Chapter – 10

Chemical Bonding

Textbook Evaluation:

I. Choose the best Answer:

Question 1.
In which of the following compound does the central atom obey the octet rule?
a) XeF_4
b) $AlCl_3$
c) SF_6
d) SCl_2

Answer:
d) SCl_2

Question 2.
In the molecule $O_A = C = O_B$, the formal charge on O_A, C and O_B are respectively.
a) -1, 0, +1
b) +1, 0, -1
c) -2, 0, +2
d) 0, 0, 0

Answer:
d) 0, 0, 0

Question 3.
Which of the following is electron deficient?
a) PH_3
b) $(CH_3)_2$
c) BH_3
d) NH_3

Answer:
c) BH_3

Question 4.
Which of the following molecule contain no π bond?
a) SO_2
b) NO_2
c) CO_2
d) H_2O

Answer:
d) H_2O

Question 5.
The ratio of number of sigma (σ) bond and pi (π) bonds in 2 – butynal is
a) 8/3
b) 5/3
c) 8/2
d) 9/2

Answer:
a) 8/3

Question 6.
Which one of the following is the likely bond angles of sulphur tetrafluo-ride molecule?
a) 120°, 80°
b) 109°28'
c) 90°
d) 89°, 117°

Answer:
d) 89°, 117°

Question 7.
Assertion:
Oxygen molecule is paramagnetic.
Reason :
It has two unpaired electron in its bonding molecular orbital

a) both assertion and reason are true and reason is the correct explanation of assertion.

b) both assertion and reason are true but reason is not the correct explanation of assertion.
c) assertion is true but reason is false.
d) both assertion and reason are false.

Answer:
c) assertion is true but reason is false.

Question 8.
According to Valence bond theory, a bond between two atoms is formed when
a) fully filled atomic orbitals overlap
b) half filled atomic orbitals overlap
c) non – bonding atomic orbitals overlap
d) empty atomic orbitals overlap

Answer:
b) half filled atomic orbitals overlap

Question 9.
In ClF_3, NF_3 and BF_3 molecules the chlorine, nitrogen and boron atoms are
a) sp^3 hybridised
b) sp^3, sp^3 and sp^2 respectively
c) sp^3 hybridised
d) sp^3d, sp^3 and sp hybridised respectively

Answer:
d) sp^3d, sp^3 and sp hybridised respectively

Question 10.
When one s and three p orbitals hybridise,
a) four equivalent orbitals at 90° to each other will be formed
b) four equivalent orbitals at 109°28’ to each other will be formed
c) four equivalent orbitals, that are lying the same plane will be formed
d) none of these

Answer:
b) four equivalent orbitals at 109°28’ to each other will be formed

Question 11.
Which of these represents the correct order of their increasing bond order.

a) $C_2^+ < C_2^{2-} < O_2^{2-} < O_2$
b) $C_2^{2-} < C_2^+ < O_2 < O_2^{2-}$
c) $O_2^{2-} < O_2 < C_2^{2-} < C_2^+$
d) $O_2^{2-} < C_2^+ < O_2 < C_2^{2-}$

Answer:
d) $O_2^{2-} < C_2^+ < O_2 < C_2^{2-}$

Question 12.
Hybridisation of central atom in PCl_5 involves the mixing of orbitals.
a) s, P_x, P_y, d_x^2, $d_x^2 - y^2$
b) s, p_x, p_y, p_{xy}, $d_x^2 - y^2$
c) s, p_x, p_y, p_z, $d_x^2 - y^2$
d) s, p_x, P_y, d_{xy}, $d_x^2 - y^2$

Answer:
c) s, p_x, p_y, p_z, $d_x^2 - y^2$

Question 13.
The correct order of O – O bond length in hydrogen peroxide, ozone and oxygen is
a) $H_2O_2 > O_3 > O_2$
b) $O_2 > O_3 > H_2O_2$
c) $O_2 > H_2O_2 > O_3$
d) $O_3 > O_2 > H_2O_2$

Answer:
b) $O_2 > O_3 > H_2O_2$

Question 14.
Which one of the following is diamagnetic?
a) O_2
b) O_2^{2-}
c) O_2^+
d) None of these

Answer:
b) O_2^{2-}

Question 15.

Bond order of a species is 2.5 and the number of electrons in its bonding molecular orbital is formed to be 8. The no. of electrons in its antibonding molecular orbital is

a) three

b) four

c) Zero

d) cannot be calculated from the given information

Answer:

a) three

Question 16.

Shape and hybridisation of IF_5 are

a) Trigonal bipyramidal, sp^3d^2

b) Trigonal bipyramidal, sp^3d

c) Square pyramidal, sp^3d^2

d) Octahedral, sp^3d^2

Answer:

c) Square pyramidal, sp^3d^2

Question 17.

Pick out the incorrect statement from the following:

a) sp^3 hybrid orbitals are equivalent and are at an angle of 109°28' with each other

b) dsp^2 hybrid orbitals are equivalent and bond angle between any two of them is 90°

c) All five sp^3d hybrid orbitals are not equivalent out of these five sp^3d hybrid orbitals, three are at an angle of 120° remaining two are perpendicular to the plane containing the other three

d) none of these

Answer:

c) All five sp^3d hybrid orbitals are not equivalent out of these five sp^3d hybrid orbitals, three are at an angle of 120° remaining two are perpendicular to the plane containing the other three

Question 18.
The molecules having same hybridisation, shape and number of lone pairs of electrons are
a) SeF_4, XeO_2F_2
b) SF_4, XeF_2
c) $XeOF_4$, TeF_4
d) $SeCl_4$, XeF_4

Answer:
a) SeF_4, XeO_2F_2

Question 19.
In which of the following molecules / ions BF_3, NO_2^- H_20 the central atom is sp^2 hybridised?
a) NH_2^- and H_2O
b) NO_2^- and H_2O
c) BF_3 and NO_2^-
d) BF_3 and NH_2^-

Answer:
c) BF_3 and NO_2^-

Question 20.
Some of the following properties of two species, NO_3^- and H_3O^+ are described below. Which one of them is correct?
a) dissimilar in hybridisation for the central atom with different structure
b) isostructural with same hybridisation for the central atom.
c) different hybridisation for the central atom with same structure.
d) none of these

Answer:
a) dissimilar in hybridisation for the central atom with different structure

Question 21.
The types of hybridisation on the five-carbon atom from right to left in the, 2,3 pentadiene.
a) sp^3, sp^2, sp, sp^2, sp^3
b) sp^3, sp, sp, sp, sp^3
c) sp^2, sp, sp^2, sp^2, sp^3

d) sp^3, sp^3, sp^2, sp^3, sp^3

Answer:
a) sp^3, sp^2, sp, sp^2, sp^3

Question 22.
XeF_2 is isostructural with
a) $SbCl_2$
b) $BaCl_2$
c) TeF_2
d) ICl_2^-

Answer:
d) ICl_2^-

Question 23.
The percentage of s-character of the hybrid orbitals in methane, ethane, ethene, and ethyne are respectively
a) 25, 25, 33.3, 50
b) 50, 50, 33.3, 25
c) 50, 25, 33.3, 50
d) 50, 25, 25, 50

Answer:
a) 25, 25, 33.3, 50

Question 24.
Of the following molecules, which have shape similar to carbondioxide?
a) $SnCl_2$
b) NO_2
c) C_2H_2
d) All of these

Answer:
c) C_2H_2

Question 25.
According to VSEPR theory, the repulsion between different parts of electrons obey the order
a) 1. p – 1. p > b. p – b. p > 1. p – b. p

b) b. p – b. p > b. p – 1. p > 1. p – b. p
c) 1. p – 1. p > b. p – 1. p > b. p – b. p
d) b. p – b. p > 1. p – 1. p > b. p – 1. p

Answer:
c) 1. p – 1. p > b. p – 1. p > b. p – b. p

Question 26.
Shape of ClF_3 is
a) Planar triangular
b) Pyramidal
c) “T” Shaped
d) none of these

Answer:
c) “T” Shaped

Question 27.
Non – Zero dipole moment is shown by
a) CO_2
b) p – dichlorobenzene
c) carbontetrachloride
d) water

Answer:
d) water

Question 28.
Which of the following conditions is not correct for resonating structures?
a) the contributing structure must have the same number of unpaired electrons
b) the contributing structures should have similar energies
c) the resonance hybrid should have higher energy than any of the contributing structure.
d) none of these

Answer:
c) the resonance hybrid should have higher energy than any of the contributing structure.

Question 29.
Among the following, the compound that contains, ionic, covalent, and Coordinate linkage is
a) NH_4Cl
b) NH_3
c) NaCl
d) none of these

Answer:
a) NH_4Cl

Question 30.
CaO and NaCl have the same crystal structure and approximately the same radii. If U is the lattice energy of NaCl, the approximate lattice energy of CaO is
a) U
b) 2U
c) U /2
d) 4U

Answer:
d) 4U

II. Write brief answer to the following questions:

Question 31.
Define the following:
i) Bond order
ii) Hybridisation
iii) σ – bond

Answer:
i) Bond order:
The number of bonds formed between the two bonded atoms in a molecule is called the bond order.

ii) Hybridisation:
Hybridisation is the process of mixing of atomic orbitals of the same atom

with comparable energy to form an equal number of new equivalent orbitals with the same energy.

iii) σ – bond:
When two atomic orbitals overlap linearly along the axis, the resultant bond is called a sigma (σ) bond.

Question 32.
What is a pi – bond?

Answer:
When two atomic orbitals overlaps sideways, the resultant covalent bond is called a pi (π) bond. When we consider x – axis as molecular axis, the p_y – p_y and p_z – p_z overlaps will result in the formation of a π – bond.

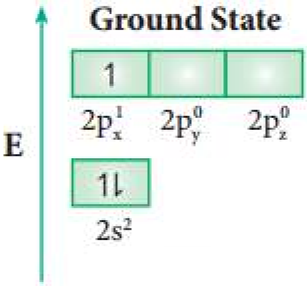
Question 33.
In CH_4, NH_3 and H_2O, the central atom undergoes sp3 hybridization – yet their bond angles are different. Why?

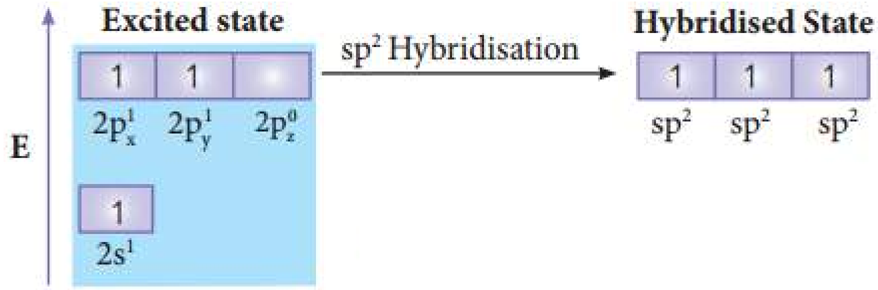
Answer:
According to VSEPR theory, as H_2O has two lone pairs so it repels the bond pairs much more and makes bond angle shorter of 104.5 degrees, and as NH_3 has one lone pair that repels the three bond pairs but not much effectively and strongly as two lone pairs of water repel one bond pair.

So the bond angle between Hydrogen atom of ammonia is 107.5 greater than that of water. Similarly, methane molecule have no lone pair and bond pair repels each other with the equal bond angle between two adjacent hydrogen atoms becomes $109°.28'$.

Question 34.
Explain Sp^2 hybridization in BF_3.

Answer:
Consider boron trifluoride molecule. The valence shell electronic configuration of boron atom is $[He]2s^2\ 2p^1$.



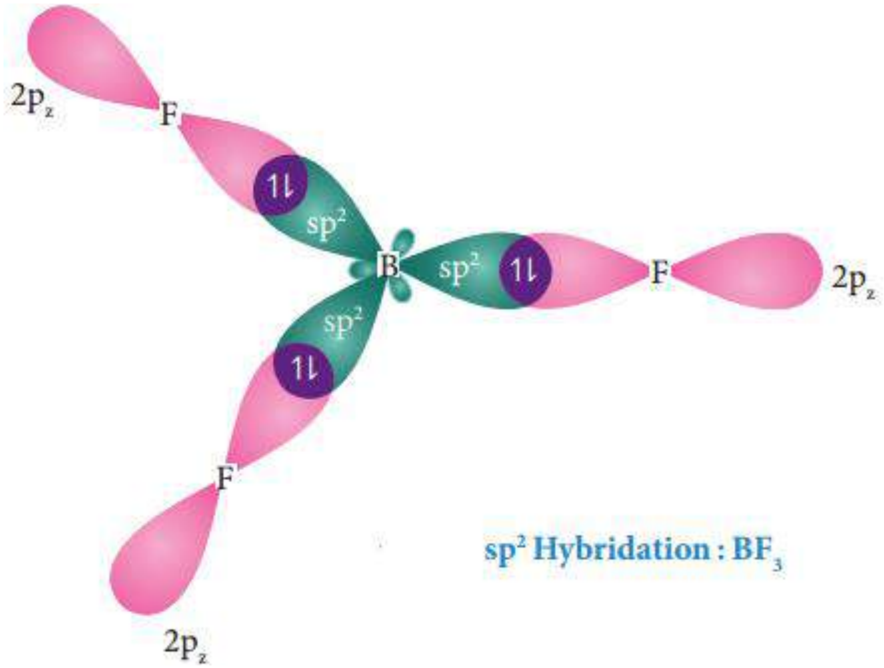


In the ground state boron has only one unpaired electron in the valence shell. In order to form three covalent bonds with fluorine atoms, three unpaired electrons are required. To achieve this, one of the paired electrons in the 2s orbital is promoted to the $2p_y$ orbital in the excite state.

In boron, the s orbital and two p orbitals (p_x and p_y) in the valence shell hybridises, to generate three equivalent sp^2 orbitals as shown in the Figure. These three orbitals lie in the same xy plane and the angle between any two orbitals is equal to 120°.

Overlap with $2p_z$ orbitals of flourine:

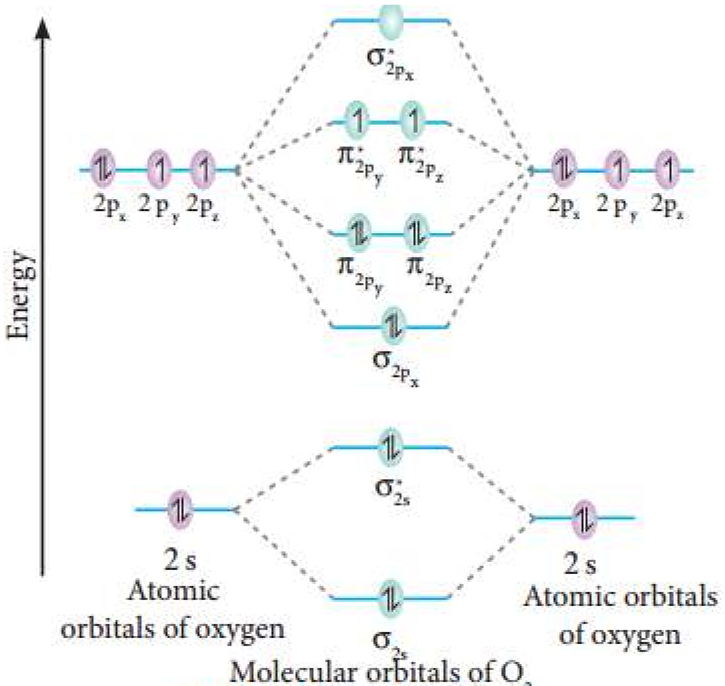
The three sp^2 hybridised orbitals of boron now overlap with the $2p_z$ orbitals of fluorine (3 atoms). This overlap takes place along the axis as shown below.



sp² Hybridation : BF_3

Question 35.
Draw the M.O diagram for oxygen molecule calculate its bond order and show that O_2 is paramagnetic.

Answer:



MO Diagram for O_2 molecule

Electronic configuration of O atom:
$1s^2\ 2s^2\ 2p^4$

Electronic configuration of O_2 molecule:
$\sigma_{1s}^2, \sigma_{1s}^{*2}, \sigma_{2s}^2, \sigma_{2s}^{*2}, \sigma_{2px}^2, \pi_{2py}^2\ \pi_{2pz}^2\ \pi_{2py}^{*1}\ \pi_{2pz}^{*1}$

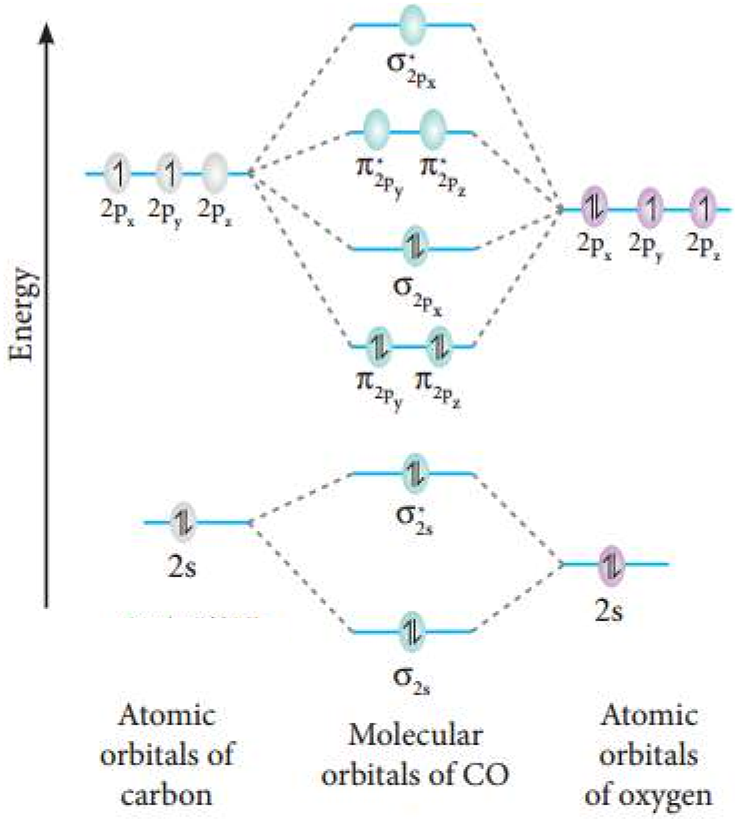
Bond order = $\frac{N_b - N_a}{2}$

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

Molecule has two unpaired electrons hence it is paramagnetic.

Question 36.
Draw MO diagram of CO and calculate its bond order.

Answer:



MO Diagram for CO molecule

Bonding in some hetero nuclear di-atomic molecules:
Molecular orbital diagram of Carbon monoxide molecule (CO)
Electronic configuration of C atom: $1s^2\ 2s^2\ 2p^2$
Electronic configuration of O atom: $1s^2\ 2s^2\ 2p^4$

Electronic configuration of CO molecule :

σ_{1s}^2, σ_{1s}^{*2}, σ_{2s}^2, σ_{2s}^{*2}, π_{2py}^2, π_{2pz}^2 σ_{2px}^2

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

$$= \frac{10-4}{2}$$

$$= 3$$

Molecule has no unpaired electrons hence it is diamagnetic.

Question 37.

What do you understand by Linear combination of atomic orbitals in MO theory?

Answer:

The wave functions for the molecular orbitals can be obtained by solving Schrodinger wave equation for the molecule. Since solving the Schrodinger equation is too complex, approximation methods are used to obtain the wave function for molecular orbitals. The most common method is the linear combination of atomic orbitals (LCAO).

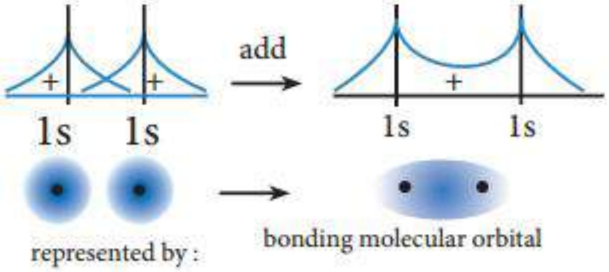
We know that the atomic orbitals are represented by the wave function ψ. Let us consider two atomic orbitals represented by the wave function ψ_A and ψ_B with comparable energy, combines to form two molecular orbitals. One is bonding molecular orbital($\psi_{bonding}$) and the other is antibonding molecular orbital ($\psi_{antibonding}$) The wave functions for these two molecular orbitals can be obtained by the linear combination of the atomic orbitals ψ_A and ψ_B as below,

$\psi_{bonding} = \psi_A + \psi_B$;
$\psi_{antibonding} = \psi_A - \psi_B$

The formation of bonding molecular orbital can be considered as the result of constructive interference of the atomic orbitals and the formation of anti-bonding molecular orbital can be the result of the destructive interference of the atomic orbitals. The formation of the two molecular orbitals from two is orbitals is shown below.

Constructive interaction:

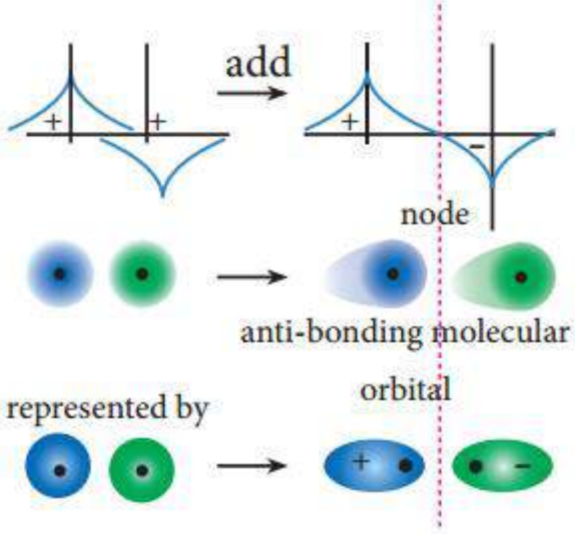
The two 1s orbitals are in phase and have the same sign,

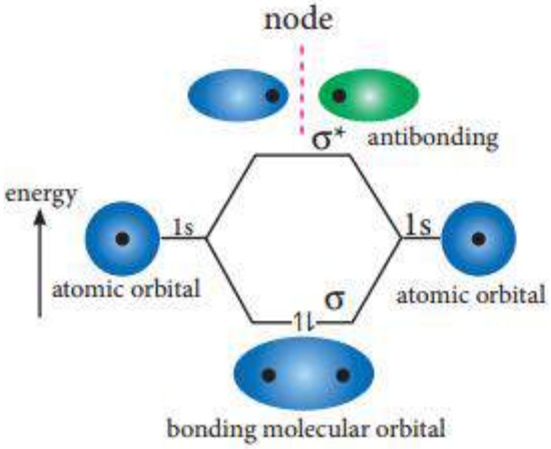


σ bonding MO

Destructive interaction:

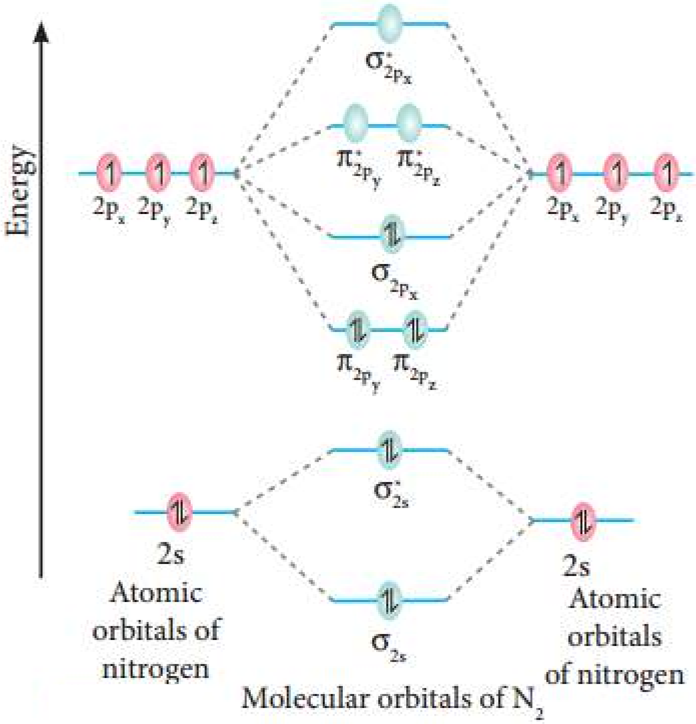
The two orbitals are out phase





Question 38.
Discuss the formation of N_2 molecule using MO theory.

Answer:



MO Diagram for N_2 molecule

Molecular orbital diagram of nitrogen molecule (N_2)
Electronic configuration of N atom $1s^2\ 2s^2\ 2p^3$
Electronic configuration of N_2 molecule:
$\sigma_{1s}^2, \sigma_{1s}^{*2}, \sigma_{2s}^2, \sigma_{2s}^{*2}, \pi_{2py}^2, \pi_{2pz}^2\ \sigma_{2px}^2$

$$\text{Bondorder} = \frac{N_b - N_a}{2}$$

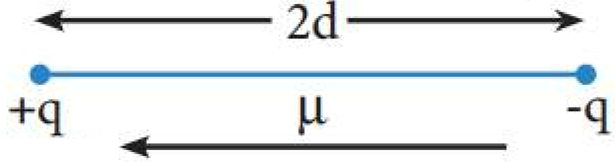
$$= \frac{10-4}{2} = 3$$

Molecule has no unpaired electrons hence it is diamagnetic.

Question 39.
What is dipole moment?

Answer:
The polarity of a covalent bond can be measured in terms of dipole moment which is defined as
$\mu = q \times 2d$

Where μ is the dipole moment, q is the charge and 2d is the distance between the two charges. The dipole moment is a vector and the direction of the dipole moment vector points from the negative charge to positive charge.



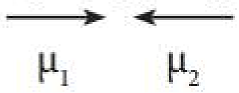
representation of dipole

The unit of dipole moment is coloumb meter (C m). It is usually expressed in Debye unit (d). The conversion factor is 1 Debye = 3.336×10^{-30} C m.

Question 40.
Linear form of carbondioxide molecule has two polar bonds. Yet the molecule has Zero dipole moment. Why?

Answer:
The linear form of carbon dioxide has zero dipole moment, even though it has two polar bonds. In CO_2, the dipole moments of two polar bonds (CO) are equal in magnitude but have opposite direction. Hence, the net dipole moment of the CO_2 is,

$\mu = \mu_1 + \mu_2 = \mu_1 + (-\mu_1) = 0$



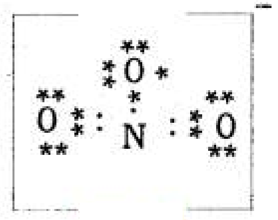
In this case $\mu = \vec{\mu_1} + \vec{\mu_2}$

$= \vec{\mu_1} + (\overrightarrow{-\mu_1}) = 0$

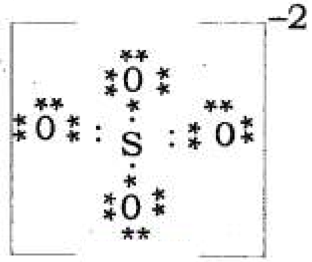
Question 41.
Draw the Lewis structures for the following species.
(i) NO_3^-
(ii) SO_4^{2-}
(iii) HNO_3
(iv) O_3

Answer:

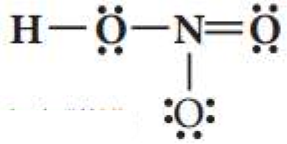
(i) NO_3^-



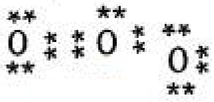
(ii) SO_4^{2-}



(iii) HNO_3



(iv) O_3



Question 42.

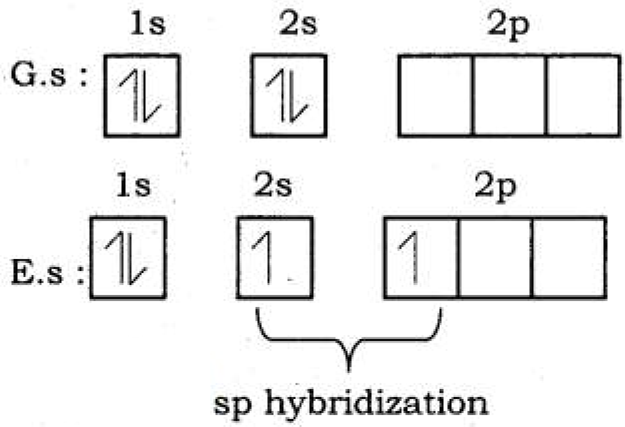
Explain the bond formation if $BeCl_2$ and $MgCl_2$.

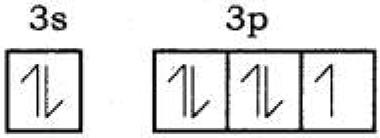
Answer:

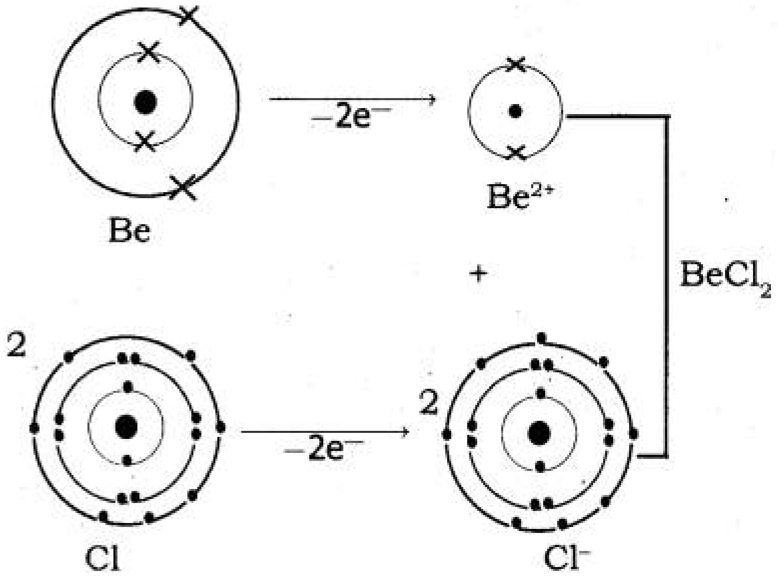
Bond formation of $BeCl_2$:

Be = 4;

Electronic configuration of Be atom is = $1s^2\ 2s^2$





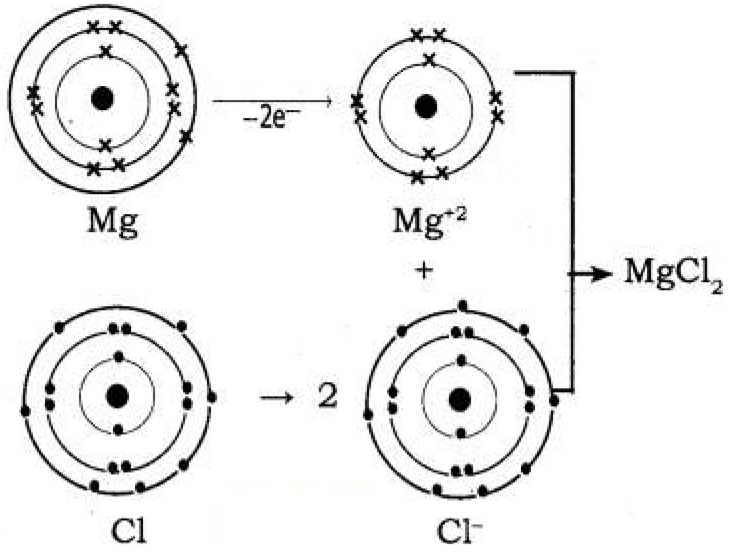


Bond formation of $MgCl_2$:
Mg (Z = 12), $1s^2\ 2s^2\ 2p^6\ 3s^2$ it loses two of its valence electron and became Mg^{2+} with inert gas configuration Neon.

The chlorine accept one electron in its valence shell and because Cl^- ion with Ar electron configuration.
$Mg + Cl_2 \rightarrow Mg^{2+} + 2\ Cl^- \rightarrow MgCl_2$

Magnesium cation and two chlorides are attracted by strong electro static force to form $MgCl_2$ crystals.
Mg = 12,

Electronic configuration: $1s^2\ 2s^2\ 2p^6\ 3s^2$
Mg^{+2}:
Electronic configuration: $1s^2\ 2s^2\ 2p^6\ 3s^0$
$Cl = 17$, $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$
Cl^-:
Electronic configuration: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$



Question 43.

Which bond is stronger σ or π? Why?

Answer:
σ bond is stronger than π bond. A sigma bond is formed by head on overlapping of orbital is more effective. Hence it is stronger bond. But pi bonds are formed by sidewise overlapping of orbitals. The sidewise overlapping of orbitals is less effective than head on overlapping. Hence it is a weaker bond.

Question 44.

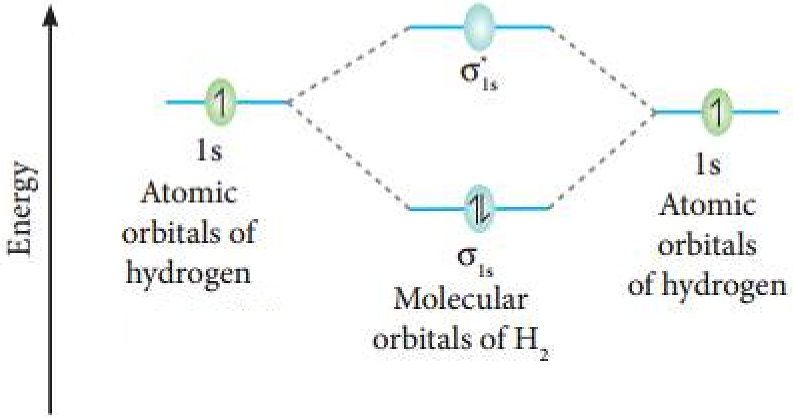
Define bond energy.

Answer:
The bond enthalpy is defined as the minimum amount of energy required to

break one mole of a particular bond in molecules in their gaseous state. The unit of bond enthalpy is kJ mol^{-1}.

Question 45.
Hydrogen gas is diatomic where as inert gases are monoatomic – Explain on the basis of MO theory.

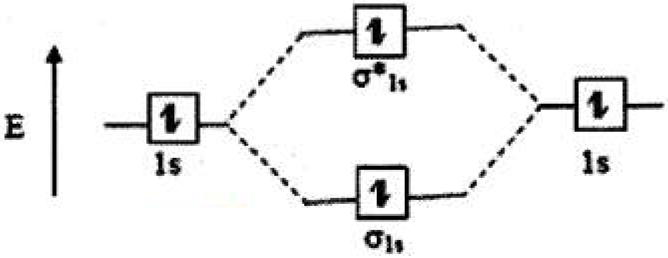
Answer:
The molecular orbital electronic configuration of hydrogen molecule is (σ_{1s}^2). The molecular orbital energy level diagram of H_2 molecule is given in



Here, $N_2 = 2$, $N_a = 0$

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

He_2: $\sigma_{1s}^2\ \sigma_{1s}^{*2}$
The molecular orbital energy level diagram of He_2 (hypothetical) is given in



Here, N_b = 2 and N_a = 2
Bond order = $\frac{N_b - N_a}{2} = \frac{2-2}{2}$ = 0

As the bond order for He_2 comes out to formed between two hydrogen atoms. But as the bond order of helium is zero, there is no bond between helium atoms and hence it is mono atomic.

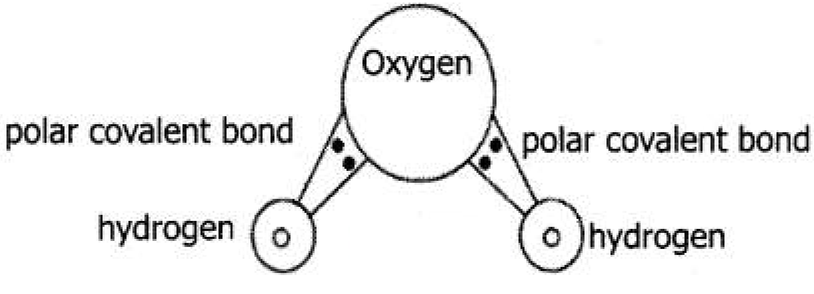
Result:
As the bond order of H_2 molecule is one, it is diatomic and a single bond is formed between two hydrogen atoms. But as the bond order of helium is zero, there is no bond between helium atoms and hence it is mono atomic.

Question 46.
What is the Polar Covalent bond? Explain with example.

Answer:
Polar covalent bond is a chemical bond in which the electrons required to form a bond is unequally shared between two atoms. The atom which is more electronegative attracts more electrons from the bonded pair than the other atom. As a result there is a slight separation of charges in a molecule in which more electronegative atom (comparatively) carries a slight negative charge and less electronegative atom carries a positive charge. The bonds formed between two atoms have a permanent electric dipole.

In water (H_2O) molecule, covalent bond exists between Hydrogen and Oxygen. Being more electronegative Oxygen carries negative charge and Hydrogen carries positive charge. In a water molecule Oxygen carries negative charge (anionic in nature) and hydrogen's carries positive charge (cationic in nature) which forms a polar covalent bond.

The size of an oxygen atom is comparatively higher than a hydrogen atom, hence it polarizes the molecule towards itself i.e., it attracts shared pair of bonding electrons towards itself and makes the bond to be more polarized. Hydrogen which is comparatively a small sized cation makes the bond to be polarized better.



Question 47.
considering x-axis as molecular axis which out of the following will form a sigma bond.

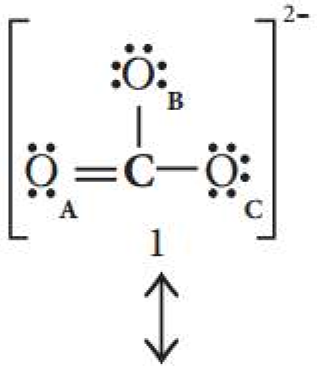
i) 1s and $2p_y$
ii) $2p_x$ and $2p_y$
iii) $2p_x$ and $2p_z$
iv) 1s and $2p_z$

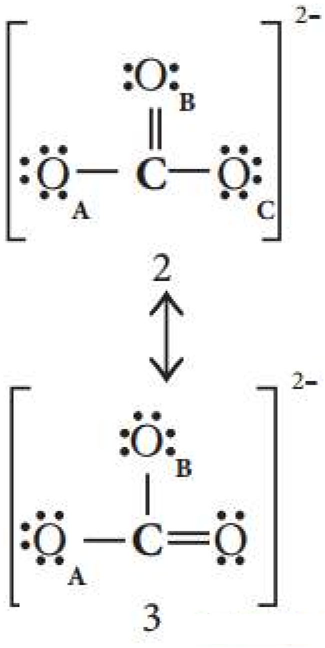
Answer:
i) 1s and $2p_y$: No sigma bond
ii) $2p_x$ and $2p_y$: sigma bond
iii) $2p_x$ and $2p_z$: No sigma bond
iv) 1s and $2p_z$: No sigma bond

Question 48.
Explain resonance with reference to carbonate ion.

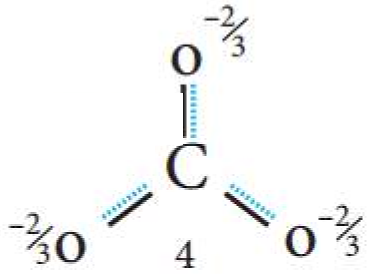
Answer:
It is evident from the experimental results that all carbon – oxygen bonds in carbonate ions are equivalent. The actual structure of the molecules is said to be resonance hybrid, an average of these three resonance forms.

It is important to note that carbonate ion does not change from one structure to another and vice versa. is not possible to picturise the reasonance hybrid by drawing a single Lewis structure. However, the following structure gives a qualitative idea about the correct structure.





(b) Resonance structure of CO_3^{2-}:

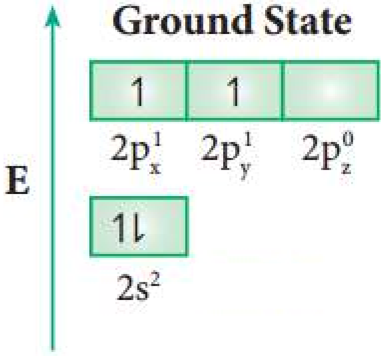


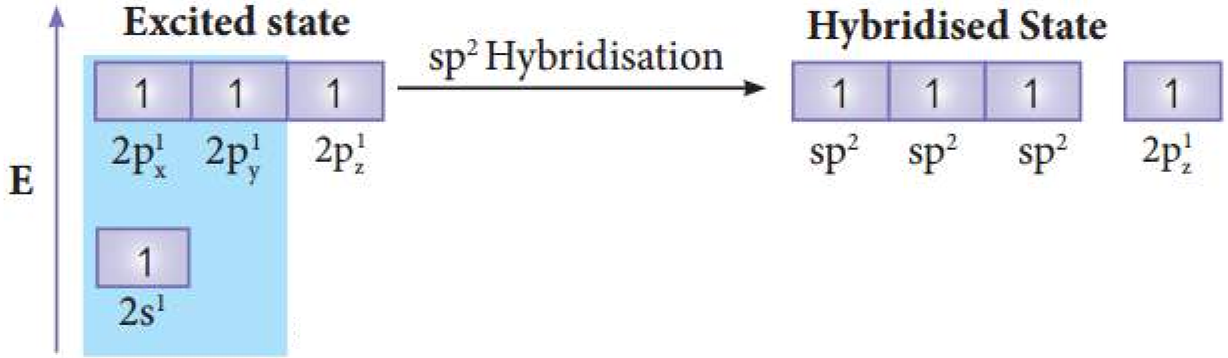
Resonance Hybrid structure of CO_3^{2-}:
It is found that the energy of the resonance hybrid (structure 4) is lower than that of all possible canonical structures (Structure 1, 2 & 3). The difference in energy between structure 1 or 2 or 3, (most stable canonical structure) and structure 4 (resonance hybrid) is called resonance energy.

Question 49.
Explain the bond formation in ethylene and acetylene.

Answer:
Bonding in ethylene:
The bonding in ethylene can be explained using hybridization concept. The molecular formula of ethylene is C_2H_4. The valency of carbon is 4. The electronic configuration of valence shell of carbon in ground state is [He]

$2s^2\ 2p_x^1\ 2p_y^1\ 2p_z^0$. To satisfy the valency of carbon promote an electron from 2s orbital to $2p_z$ orbital in the excited state.





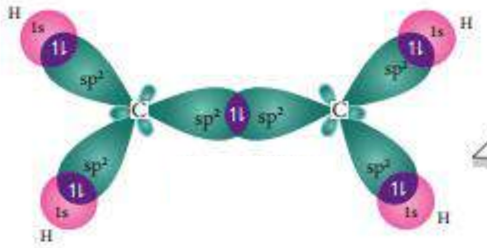
In ethylene both the carbon atoms undergoes sp^2 hybridisation involving 2s, $2p_x$, and $2p_y$, orbitals, resulting in three equivalent sp^2 hybridised orbitals lying in the xy plane at an angle of 120° to each other. The unhybridised $2p_z$ orbital lies perpendicular to the xy plane.

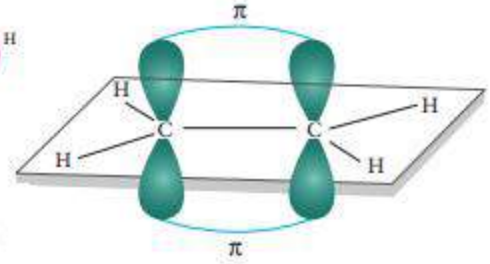
Formation of sigma bond:

One of the sp^2 hybridised orbitals of each carbon lying on the molecular axis (x-axis) linearly overlaps with each other resulting in the formation a C-C sigma bond. Other two sp^2 hybridised orbitals of both carbons linearly overlap with the four is orbitals of four hydrogen atoms leading to the formation of two C-H sigma bonds on each carbon.

Formation of sigma bond:

The unhybridized $2p_z$ orbital of both carbon atoms can overlap only sideways as they are not in the molecular axis. This lateral overlap results in the formation of a pi bond between the two carbon atoms as shown in the figure.

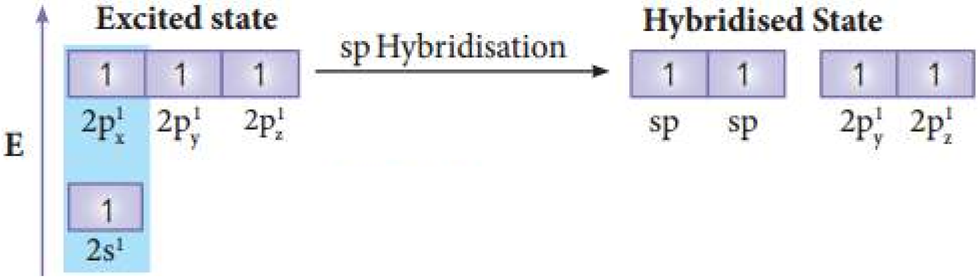




Bonding in acetylene :

Similar to ethylene, the bonding in acetylene can also be explained using hybridisation concept. The molecular formula of acetylene is C_2H_2. The electronic configuration of valence shell of carbon in ground state is [He] $2s^2\ 2p_x^1\ 2p_y^1\ 2p_z^0$. To satisfy the valency of carbon promote an electron from 2s orbital to 2pz orbital in the excited state.

In acetylene molecule, both the carbon atoms are in sp hybridized state. The 2s and $2p_x$ orbitals, resulting in two equivalent sp hybridized orbitals lying in a straight line along the molecular axis (x-axis). The unhybridized $2p_y$ and $2p_z$ orbitals lie perpendicular to the molecular axis.



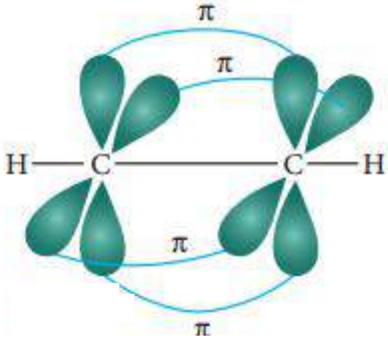
Formation of sigma bond:

One of the two sp hybridized orbitals of each carbon lineraly overlaps with each other resulting in the formation a C – C sigma bond. The other sp hybridized orbitals of both carbons linearly overlap with the two 1s orbitals of two hydrogen atoms leading to the formation of one C – H sigma bonds on each carbon.

Formation of pi bond :

The unhybridized $2p_y$ and $2p_z$ orbitals of each carbon overlap sideways. This lateral overlap results in the formation of two pi bonds ($p_y - p_y$ and $p_z - p_z$)

between the two carbon atoms as shown in the figure.



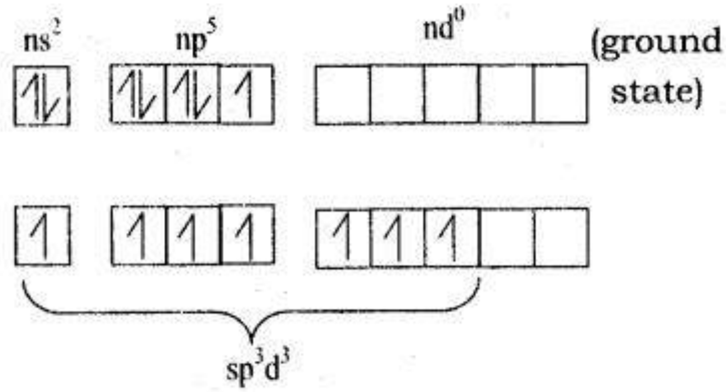
Question 50.
What type of hybridisations are possible in the following geometries?
a) octahedral b) tetrahedral c) square planar

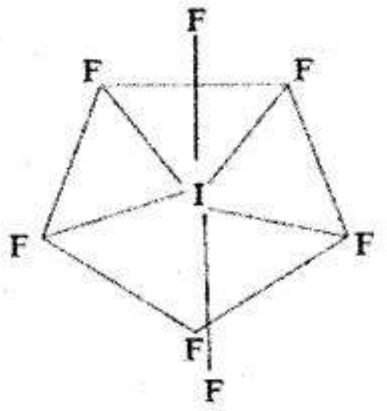
Answer:
a) octahedral: sp^3d^2
b) tetrahedral: sp^3
c) square planar: dsp^2

Question 51.
Explain VSEPR theory. Applying this theory to predict the shapes of IF_7 and SF_6.

Answer:
Lewis concept of structure of molecules deals with the relative position of atoms in the molecules and sharing of electron pairs between them. However, we cannot predict the shape of the molecule using Lewis concept. Lewis theory in combination with VSEPR theory will be useful in predicting the shape of molecules.

IF_7:
Iodine has 7 valence electrons in the valence shell. In excited state it has 6 valency electrons by 1st and 2nd excited state & under sp^3d^2, hybridization and combines with 7 Fluorine to get pentagonal bipyramidal shape. There are no lone pairs.
$I = ns^2\ np^5\ nd^0$



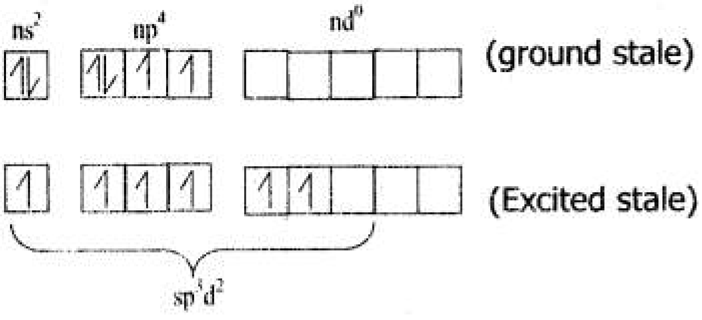


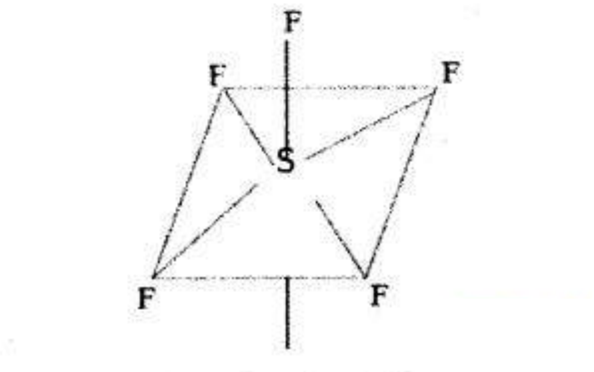
pentagonal bipyramidal

SF$_6$:

Sulphar attain six valence electron in 1st and 2nd excited states undergoes sp^{3}d^2 hybridization and combines with six ‘F’ atoms, as there no lone pair electrons it geometry in octahedral.

S = 16 = ns^2 np^4 nd^0

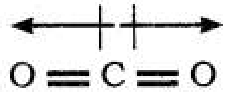




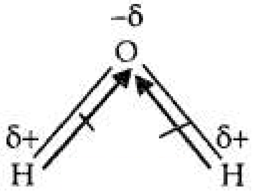
Octahedral

Question 52.
CO_2 and H_2O both are triatomic molecule but their dipole moment values are different. Why?

Answer:



Sum of the dipole moment are cancelled.



Water is ‘v’ shape sum of the dipole moments are not equal to zero.

Question 53.
Which one of the following has highest bond order?
(i) N_2
(ii) N_2^+
(iii) N_2^-

Answer:
(i) N_2
$N_2 = 14$
$\sigma_{1s}^2 \sigma_{1s}^{*2} \sigma_{2s}^2 \sigma_{2s}^{*2} \pi_{2py}^2 \pi_{2pz}^2 \pi_{2px}^2$
Bond order = 6/2 = 3

(ii) N_2^+

$\sigma_{1s}^2\ \sigma_{1s}^{*2}\ \sigma_{2s}^2\ \sigma_{2s}^{*2}\ \pi_{2py}^2\ \pi_{2pz}^2\ \pi_{2px}^1$
Bond order = 5/2 = 2.5

(iii) N_2^-

$\sigma_{1s}^2\ \sigma_{1s}^{*2}\ \sigma_{2s}^2\ \sigma_{2s}^{*2}\ \pi_{2py}^2\ \pi_{2pz}^2\ \pi_{2px}^{*1}$
Bond order = 5/2 = 2.5
The highest bond order is N_2

Question 54.
Explain the covalent character in ionic bond.

Answer:
Like the partial ionic character in covalent compounds, ionic compounds show partial covalent character. For example, the ionic compound, lithium chloride shows covalent character and is soluble in organic solvents such as ethanol.

The partial covalent character in ionic compounds can be explained on the basis of a phenomenon called polarisation. We know that in an ionic compound, there is an electrostatic attractive force between the cation and anion. The positively charged cation attracts the valence electrons of anion while repelling the nucleus.

This causes a distortion in the electron cloud of the anion and its electron density shift towards the cation, which results in some sharing of the valence electrons between these ions. Thus, a partial covalent character is developed between them. This phenomenon is called polarisation.

The ability of a cation to polarise an anion is called its polarising ability and the tendency of an anion to get polarised is called its polarisability.

Question 55.
Describe Fajan's rule.

Answer:
(i) To show greater covalent character, both the cation and anion should have high charge on them. Higher the positive charge on the cation, greater will be the attraction on the electron cloud of the anion. Similarly higher the magnitude of negative charge on the anion, greater is its polarisabiity. Hence, the increase in charge on cation or in anion increases the covalent character.

Let us consider three ionic compounds aluminum chloride, magnesium chloride and sodium chloride. Since the charge of the cation increase in the order $Na^+ < Mg^{2+} < Al^{3+}$ the covalent character also follows the same order $NaCl < MgCl_2 < AlCl_3$.

(ii) The smaller cation and larger anion show greater covalent character due to the greater extent of polarisation. Lithium chloride is more covalent than sodium chloride. The size of Li^+ is smaller than Na^+ and hence the polarizing power of Li^+ is more. Lithium iodide is more covalent than lithium chloride as the size of I^- is larger than the Cl^-. Hence I^- will be more polarized than Cl^- by the cation, Li^+.

(iii) Cations having ns^2 np^6 nd^{10} configuration show greater polarizing power than the cations with ns^2 np^6 configuration. Hence, they show greater covalent character. CuCl is more covalent than NaCl. Compared to Na^+ (1.13 Å). Cu^+(0.6 Å) is small and have $3s^2$ $3p^6$ $3d^{10}$ configuration.
Electronic configuration of Cu^+: [Ar] $3s^2$, $3p^6$, $3d^{10}$
Electronic Configuration of Na^+: [He] $2s^2$, $2p^6$.