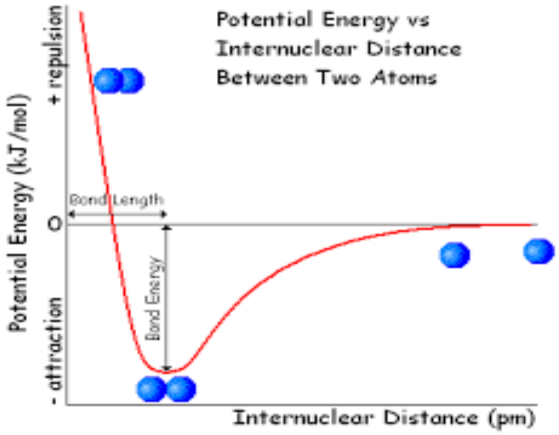
Previous HSE Questions And Answers Of The Chapter "Chemical Bonding And Molecular Structure"

1. Draw the potential energy curve for the formation of a hydrogen molecule on the basis of inter-nuclear distance between the hydrogen atoms. (2)

   Ans:



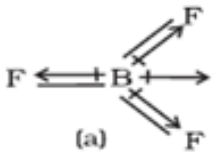
2. (i) What is meant by dipolemoment ? (1)

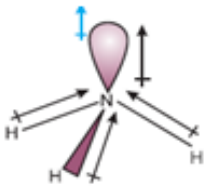
   (ii) Dipolemoment of BF_3 is zero, but that of NH_3 is not zero. Why ? (2)

   Ans: (i) Dipolemoment is defined as the product of the magnitude of charge at one end (Q) and the distance between the charges (r).

   Mathematically, $\mu = Q \times r$.

   (ii) BF_3 has planar triangular shape. Here the resultant of any 2 bond dipoles is equal and opposite to the third. So its net dipole moment is zero. But NH_3 has pyramidal geometry. Here the bond dipoles and the orbital dipoles are in opposite direction, but they do not get cancelled each other. So NH_3 has a net dipole moment.





3. (i) A molecule of the type AB_2E_2 has 2 bond pairs of electrons and 2 lone pairs of electrons. The most stable structure of this molecule is _____ .

   (A) Tetrahedral (B) Bent (C) Square planar (D) Square pyramid (1)

   (ii) Write the important postulates of VSEPR theory. (3)

   Ans: (i) (B) Bent

   (ii) The important postulates of this theory are:

   - *The shape of the molecule depends on the no. of valence shell electron pairs around the central atom.*
   - *The valence shell electron pairs repel each other.*
   - *In order to reduce the repulsion, the electron pairs stay at maximum distance.*
   - *Presence of lone pairs of electron causes distortion in the expected geometry of the molecule.*
   - *The repulsion between two lone pairs of electrons is different from those between two bond pairs or between a lone pair and bond pair. The repulsion decreases in the order lone pair - lone pair > lone pair – bond pair > bond pair - bond pair.*
   - *As the angle between the electron pairs increases, the repulsion decreases.*

4. (i) Write the molecular orbital configuration of O_2 molecule. Account for its paramagnetic character. (2)
(ii) Calculate the bond order of O_2 molecule. (2) [December 2021]

Ans: (i) M.O configurationof O_2 is: $\sigma 1s^2$ $\sigma^* 1s^2$ $\sigma 2s^2$ $\sigma^* 2s^2$ $\sigma 2p_z^2$ $\pi 2p_x^2$ $\pi 2p_y^2$ $\pi^* 2p_x^1$ $\pi^* 2p_y^1$

O_2 is paramagnetic due to the presence of unpaired electrons.

(ii) Bond order (B.O) = ½ [Nb – Na]

= ½ [10 – 6] = ½ x 4 = 2

5. Fill in the blanks :

Molecule	Structure	Bond Angle
BF_3	.....	120^0
$BeCl_2$	Linear	.....

(2)

Ans:

Molecule	*Structure*	*Bond Angle*
BF_3	*Planar Triangular or Trigonal planar*	*120^0*
$BeCl_2$	*Linear*	*180^0*

6. (i) What is bond order according to M.O. theory ? (1)
(ii) He_2 molecule does not exist, why ? (2)

Ans: (i) It is defined as the half of the difference between no. of bonding electrons and no. of anti-bonding electrons. OR, Bond order (B.O) = ½ [Nb – Na]

(ii) M.O. configuration of He_2 is $\sigma 1s^2$ $\sigma^* 1s^2$.

Bond order (B.O) = ½ [Nb – Na]

= ½ [2 – 2] = ½ x 0 = 0

Since bond order is zero, He_2 molecule does not exist.

7. (i) Write any two postulates of VSEPR theory. (2)
(ii) Hydrogen bonds are of two types, which are they ? Write one example for each. (2)

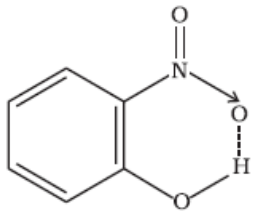
Ans: (i) Refer the answer of Question no. 3 (ii)

(ii) Intermolecular H bond and intramolecular H bond.

E.g. for Intermolecular H bond: H bonding in water, NH_3, HF etc.

….H-F …….. H-F …… H-F …… H-F ……

E.g. for Intramolecular H bond: H bond in o-nitrophenol



8. (i) Hybridisation of Carbon in CH_4 is
(A) sp^2 (B) sp (C) sp^3 (D) sp^3d (1)
(ii) Write any two characteristics of hybridisation. (1)
(iii) O_2 molecule is paramagnetic, explain using M.O. theory. (2) [September 2021]

Ans: (i) (C) sp^3

(ii) The important characteristics of hybridisation are:

1. The number of hybrid orbitals formed is equal to the number of atomic orbitals undergo hybridization.

2. The hybrid orbitals are always equivalent in energy and in identical shape.

3. The hybrid orbitals are more effective in forming stable bonds than the pure atomic orbitals.

4. The hybrid orbitals are directed to some fixed positions in space. So the type of hybridization gives the shape of the molecule. [Any 2 required]

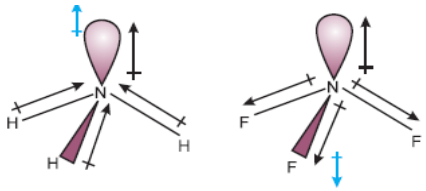
(iii) Refer the answer of Question no.4 (i)

9. (a) Define Bond angle. (1)

(b) NH_3 and NF_3 molecules have a pyramidal shape with a lone pairs of electrons on nitrogen atom. But the dipole moment of NH_3 is 4.9 x 10^{-30} Cm and that of NF_3 is 0.8 x 10^{-30} Cm. Give reason. (2)

Ans: (a) It is defined as the angle between the orbitals containing bonding electron pairs around the central atom in a molecule.

(b) This is because in NH_3, the orbital dipole due to lone pair is in the same direction as the resultant dipole moment of the three N – H bonds. But in NF_3, the orbital dipole is in the opposite direction to the resultant dipole moment of the three N-F bonds. So the dipole moments get partially cancelled.



10. (a) The bond angle in water is lower than the tetrahedral angle. Why? (1)

(b) Give 1 example of a molecule in which the central atom is in sp hybridisation. Predict its geometry. (1)

(c) Write the MO configuration of N_2 molecule and calculate its bond order. (2) [Dec 2020]

Ans: (a) Because of the presence of lone pairs of electrons in water.

(b) $BeCl_2$. Its geometry is linear.

(c) N_2 molecule contains 14 electrons.

Its M.O configuration is: $\sigma 1s^2$ $\sigma^* 1s^2$ $\sigma 2s^2$ $\sigma^* 2s^2$ $\pi 2p_x^2$ $\pi 2p_y^2$ $\sigma 2p_z^2$.

Bond order (B.O) = ½ [Nb – Na]

= ½ [10 – 4] = ½ x 6 = 3

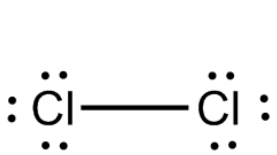
11. (a) Give two examples of compounds having expanded octet. (1)

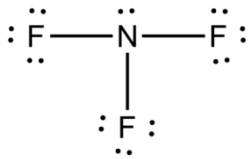
(b) Draw the Lewis dot symbols of (i) Cl_2 (ii) NF_3 (2)

Ans: (a) PCl_5 and SF_6

(b) Lewis dot symbols

(i) Cl_2 *(ii) NF_3*





12. (a) Predict the hybridisation of phosphorous atom in PCl_5 molecule. (1)

(b) Account for the high reactivity of PCl_5 molecule. (1)

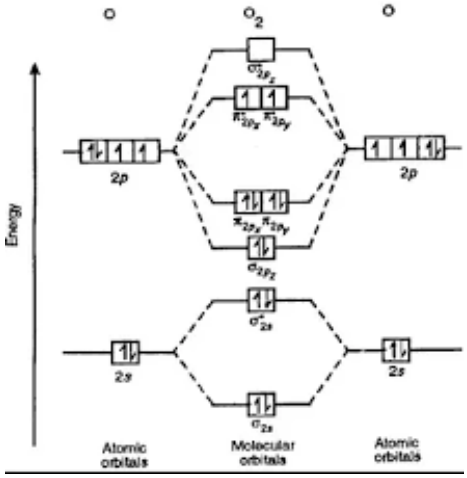
(c) Draw the MO energy level diagram of O_2 molecule. (2) [March 2020]

Ans: (a) sp^3d

(b) In PCl_5, the axial bond pairs suffer more repulsion from the equatorial bond pairs. So the axial bond length is greater than the equatorial bond length. So PCl_5 is highly unstable and is very reactive.

(c) O_2 molecule contains 16 electrons.

Its M.O configuration is: $\sigma 1s^2$ σ^*1s^2 $\sigma 2s^2$ σ^*2s^2 $\sigma 2p_z^2$ $\pi 2p_x^2$ $\pi 2p_y^2$ $\pi^*2p_x^1$ $\pi^*2p_y^1$



13. The dipole moment of BeF_2 is zero, while that of H_2O is 1.85 D. Account for this the on basis of their molecular structure. (2)

Ans: BeF_2 has linear shape and hence its bond dipole cancels each other. But water has a bent structure and hence its bond dipoles do not cancel each other. So it has a net bond dipole of 1.85D.

14. (a) A molecule of the type AB_4E has 4 bond pairs of electrons and 1 lone pair ofelectron. Predict the most stable structure of this compound. (1)

(b) Hydrogen fluoride is a liquid, while hydrogen chloride is a gas. Why ? (1)

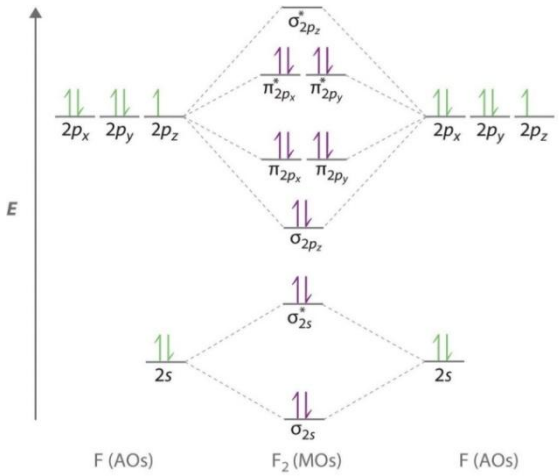
Ans: (a) See-saw shape

(b) This is because of the association of molecules through inter molecular hydrogen bonding in HF.

15. Draw the molecular orbital diagram for F_2 molecule. Account for its magnetic character. (3) [July 2019]

Ans: M.O configuration of F_2 is $\sigma 1s^2$ σ^*1s^2 $\sigma 2s^2$ σ^*2s^2 $\sigma 2p_z^2$ $\pi 2px^2$ $\pi 2p_y^2$ $\pi^*2p_x^2$ $\pi^*2p_y^2$

M.O Diagram is:



Due to the presence of only paired electrons, F_2 is diamagnetic.

16. Represent the Lewis structure of Ozone (O_3) molecule and assign the formal charge on each atom. (2)

Ans:

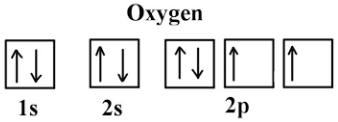
Formal charge = Total number of valence electrons on the free atom – Total no. of lone pairs of electron – ½ [Total no. of bonding electrons]

Formal charge on first O atom = 6 – 2 – ½ (6) = +1
Formal charge on second O atom = 6 – 4 – ½ (4) = 0
Formal charge on third O atom = 6 – 6 – ½ (2) = -1

17. Among NaCl, $BeCl_2$ and $AlCl_3$, which one is more covalent? Justify the answer. (2)
Ans: $AlCl_3$. According to Fajans rule, smaller the size and greater the charge of the cation, greater will be the polarizing power and hence the covalent character. So $AlCl_3$ has the most covalent character.
18. Write the molecular orbital electronic configuration of N_2 and O_2 molecules. Compare the stability and magnetic behaviour of these molecules on the basis of M. O. theory. (3) [March 2019]

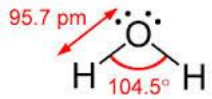
Ans: N_2 molecule contains 14 electrons.
Its M.O configuration is: $\sigma 1s^2\ \sigma^*1s^2\ \sigma 2s^2\ \sigma^*2s^2\ \pi 2p_x^2\ \pi 2p_y^2\ \sigma 2p_z^2$.
O_2 molecule contains 16 electrons.
Its M.O configuration is: $\sigma 1s^2\ \sigma^*1s^2\ \sigma 2s^2\ \sigma^*2s^2\ \sigma 2p_z^2\ \pi 2p_x^2\ \pi 2p_y^2\ \pi^*2p_x^1\ \pi^*2p_y^1$
Bond order (B.O) = ½ [Nb – Na]
For N_2, B.O = ½ [10 – 4] = ½ x 6 = 3
For O_2, B.O = ½ [10 – 6] = ½ x 4 = 2
Since N_2 has higher bond order than O_2, it is more stable.
N_2 is diamagnetic due to the absence of unpaired electrons, while O_2 is paramagnetic due to the presence of unpaired electrons.

19. If Z-axis is the internuclear axis, name the type of covalent bond formed by the overlapping of two p_y-orbitals. (1)
Ans: π bond
20. Write any two limitations of octet rule. (2)
Ans: a) It could not explain the stability of compounds containing less than 8 electrons around the central atom. E.g. LiCl, BeH_2, BCl_3 etc.
b) It could not explain the stability of molecules containing odd number of electrons like NO, NO_2 etc.
21. The diatomic species Ne_2, does not exist, but Ne_2^- can exist. Explain on the basis of molecular orbital theory. (4) [August 2018]
Ans: M.O. configuration of Ne_2 is $\sigma 1s^2\ \sigma^*1s^2\ \sigma 2s^2\ \sigma^*2s^2\ \sigma 2p_z^2\ \pi 2px^2\ \pi 2p_y^2\ \pi^*2p_x^2\ \pi^*2p_y^2\ \sigma^*2\ p_z^2$
Bond order (B.O) = ½ [Nb – Na]
For Ne_2, B.O = ½ [10 – 10] = ½ x 0 = 0
For Ne_2^-, B.O = ½ [11 – 10] = ½ x 1 = 0.5
Since B.O of Ne_2 is zero, it does not exist. But Ne_2^- has a +ve bond order, so it exists.
22. Predict the shape of XeF_4 molecule, according to VSEPR theory. (1)
Ans: XeF_4 contains 6 VSEPs, out of them 4 are bond pairs and 2are lone pairs of electrons.
So the shape is square planar.
23. By using the concept of hybridization, explain the structure of H_2O molecule. (2)
Ans: In H_2O, the central atom O has the electronic configuration $1s^2 2s^2 2p^4$.



Now the one s-orbital and three p-orbitals of O undergo sp^3 hybridisation to form 4 sp^3 hybrid orbitals. Two of these sp^3 hybrid orbitals are occupied by lone pairs and the other two sp^3 hybrid orbitals overlap with 1s orbital of hydrogen to form 2 O-H bonds. Due to the greater repulsion between lone pairs,

the shape is distorted to angular shape or bent structure or inverted 'v' shape and the bond angle becomes 104.5^0.



24. Write the molecular orbital electronic configurations of N_2 and O_2 and calculate their bond orders. Give a comparison of their stability and magnetic behaviour. (4) [March 2018]

Ans: M.O configuration of N_2 is: $\sigma 1s^2$ $\sigma^* 1s^2$ $\sigma 2s^2$ $\sigma^* 2s^2$ $\pi 2p_x^2$ $\pi 2p_y^2$ $\sigma 2p_z^2$.

Bond order (B.O) = ½ [Nb – Na]

= ½ [10 – 4] = ½ x 6 = 3

O_2 molecule contains 16 electrons.

Its M.O configuration is: $\sigma 1s^2$ $\sigma^* 1s^2$ $\sigma 2s^2$ $\sigma^* 2s^2$ $\sigma 2p_z^2$ $\pi 2p_x^2$ $\pi 2p_y^2$ $\pi^* 2p_x^1$ $\pi^* 2p_y^1$

B.O = ½ [10 – 6] = ½ x 4 = 2

Since B.O of N_2 is greater than that of O_2, N_2 is stabler than O_2.

Due to the absence of unpaired electrons, N_2 is diamagnetic, but O_2 is paramagnetic due to the presence of unpaired electrons.

25. a) The hybridization of C in ethene is .....

i) sp ii) sp^2 iii) sp^3 iv) sp^3d (1)

b) Explain sp^3d^2 hybridization with an example. (3)

c) Calculate the bond order of Lithium molecule. (At. no. of Li is 3) (1) [July 2017]

Ans: a) sp^2

b) sp^3d^2 hybridization is the process of inter mixing of one s-orbital, three p-orbitals and two d-orbitals to form six new orbitals having equivalent energy and shape.

E.g. Formation of SF_6

In SF_6, the central atom S is in sp^3d^2 hybridisation. Thus 6 new sp^3d^2 hybrid orbitals are formed. These hybrid orbitals overlap with p- orbitals of fluorine atoms to form 6 S–F sigma bonds. Thus SF_6 molecule has a regular octahedral geometry with bond angle 90^0.

c) M.O. configuration of Li_2 is $\sigma 1s^2$ $\sigma^* 1s^2$ $\sigma 2s^2$.

Bond order (B.O) = ½ [Nb – Na]

= ½ [4 – 2] = ½ x 2 = 1

26. The geometry of the molecule is decided by the type of hybridisation.

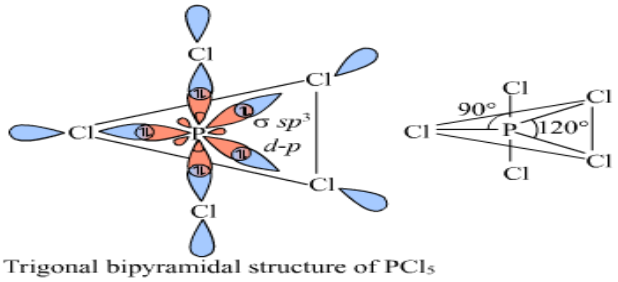
a) Discuss the shape of PCl_5 molecule using hybridisation. (2)

b) Give the reason for the high reactivity of PCl_5. (2)

c) Isoelectronic species have the same bond order. Among the following choose the pair having same bond order.

CN^-, O_2^-, NO^+, CN^+ (1) [March 2017]

Ans: a) In PCl_5, the central atom is in sp^3d hydridisation. The 5 sp^3d hybrid orbitals formed are directed to the five corners of a regular trigonal bipyramid with bond angles 120^0 and 90^0.



Trigonal bipyramidal structure of PCl_5

b) PCl_5 contains two types of P – Cl bonds - 3 equatorial bonds and 2 axial bonds. The axial bond pairs suffer more repulsion from the equatorial bond pairs. So the axial bond length is greater than the equatorial bond length. So PCl_5 is highly unstable and is very reactive.

c) CN^- and NO^+.

27. VSEPR theory is used to predict the shape and bond angle of molecules.

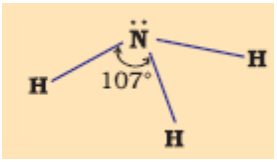
a) Write the postulates of VSEPR theory. (2)

b) Explain the shape and bond angle of NH_3 molecule using VSEPR theory. (2)

c) PCl_5 molecule is unsymmetric. Why? (2) [September 2016]

Ans: a) Refer the answer of Question no. 3(ii)

b) In ammonia, the central atom N has 5 valence electrons ($_7N$ – 2,5). Among these electrons, three are used for the formation of bonds with hydrogen atoms and the remaining 2 electrons stay as lone pairs. So there are 4 VSEPs. Hence the expected shape of the molecule is tetrahedral. But due to the presence of lone pairs, the shape is distorted to triangular pyramid and the bond angle changes from $109^0 28^l$ to 107^0.



c) Refer the answer of Question no. 26 a) and b)

28. The electronic configuration of a molecule can give information about bond order.

i) Write the molecular orbital configuration of F_2 molecule.

ii) Find its bond order. (2)

b) Give any two factors influencing the formation of an ionic bond. (2)

c) Give the shape of the following species. i) NH_4^+ ii) $HgCl_2$ (1) [March 2016]

Ans: a) (i) M.O configuration of F_2 is $\sigma 1s^2\ \sigma^* 1s^2\ \sigma 2s^2\ \sigma^* 2s^2\ \sigma 2p_z^2\ \pi 2px^2\ \pi 2p_y^2\ \pi^* 2p_x^2\ \pi^* 2p_y^2$

(ii) Bond order (B.O) = ½ [Nb – Na]

= ½ [10 – 8] = ½ x 2 = 1

b) The factors favouring the formation of ionic bond are:

i) Low ionisation enthalpy of the electropositive atom (metal atom).

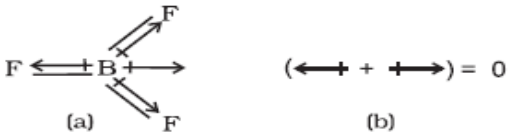
ii) High negative electron gain enthalpy of the electronegative atom (non-metal atom).

c) i) NH_4^+- Tetrahedral ii) $HgCl_2$ - Linear

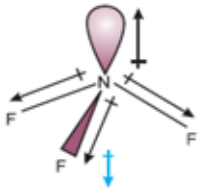
29. a) The net dipole moment of a polyatomic molecule depends on the spatial arrangement of various bonds in the molecule. The dipole moment of BF_3 is zero while that of NF_3 is not zero. Justify. (2)

b) The type of hybridization indicates the geometry of a molecule. In water molecule, the oxygen atom is sp^3 hybridized. But water molecule has no tetrahedral geometry. Explain (2)

Ans: a) BF_3 has planar triangular shape. Here the resultant of any 2 bond dipoles is equal and opposite to the third. So its net dipole moment is zero.



But NF_3 has pyramidal geometry. Here the bond dipoles and the orbital dipoles are in opposite direction but they do not get cancelled each other. So NF_3 has a net dipole moment.



b) Water molecule contains 2 bond pairs and 2 lone pairs of electrons. Due to the greater repulsion between lone pairs, the shape is distorted from tetrahedral to angular shape or bent structure or inverted 'v' shape.

30. The formation of molecular orbitals can be described bv the linear combination of atomic orbitals.
    a) Which one of the following correctly represents the formation of bonding molecular orbital from the atomic orbitals having wave functions ψ_A and ψ_B?
    i) $\psi_A \times \psi_B$ ii) ψ_A / ψ_B iii) $\psi_A + \psi_B$ iv) $\psi_A - \psi_B$ (1)
    b) Write the electronic configuration of oxygen molecule on the basis of Molecular Orbital Theory. Justify the presence of double bond in it and account for its paramagnetic character. (2)

[October 2015]

Ans: a) $\psi_A + \psi_B$

b) O_2 molecule contains 16 electrons.

Its M.O configuration is: $\sigma 1s^2$ $\sigma^* 1s^2$ $\sigma 2s^2$ $\sigma^* 2s^2$ $\sigma 2p_z^2$ $\pi 2p_x^2$ $\pi 2p_y^2$ $\pi^* 2p_x^1$ $\pi^* 2p_y^1$

B.O = ½ [10 – 6] = ½ x 4 = 2

Since the B.O = 2, O_2 contains double bond.

Due to the presence of unpaired electrons, O_2 is paramagnetic.

31. Molecular orbital theory was developed by F. Hund and R.S. Mullikken.
    a) One-half of the difference between the number of electrons in the bonding and antibonding molecular orbitals is called …….. (1)
    b) i) Write the molecular electronic configuration of the N_2 molecule. (1)
    ii) Predict the stability and magnetic property of N_2 with reasons. (3)

Ans: a) Bond order

b) i) M.O configuration of N_2 is: $\sigma 1s^2$ $\sigma^* 1s^2$ $\sigma 2s^2$ $\sigma^* 2s^2$ $\pi 2p_x^2$ $\pi 2p_y^2$ $\sigma 2p_z^2$.

ii) Bond order (B.O) = ½ [Nb – Na]

= ½ [10 – 4] = ½ x 6 = 3

Since bond order is +ve, N_2 is stable. Due to the presence of only paired electrons, N_2 is diamagnetic.

32. In order to explain the geometrical shapes of molecules, the concept of hybridisation was introduced.
    a) The geometry of SF_6 molecule is ……..
    i) Tetrahedral ii) Planar iii) Octahedral iv) Trigonal bipyramidal (1)
    b) i) Define the term hybridisation. (1)
    ii) Explain sp^3 hybridisation taking methane (CH_4) as an example. (3) [March 2015]

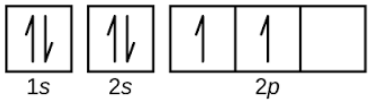
Ans: a) Octahedral

b) i) It is the process of inter mixing atomic orbitals having slightly different energies to form new orbitals having equivalent energy and identical shape.

ii) In CH_4, the central atom C has the electronic configuration

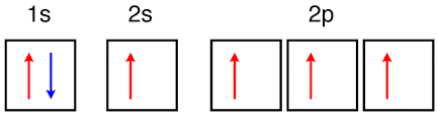
$_6C$ – $1s^2 2s^2 2p^2$

C (ground state) –

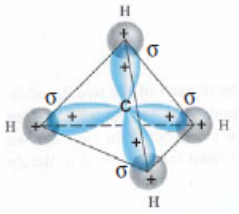


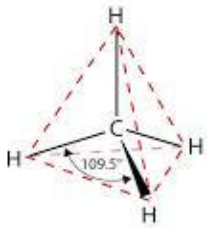
In order to explain the tetra valency of C, it is suggested that one of the electrons of 2s orbital is promoted to 2p orbital.

C (excited state) –



Now, one s-orbital and three p-orbitals undergo sp^3 hybridisation. These sp^3 hybrid orbitals are directed to the four corners of a regular tetrahedron with bond angle $109^0 28^l$. Each of these sp^3 hybrid orbitals overlap with 1s orbital of H to form four C-H σ bonds.





33. a) Molecular orbitals are formed by the linear combination of atomic orbitals (LCAO). Give the salient features of molecular orbital theory. (3)
    b) Explain sp^3d hybridisation with a suitable example. (2)

Ans: a) The important postulates of this theory are:
i) In molecules, the electrons are present in some special type of orbitals called molecular orbitals.
ii) The atomic orbitals of comparable energy and proper symmetry combine to form molecular orbitals.
iii) Atomic orbitals are monocentric, while molecular orbitals are polycentric.
iv) The number of molecular orbitals formed = the number of atomic orbitals combined. i.e. if 2 atomic orbitals combined, 2 molecular orbitals are formed. One is called bonding molecular orbital (BMO) and the other is called anti-bonding molecular orbitals (ABMO)
v) The BMO has lower energy and greater stability than the corresponding ABMO.
vi) The molecular orbitals give the electron probability distribution around a group of nuclei.
vii) The molecular orbitals are filled according to 3 rules – Aufbau principle, Pauli's exclusion principle and Hund's rule. [Any 6 required]

b) sp^3d hybridization is the process of inter mixing of one s-orbital, three p-orbitals and one d-orbital to form five new orbitals having equivalent energy and shape.

E.g. Formation of PCl_5. In PCl_5, the central atom is in sp^3d hydridisation. The 5 sp^3d hybrid orbitals formed are directed to the five corners of a regular trigonal bipyramid with bond angles 120^0 and 90^0.

34. a) The shape of the molecules is based on the VSEPR theory. Give the salient features of this theory. (3)
    b) Draw the potential energy curve for the formation of a hydrogen molecule on the basis of inter nuclear distance of the hydrogen atoms. (2) [August 2014]

Ans: a) Refer the ans. Of the qn. No. 3 (ii)
b) Refer the answer of the Qn. No. 1

35. a) He_2 cannot exist as stable molecule. Justify this statement on the basis of bond order. (1)
    b) State Fajan's rule regarding the partial covalent character of an ionic bond. (1)
    c) Which has higher boiling point – o-nitrophenol or p-nitrophenol? Give reason. (3) [March 2014]

Ans: a) The bond order of He_2 is zero. So He_2 cannot exist.
b) Fajan's rule states that:
i) The smaller the size of the cation and the larger the size of the anion, the greater the covalent character of an ionic bond.
ii) The greater the charge on the cation, the greater the covalent character of the ionic bond.

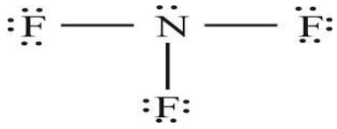
c) p-nitrophenol. This is because of the presence of inter molecular hydrogen bonding in p-nitrophenol.

36. a) Only valence electrons of atoms take part in chemical combination. Draw the Lewis representation of NF_3. (1)

b) Define dipole moment. The dipole moment of BF_3 is zero. Why?(2)

c) Based on bond order compare the relative stability of O_2 and O_2^{2-}. (2) [September 2013]

Ans: a)



b) Dipole moment is the product of the magnitude of charge at one end (Q) and the distance between the charges (r).

c) O_2 molecule contains 16 electrons.

Its M.O configuration is: $\sigma 1s^2\ \sigma^*1s^2\ \sigma 2s^2\ \sigma^*2s^2\ \sigma 2p_z^2\ \pi 2p_x^2\ \pi 2p_y^2\ \pi^*2p_x^1\ \pi^*2p_y^1$

B.O = ½ [10 – 6] = ½ x 4 = 2

O_2^{2-} molecule contains 18 electrons.

Its M.O configuration is: $\sigma 1s^2\ \sigma^*1s^2\ \sigma 2s^2\ \sigma^*2s^2\ \sigma 2p_z^2\ \pi 2p_x^2\ \pi 2p_y^2\ \pi^*2p_x^2\ \pi^*2p_y^2$

B.O = ½ [10 – 8] = ½ x 2 = 1

O_2 is more stable, since its B.O is higher than that of O_2^{2-}.

37. The Valence Shell Electron Pair Repulsion (VSEPR) theory helps in predicting the shapes of covalent molecules.

a) Arrange the bond pair electron and lone pair electron in the decreasing order of the repulsive interactions among them. (1)

b) A molecule of the type AB_3E_2 has three bond pairs and two lone pairs of electrons. Predict the most stable arrangement of electron pairs in this molecule. (1)

c) The bond order value is an important property of a molecule. How is bond order related to bond length? (1)

d) Write the electronic configuration of an oxygen molecule and justify its magnetic character. (2)

[March 2013]

Ans:

a) The decreasing order of repulsion is lone pair - lone pair > lone pair - bond pair > bond pair - bond pair.

b) T-shape

c) Bond order is inversely proportional to bond length.

d) Refer the ans. of the qn. No. 18 (b)

38. a) The ionic bonds have partial covalent character and the covalent bonds also show some ionic character.

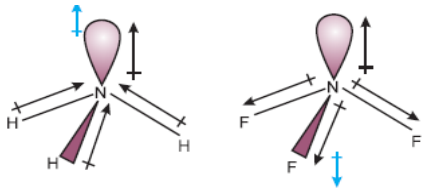
i) Explain the covalent character of Lithium chloride using Fajan's rule (1)

ii) NF_3 and NH_3 show dipole moment. But the dipole moment of NF_3 is less than that of NH_3. Why? (1)

b) The covalent bond can be explained by Molecular Orbital Theory (MOT). Using MO diagram explain the paramagnetic nature of oxygen molecule. (3) [September 2012]

Ans: a) i) LiCl is covalent due to the small size of the cation Li^+ and large size of the anion Cl^-.

ii) This is because in NH_3, the orbital dipole due to lone pair is in the same direction as the resultant dipole moment of the three N – H bonds. But in NF_3, the orbital dipole is in the opposite direction to the resultant dipole moment of the three N-F bonds. So the dipole moments get partially cancelled.



b) Refer the ans. of the qn. No. 18 (b)

39. Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT) are the two important theories of chemical bonding.
    a) Out of the following which is the hybridisation of phosphorus in PCl_5? (sp^3, sp^2, dsp^2, sp^3d) (1)
    b) Explain the geometry of PCl_5 molecule and account for its high reactivity. (2)
    c) Write the molecular orbital configuration of the C_2 molecule and calculate its bond order. (2)
    [March 2012]

    Ans: a) sp^3d

    b) Refer the ans. of the qn. No. 14

    c) *M.O configuration of C_2 is: $\sigma 1s^2$ $\sigma^* 1s^2$ $\sigma 2s^2$ $\sigma^* 2s^2$ $\pi 2p_x^2$ $\pi 2p_y^2$*

    Bond order (B.O) = ½ [Nb – Na]

    = ½ [8 – 4] = ½ x 4 = 2

40. a) Hydrogen bonding plays an important role in determining the physical properties of substances.
    i) Illustrate hydrogen bonding using an example. (1½)
    ii) Compare the boiling points of o-nitro phenol and p-nitro phenol based on hydrogen bonding. (1½)
    b) Describe the hybridisation and structure of PCl_5 molecule. (2) [September 2011]

    Ans: a) i) The weak attractive force between Hydrogen atom of one molecule and electronegative atom (like F, O or N) of the same or different molecule is termed as Hydrogen bond.

    E.g. Hydrogen bonding in HF

    ….H-F …….. H-F …….. H-F …… H-F ……

    ii) The molecules of p-nitrophenol are associated through inter molecular hydrogen bonding. So it has higher boiling point than o-nitrophenol.

    b) Refer the ans. of the qn. No. 14 (a)

41. The attractive force which holds atoms together in a molecule is called a chemical bond.
    a) Explain the formation of a H_2 molecule on the basis of the valence bond theory (VBT). (2½)
    b) Using the molecular orbital theory (MOT), explain why Ne_2 molecule does not exist? (1½)
    c) Calculate the bond order of dinitrogen (N_2). (1) [March 2011]

    Ans: a) Consider 2 hydrogen atoms. When the two atoms are at large distance from each other, there is no interaction between them. So their potential energy is zero. When the two atoms approach each other, new attractive and repulsive forces begin to operate. Experimentally it has been found that the magnitude of new attractive forces is more than the new repulsive forces. So the two atoms approach each other and potential energy decreases. At a particular stage, the net attractive force balances the net repulsive forces and the energy becomes minimum. At this stage, the hydrogen atoms are said to be bonded together to form a stable molecule.

    Or, Draw the potential energy diagram as in the ans. of the qn. No. 1

    b) B.O of Ne_2 is zero. So it does not exist.

    c) Ref. the answer of no. 24

42. VSEPR theory is used to predict the shape of covalent molecules.
    a) State the main postulates of VSEPR theory. (3)

b) Based on VSEPR theory predicts the shape of H_2O and NH_3. (2) [October 2010]

Ans: a) Refer the ans. of the qn. No.3 (ii)

b)Water molecule contains 4 VSEPs – 2 bond pairs and 2 lone pairs. Hence the expected shape of the molecule is tetrahedral. But due to the greater repulsion between lone pairs, the shape is distorted to bent or angular structure and the bond angle changes to 104.5^0.

NH_3 molecule also contains 4 VSEPs – 3 bond pairs and 1 lone pair. Due to the greater repulsion between lone pair and bond pairs of electrons, it has pyramidal geometry with bond angle 107^0.

43. The stability and magnetic properties of a molecule can be explained using the molecular orbital theory proposed by F. Hund and R.S. Mulliken.

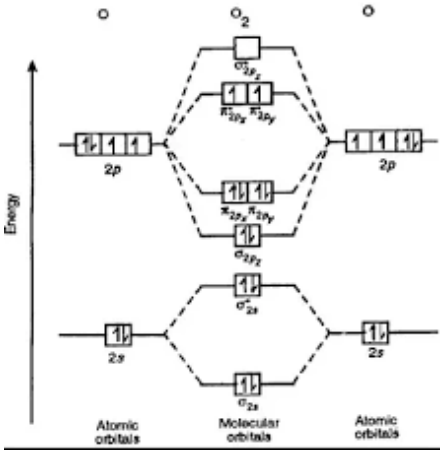
a) Define bond order according to the M.O theory.

b) Draw the energy level diagram for the formation of O_2 molecule.

c) Calculate the bond order and predict the magnetic character of O_2 molecule. [March 2010]

Ans: a) It is the half of the difference between the number of bonding electrons (N_b) and the number of anti-bonding electrons (N_a).

b)



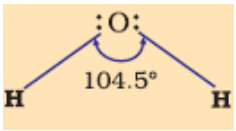
c) *Refer the ans. of the qn. No.18(b)*

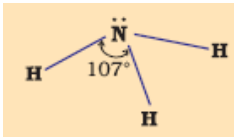
44. a) What do you understand by bond pair electrons and lone pair electrons? (2)

b) Explain the bond pair electrons and lone pair electrons H_2O and NH_3 molecules with suitable drawings. (3) [March 2009]

Ans: a)The valence electron pairs which particilate in bond formation are called bond pairs and which do not participate in bond formation are called lone pairs.

b) Refer the ans. of the qn. No. 30 (b)





45. Water is a liquid while H_2S is a gas.

a) Suggest the reason for the above fact. (1)

b) Explain the phenomenon. (2) [February 2008]

Ans: a)Water molecules are associated through inter molecular hydrogen bonding which is absent in H_2S.

b) It is the H bond formed by H atom of one molecule and the electronegative atom of another molecule.

E.g. Hydrogen bonding in HF

….H-F …….. H-F …….. H-F …… H-F ……