belongs to d-block of the periodic table and known to be a transition element. In transition elements, electrons of ns and $(n-1)d$ subshell take part in bond formation.
7. (b) For sp^2 hybridisation, generally the geometry is usually taken to be triangular planar.
Thus, bond angle should be $120°$.
8. (a) The given electronic configuration of A shows that it is a noble gas because the octet is complete and hence it will be the stable form.
9. (b) The electronic configuration of C represents chlorine. Its stable form is Cl_2 i.e., C_2.
10. (d) The electronic configurations show that B represents phosphorus and C represents chlorine. The stable compound formed will be PCl_3 i.e., BC_3.
11. (b) The bond between B and C will be covalent as both B and C are non-metal atoms.
12. (a) Out of the given electronic configuration, $2s^2 2p^5$ represents fluorine which is the most electronegative element, while $3s^2 3p^5 4s^2 4p^5$ and $5s^2 5p^5$ represents chlorine, bromine and iodine respectively.
13. (b) BF_4^- and NH_4^+ both the species are tetrahedral and sp^3 hybridised.
14. (b) Applying the formula to find the hybridisation of central atom (nitrogen) :
For, $NO_2{}^{+} = \frac{1}{2}[5+0+0-1] = 2 \Rightarrow sp$-hybridised
$NO_3^- = \frac{1}{2}[5+0+1-0] = 3 \Rightarrow sp^2$-hybridised
$NH_4^+ = \frac{1}{2}[5+4+0-1] = 4 \Rightarrow sp^3$-hybridised

15. (b) Strength of H-bonding is in the order :

$$HF > H_2O > NH_3$$

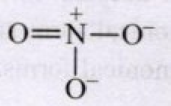
Also, each H_2O molecule is linked to four other H_2O molecules through H-bonds while each HF molecule is linked only to two other HF molecules.

Hence, decreasing order of b.p. will be : $H_2O > HF > NH_3$

16. (d) In NO_3^-⬚$^-$ion,

number of bond pairs (or shared pairs) $= 4$

number of lone pairs $= 0$



17. (c) The electronic configuration of the given molecules are:

$N_2^+ = \sigma 1s^2 \sigma \ast 1s^2 \sigma 2s^2 \sigma \ast 2s^2 \pi 2p_x^2 = \pi p_y^2 \sigma 2p_z^1;$

1 unpaired e^-

$O_2 = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \sigma 2p_z^2 \pi 2p_x^2 \approx \pi 2p_y^2$

$\pi \ast 2p_x^1 \approx \pi \ast 2p_y^1$; 2 unpaired e^-s

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

$\pi^* 2p_x^2 \approx \pi^* 2p_y^2$; no unpaired e^-s

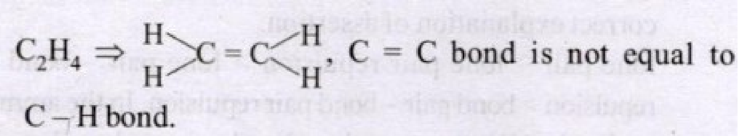
$B_2 = \sigma 1s^2 \sigma \ast 1s^2 \sigma 2s^2 \sigma \ast 2s^2 \pi 2p_x^1 \approx \pi 2p_y^1;$

2 unpaired e^-s

Trick: We know that O_2 molecule has 2 unpaired electrons. Thus, O_2⬚$^{2-}$ will not have any unpaired electrons.

18. (c) XeF_4 ⇒ square planar, all bonds are equal.

BF_4^- ⇒ tetrahedral, all bonds are equal.



C_2H_4 ⇒ , C = C bond is not equal to C – H bond.

SiF_4 ⇒ tetrahedral, all bonds are equal.

19. (b) E.C of O_2 :

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

$\pi \ast 2p_x^1 \approx \pi \ast 2p_y^1$

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

E.C of O_2^+:

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

$\pi^* 2p_x^1 \approx \pi \ast 2p_y^0$

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

E.C of O_2^-:

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

$\pi \ast 2p_x^2 \approx \pi \ast 2p_y^1$

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

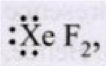
Hence, the correct order of bond order will be :

$O_2^- < O_2 < O_2^+$.

20. (a)

21. (a) For molecules like B_2, C_2, N_2 etc. the increasing order of energies of various molecular orbitals is

$\sigma 1s < \sigma 1s < \sigma 2s < \sigma 2s < (2p_x = 2p_y) < 2p_z < ($⬚$^*2p_x =\ast 2p_y) <$ ⬚$^*2p_z$

22. (c)  due to 3 lone pairs, the lp-lp repulsions are maximum.
While IF_5 ⇒ one lone pair of electrons
SF_4 ⇒ one lone pair of electrons
ClF_3 ⇒ two lone pair of electrons

23. (c) We know that in O_2 molecule, there are two unpaired e^-, thus, in O_2^+, there will be one unpaired e^-.
24. (d) In BF_3, hybridisation is sp^2 and number of electrons are 6.
25. (c) BF_3, BeF_2, CO_2 and 1, 4-dichlorobenzene all are symmetrical molecules.
26. (d) For He_2 molecule, Electronic configuration is $\sigma 1s^2, \sigma * 1s^2$

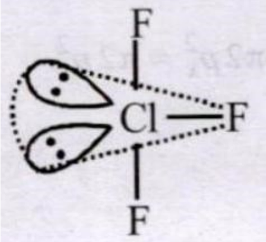
Bond order $= \frac{1}{2}(N_b - N_a) = \frac{1}{2}(2-2) = 0$

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

27. (a)
28. (c) Only π bond is present in C_2 molecule.

$\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \pi 2p^2 \square_x = \pi 2p^2$

29. (b) The structure of ClF_3 is



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

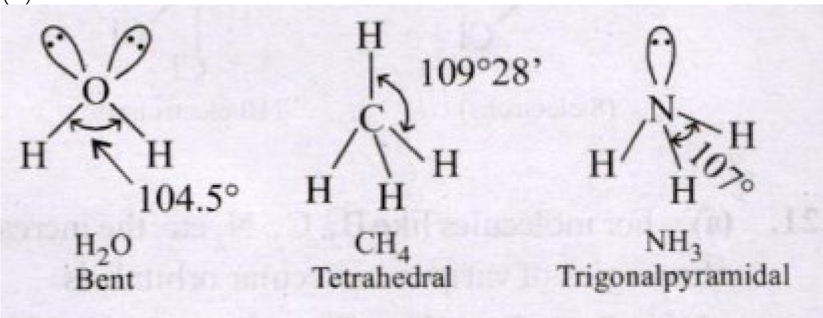
30.

(b) Species	Total elec.	B.O.
NO	15	2.5
CN	13	2.5
CN^-	14	3
CN^+	12	2

31. (b) CN^- and CO have same no. of electrons and have same bond order equal to 3 .
32. (b) IBr_2^-, XeF_2

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

33. (b)



Note: 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°.