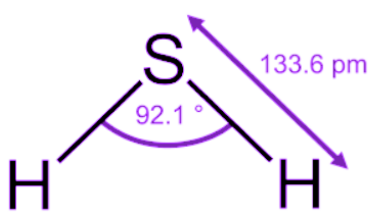
Class 11 Chemical Bonding and Molecular Structure Important Questions with Answers

Short Answer Type Questions

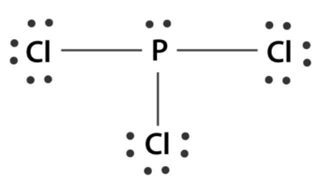
1. Explain the non linear shape of H_2S and non planar shape of PCl_3 using valence shell electron pair repulsion theory.

Answer.

- The main atom in H_2S is S, which has two lone pairs. These lone pairs cause repulsion and displace the H-S bond, resulting in a non-linear shape.



- PCl_3 has a trigonal planar structure. P has three single bonds and one lone pair (pair of unshared electrons). Each chlorine atom has a single 3p orbital that is completely occupied. The overlap of a phosphorus sp^3 hybrid orbital with a singly occupied chlorine 3p orbital results in the formation of P–Cl bonds. Three lone pairs are held by each Cl atom.



2. Using molecular orbital theory, compare the bond energy and magnetic character of O_2^+ and O_2^- species.

Answer.

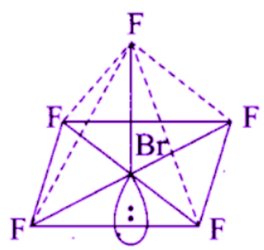
The electronic configurations of O_2^+ and O_2^- species are as follows:

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

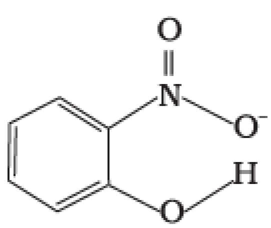
In O_2^+ the bond order is (10 – 5)/2 = 2.5
In O_2^- the bond order is (10 – 7)/2 = 1.5
Bond dissociation energy is directly proportional to bond order, and unpaired electrons determine paramagnetic character. Both O_2^+ and O_2^- have high dissociation energy and are paramagnetic.

3. Explain the shape of BrF_5.

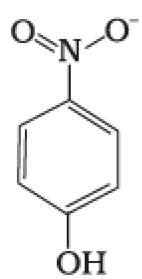
Answer.
In BrF_5 the central atom Br is surrounded by five bonded pairs and one lone pair. This forms the shape of square pyramidal.



4. Structures of molecules of two compounds are given below:



(I)



(II)

(a) Which of the two compounds will have intermolecular hydrogen bonding and which compound is expected to show intramolecular hydrogen bonding.

(b) The melting point of a compound depends on, among other things, the extent of hydrogen bonding. On this basis explain which of the above two compounds will show higher melting point.

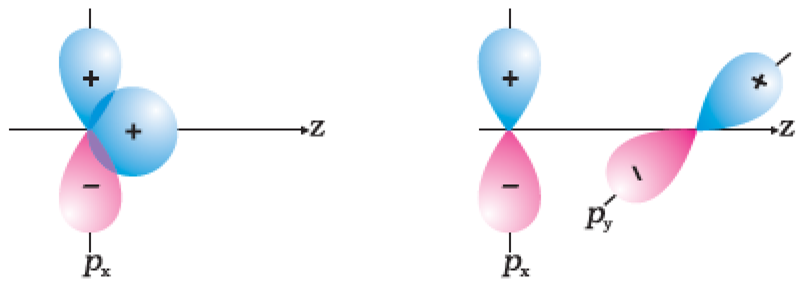
(c) Solubility of compounds in water depends on power to form hydrogen bonds with water. Which of the above compounds will form a hydrogen bond with water easily and be more soluble in it.

Answer.
(a) Since the NO_2 and OH groups in compound (I) are close together, intramolecular hydrogen bonding will form (II). Compound (II) will show intermolecular hydrogen bonding.

(b) Since it forms intramolecular hydrogen bonds, compound (II) has a higher melting point. As a result, more and more molecules are linked together via hydrogen bond formation.

(c) Due to intramolecular hydrogen bonding, compound (I) cannot form hydrogen bonds with water and is thus less soluble in it, whereas compound (II) can form hydrogen bonds with water more easily and is thus more soluble in water.

5. Why does type of overlap given in the following figure not result in bond formation?



Answer.
- In the first figure, the ++ overlap equals the +- overlap, so these cancel out and the net overlap is zero.
- Since the two orbitals are perpendicular to each other in the second figure, no overlap is possible.

6. Explain why PCl_5 is trigonal bipyramidal whereas IF_5 is square pyramidal.

Answer.
P is surrounded by 5 bond pairs and no lone pairs in PCl_5, whereas iodine atom is surrounded by 5 bond pairs and one lone pair in IF_5, so the shape of PCl_5 is trigonal bipyramidal and IF_5 is square pyramidal

7. In both water and dimethyl ether ($CH_3–O–CH_3$), oxygen atom is central atom, and has the same hybridization, yet they have different bond angles. Which one has a greater bond angle? Give reason.

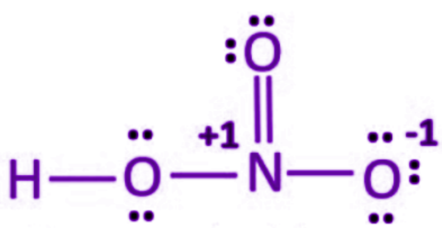
Answer.

The bond angle of dimethyl ether will be greater. More repulsion will exist between bond pairs of CH_3 groups attached in ether than between bond pairs of hydrogen atoms attached to oxygen in the water. The carbon of CH_3 in ether is attached to three hydrogen atoms via bonds, and the electron pair of these bonds contribute to the electronic charge density on the carbon atom. As a result, the repulsion between two CH_3 groups will be greater than that between two hydrogen atoms.

8. Write Lewis structure of the following compounds and show a formal charge on each atom. HNO_2, NO_2, H_2SO_4

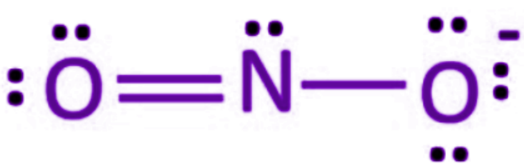
Answer.

- The Lewis structure of HNO_3 is-



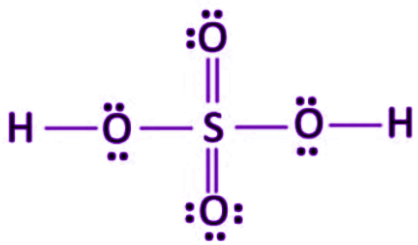
Formal charge = Valence Electrons – Unbonded Electrons – ½ Bonded Electrons
Formal charge on O that has double bond = 6 – 4 –½ (4) = 0
Formal charge on O that is attached to H atom = 6 – 4 –½ (4) = 0
Formal charge on O that has single bond = 6 – 6 –½ (2) = – 1
Formal charge on H = 1 – 0 – ½ (2) = 0
Formal charge on N = 5 – 0 – ½ (8) = +1

- The Lewis structure of NO_2 is-



Formal charge = Valence Electrons – Unbonded Electrons – ½ Bonded Electrons
Formal charge on O that has double bond = 6 – 4 –½ (4) = 0
Formal charge on O that has single bond = 6 – 6 –½ (2) = – 1
Formal charge on N = 5 – 2 – ½ (6) = 0

- The Lewis structure of H_2SO_4 is-



Formal charge = Valence Electrons – Unbonded Electrons – ½ Bonded Electrons
Formal charge on O that has double bond = 6 – 4 –½ (4) = 0
Formal charge on O that has single bond = 6 – 4 –½ (4) = 0
Formal charge on H = 1 – 0 – ½ (2) = 0
Formal charge on S = 6 – 0 – ½ (12) = 0

9. The energy of σ2pz molecular orbital is greater than π2px and π2py molecular orbitals in nitrogen molecule. Write the complete sequence of energy levels in the increasing order of energy in the molecule. Compare the relative stability and the magnetic behaviour of the following species: N_2, N_2^+, N_2^-, N_2^{2+}

Answer.

(a) N_2 molecule has electronic configuration-
$\sigma 1s^2, \sigma{*}1s^2, \sigma 2s^2, \sigma{*}2s^2, \pi 2p_x^2 = \pi 2p_y^2, \sigma 2p_z^2$
Here, $N_b = 10$, $N_a = 4$
Hence, Bond Order = ½ ($N_b – N_a$) = ½ (10 – 4) = 3
The presence of no unpaired electron indicates it to be diamagnetic.

(b) N_2^+ molecule has electronic configuration-
$\sigma 1s^2, \sigma{*}1s^2, \sigma 2s^2, \sigma{*}2s^2, \pi 2p_x^2 = \pi 2p_y^2, \sigma 2p_z^1$
Here, $N_b = 9$, $N_a = 4$
Hence, Bond Order = ½ ($N_b – N_a$) = ½ (9 – 4) = 2.5
The presence of 1 unpaired electron indicates it to be paramagnetic.

(c) N_2^- molecule has electronic configuration-
$\sigma 1s^2, \sigma{*}1s^2, \sigma 2s^2, \sigma{*}2s^2, \pi 2p_x^2 = \pi 2p_y^2, \sigma 2p_z^2, \pi{*}2p_x^1$
Here, $N_b = 10$, $N_a = 5$
Hence, Bond Order = ½ ($N_b – N_a$) = ½ (10 – 5) = 2.5
The presence of 1 unpaired electron indicates it to be paramagnetic.

(d) N_2^{2+} molecule has electronic configuration-
$\sigma 1s^2$, $\sigma * 1s^2$, $\sigma 2s^2$, $\sigma * 2s^2$, $\pi 2p_x^2 = \pi 2p_y^2$
Here, $N_b = 8$, $N_a = 4$
Hence, Bond Order = ½ ($N_b - N_a$) = ½ (8 – 4) = 2
The presence of no unpaired electron indicates it to be diamagnetic

Since bond dissociation energies are directly proportional to bond orders, the dissociation energies of these molecular species in the order are also proportional.
$N_2 > N_2^- = N_2^+ > N_2^{+2}$
In the above order, the greater the bond dissociation energy, the greater the stability of these species.

10. What is the effect of the following processes on the bond order in N_2 and O_2?
(i) $N_2 \rightarrow N_2^+ + e^-$
(ii) $O_2 \rightarrow O_2^+ + e^-$

Answer.
(i) $N_2 \rightarrow N_2^+ + e^-$
The bond order in N_2 is 3 while that in N_2^+ is 2.5. This indicates that the bond order decreases.

(ii) $O_2 \rightarrow O_2^+ + e^-$
The bond order in O_2 is 2 while that in O_2^+ is 2.5. This indicates that the bond order increases.

11. Give reasons for the following:

(i) Covalent bonds are directional bonds while ionic bonds are nondirectional.
(ii) Water molecule has bent structure whereas carbon dioxide molecule is linear.
(iii) Ethyne molecule is linear.

Answer.
(i) A covalent bond is formed by the overlapping of half-filled atomic orbitals with definite directions, i.e., shared electron pair/pairs are localised between two atoms. As a result, a covalent bond is also known as a directional bond. Since each ion in an ionic compound has an influence in all directions, it is surrounded by a number of oppositely charged ions with no definite direction and, therefore, is non-directional.

(ii) The central oxygen atom in water is sp^3 hybridised, whereas the central carbon atom in CO_2 is sp-hybridised. The net dipole moment of CO_2 is zero, whereas H_2O has a significant value. This demonstrates that CO_2 has a linear structure, whereas water has a bent structure.

(iii) Each carbon atom in ethyne is sp-hybridized, resulting in a linear structure.

12. What is an ionic bond? With two suitable examples explain the difference between an ionic and a covalent bond?

Answer.

Ionic bonds are chemical bonds formed between two atoms as a result of the transfer of one or more electrons from one atom to the other. Such a bond is only possible between atoms of different characteristics, with one atom having a tendency to lose electrons and the other atom having a tendency to accept electrons.

Distinctive features:

(i) Ionic bonds can form between dissimilar atoms, such as electropositive and electronegative atoms, whereas covalent bonds can form between similar and dissimilar atoms.

(ii) An ionic bond is neither rigid nor directional. It does not exhibit isomerism, whereas a covalent bond is rigid and directional, causing space isomerism.

13. Arrange the following bonds in order of increasing ionic character giving reason.

N – H, F – H, C – H and 0 – H.

Answer.

When there is a sufficient difference in the electronegativity of the two atoms, the ionic character is observed in a covalent bond.

Ionic character ∝ Electronegativity difference.

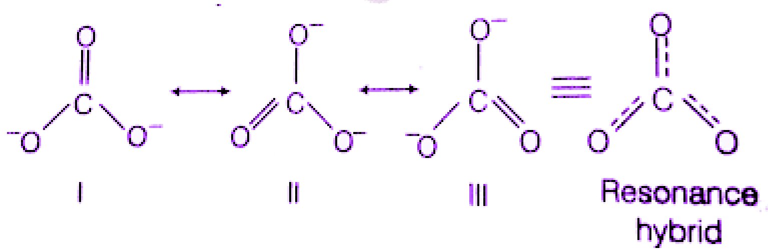
The following is an order of increasing ionic character.

C – H < N – H < O – H < F – H

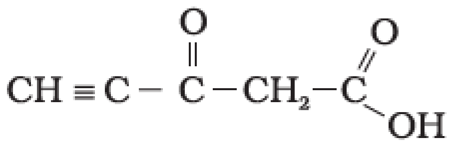
14. Explain why CO_2^{2-} ion cannot be represented by a single Lewis structure. How can it be best represented?

Answer.

In the carbonate ion CO_3^{2-}. The lengths of the three C to O bonds are all the same. A single Lewis structure cannot demonstrate this. The ion is a composite of three different structures.



15. Predict the hybridization of each carbon in the molecule of organic compound given below. Also indicate the total number of sigma and pi bonds in this molecule.



Answer.

There are a total of 5 carbon atoms in the given structure:

- 2are sp hybridised and linked through a triple bond.
- 2are sp^2 hybridised and linked through double bonds to O atoms.
- 1is sp^3 hybridised and linked to two carbon atoms and two H atoms through single bonds.

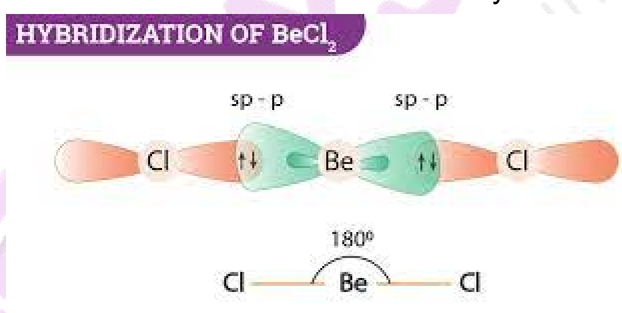
There are 11σ bonds and 4 π bonds in the molecule.

16. Group the following as linear and non-linear molecules:

H_2O, HOCl, $BeCl_2$, Cl_2O

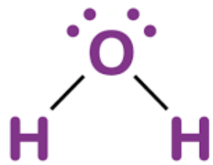
Answer.

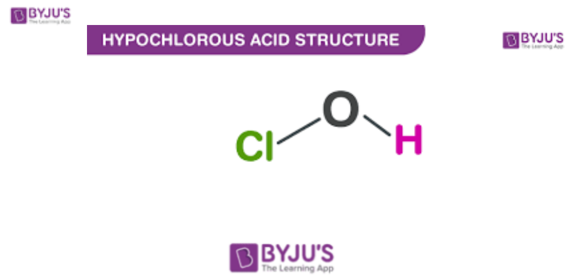
Only $BeCl_2$ is linear because the central atom O is surrounded by two lone pairs in the others.

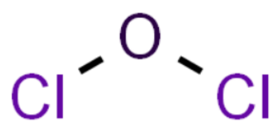


Molecules are non-linear due to lone pair – lone pair repulsion.

H_2O, HOCl, Cl_2O are non-linear molecules.







17. Elements X, Y and Z have 4, 5 and 7 valence electrons respectively.

(i) Write the molecular formula of the compounds formed by these elements individually with hydrogen.
(ii) Which of these compounds will have the highest dipole moment?

Answer.
(i) The molecular formula of the compounds are as follows:

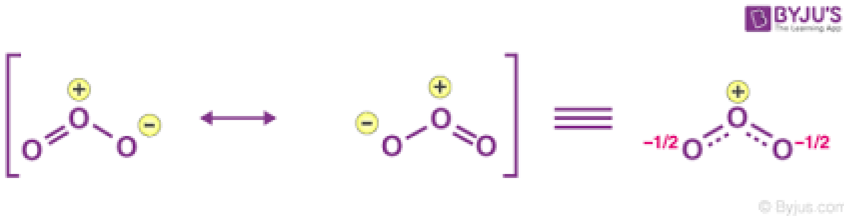
- XH_4
- YH_3
- ZH_1

(ii) X,Y, and Z each have 4,5 and 7 electrons. These elements are from the second period and the 14th, 15th, and 17th groups. The electronegativity of elements increases from group 1 to group 17.
As a result, H – Z will have the greatest dipole moment.

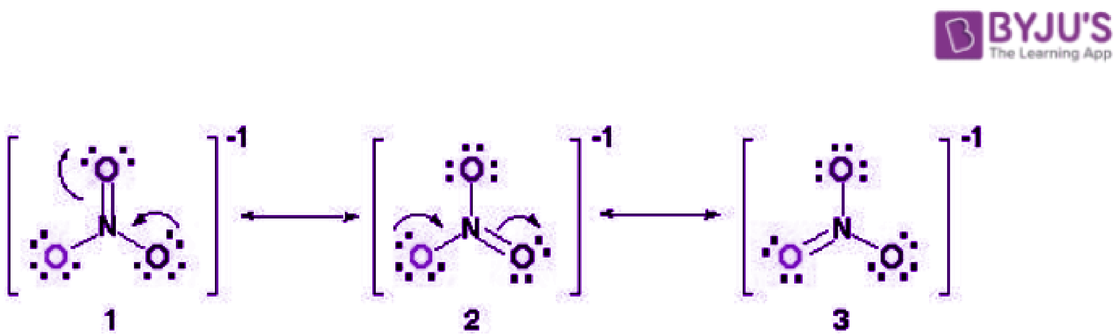
18. Draw the resonating structure of

(i) Ozone molecule
(ii) Nitrate ion

Answer.
(i) Ozone molecule



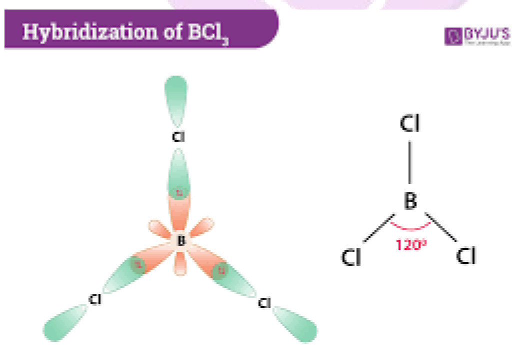
(ii) Nitrate ion



19. Predict the shapes of the following molecules on the basis of hybridization.
BCl_3, CH_4, CO_2, NH_3

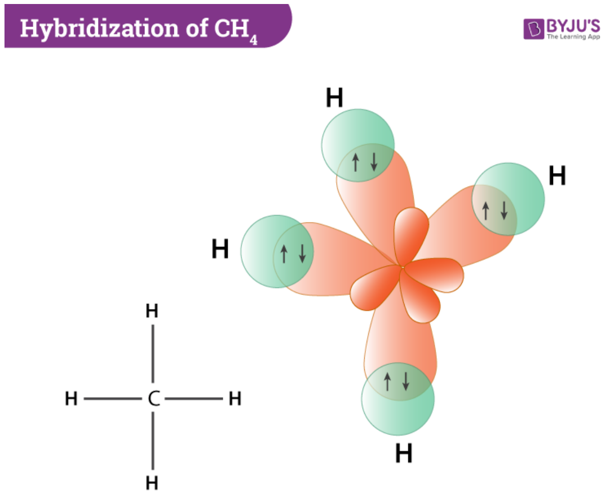
Answer.

- BCl_3 has sp^2 hybridization and trigonal planar structure.

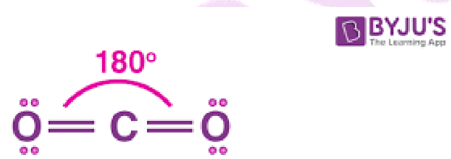


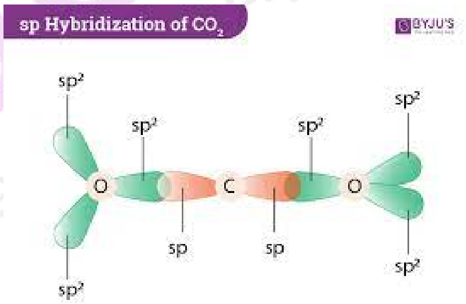
Trigonal planar structure of BCl_3

- CH_4 has sp^3 hybridization and tetrahedral structure.

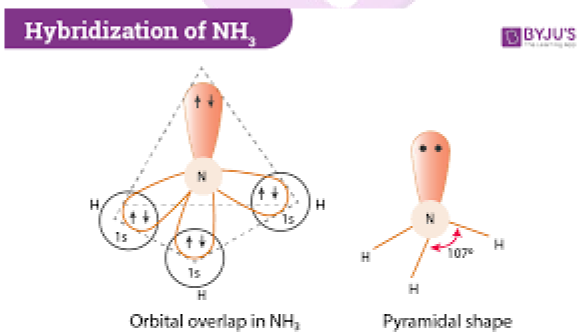


- CO_2 has sp hybridization and linear structure.





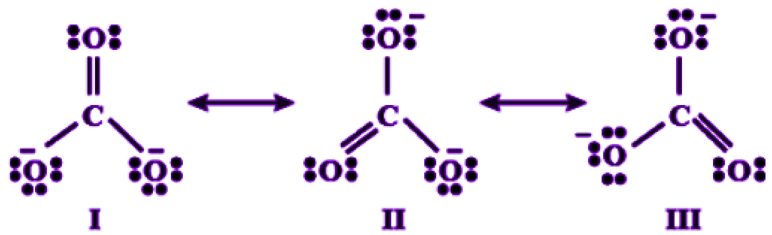
- NH_3 has sp hybridization and pyramidal structure.



20. All the C-O bonds in carbonate ion (CO_3^{2-}) are equal in length. Explain.

Answer.

Carbon is bonded to three oxygen atoms in carbonate ion. It has double bonds with two oxygen atoms and a single bond with one oxygen. Since bonds are not fixed and show resonance, all C – O bonds are the same length.



21. What is meant by the term average bond enthalpy? Why is there a difference in bond enthalpy of O – H bond in ethanol (C_2H-OH) and water?

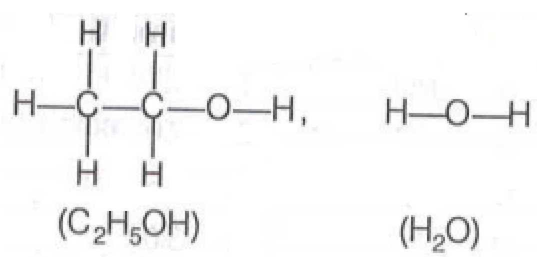
Answer.
Average Bond Enthalpy is calculated by dividing total bond dissociation enthalpy by the number of bonds broken.

All identical bonds in a molecule do not have the same bond enthalpies, for example, in water (H_2O), there are two O – H bonds, but when the first O – H bond breaks, the second O – H bond changes due to charge. As a result, average bond enthalpy is used in polyatomic molecules and is calculated by dividing total bond dissociation enthalpy by the number of bonds broken.

$H_2O \rightarrow H + OH$; $\Delta_a H_1 = 502$ KJ/mol
$OH \rightarrow H + O$; $\Delta_b H_2 = 427$ KJ/mol

Average Bond Enthalpy = (502 + 427)/2 = 464.5 KJ/mol.

Due to the different electronic environment around the oxygen atom, the bond enthalpies of O – H in C_2H_5OH and H_2O differ.



In ethanol, O – H is attached to the carbon atom, whereas in water, O – H is attached to the hydrogen atom.

Matching Type Questions

1. Match the species in Column I with the type of hybrid orbitals in Column II.

Column I	Column II
(i) SF_4	(a) $sp^3\ d^2$
(ii) IF_5	(b) $d^2\ sp^3$
(iii) NO_2^+	(c) sp^3d
(iv) NH_4^+	(d) sp^3
	(e) sp

Answer.

Column I	Column II
(i) SF_4	(c) sp^3d
(ii) IF_5	(a) sp^3 d
(iii) NO_2^+	(e) sp
(iv) NH_4^+	(d) sp^3

2. Match the species in Column I with the geometry/shape in Column II.

Column I	Column II
(i) H_3O^+	(a) Linear
(ii) $HC \equiv CH$	(b) Angular
(iii) ClO_2^-	(c) Tetrahedral
(iv) NH_4^+	(d) Trigonal bipyramidal
	(e) Pyramidal

Answer.

Column I	Column II
(i) H_3O^+	(e) Pyramidal
(ii) HC ≡ CH	(a) Linear
(iii) ClO_2^-	(b) Angular
(iv) NH_4^+	(c) Tetrahedral

3. Match the species in Column I with the bond order in Column II.

Column I	Column II
(i) NO	(a) 1.5
(ii) CO	(b) 2.0
(iii) O_2^-	(c) 2.5
(iv) O_2	(d) 3.0

Answer.

Column I	Column II
(i) NO	(c) 2.5
(ii) CO	(d) 3.0
(iii) O_2^-	(a) 1.5
(iv) O_2	(b) 2.0

4. Match the items given in Column I with examples given in Column II.

Column I	Column II
(i) Hydrogen bond	(a) C
(ii) Resonance	(b) LiF

(iii) Ionic Solid	(c) H_2
(iv)Covalent Solid	(d) HF
	(e) O_3

Answer.

Column I	Column II
(i) Hydrogen bond	(d) HF
(ii) Resonance	(e) O_3
(iii) Ionic Solid	(b) LiF
(iv)Covalent Solid	(a) C

5. Match the shape of molecules in Column I with the type of hybridization in Column II.

Column I	Column II
(i) Tetrahedral	(a) sp^2
(ii) Trigonal	(b) sp
(iii) Linear	(c) sp^3

Answer.

Column I	Column II
(i) Tetrahedral	(c) sp^3
(ii) Trigonal	(a) sp^2
(iii) Linear	(b) sp

Assertion and Reason Type Questions

In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

1. Assertion (A): Sodium chloride formed by the action of chlorine gas on sodium metal is a stable compound.
Reason (R): This is because sodium and chloride ions acquire octet in sodium chloride formation.

(i) A and R both are correct, and R is the correct explanation of A.
(ii) A and R both are correct, but R is not the correct explanation of A.
(iii) A is true but R is false.
(iv) A and R both are false.

Answer.
The correct option is (i) A and R both are correct, and R is the correct explanation of A.
Na (2, 8, 1) + Cl (2, 8, 7) → NaCl (2, 8)(2, 8, 8)
Sodium and chloride ions have complete octets in NaCl.
As a result, NaCl is a stable compound.

2. Assertion (A): Though the central atom of both NH_3 and H_2O molecules are sp^3 hybridised, yet H-N-H bond angle is greater than that of H-O-H.
Reason (R): This is because nitrogen atom has one lone pair and oxygen atom has two lone pairs.

(i) A and R both are correct, and R is the correct explanation of A.
(ii) A and R both are correct, but R is not the correct explanation of A.
(iii) A is true but R is false.
(iv) A and R both are false.

Answer.
The correct option is (i) A and R both are correct, and R is the correct explanation of A.
Lone pair has more repulsion than bond pair. Since H_2O has 2 lone pairs, it has a smaller angle.

3. Assertion (A): Among the two O – H bonds in H_20 molecule, the energy required to break the first O-H bond and the other O – H bond is the same.
Reason (R): This is because the electronic environment around oxygen is the same even after breakage of one O – H bond.

(i) A and R both are correct, and R is the correct explanation of A.
(ii) A and R both are correct, but R is not the correct explanation of A.
(iii) A is true but R is false.
(iv) A and R both are false.

Answer.
The correct option is (iv) A and R both are false.
The enthalpy of the bond in H – O – H is not the same for both O – H bonds.

This is because the electronic charge on the oxygen atom changes after breaking one O – H bond

Long Answer Type Questions

1. i) Discuss the significance/ applications of dipole moment.
(ii) Represent diagrammatically the bond moments and the resultant dipole moment in CO_2, NF_3 and $CHCl_3$.

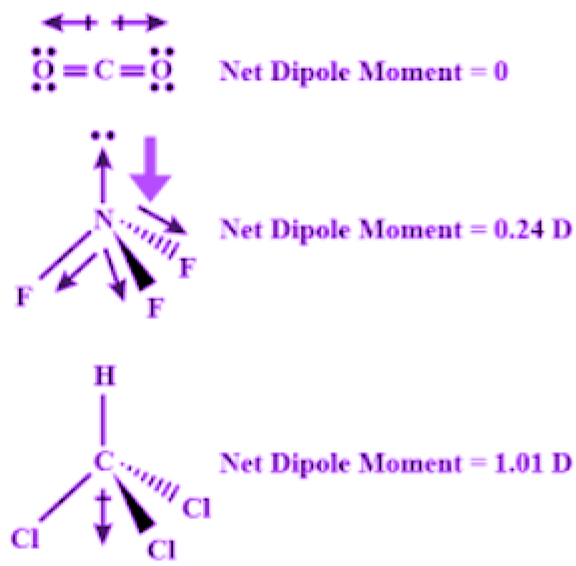
Answer.
Dipole moment (μ) = charge (Q) × separation distance (r). Debye units are commonly used to express dipole moment (D).

(a) It aids in the prediction of the polar and non-polar nature of compounds. Non-polar molecules have no dipole moment, whereas polar molecules have a dipole moment.
(b) It is possible to predict the nature of a chemical bond formed by knowing the electronegativities of the atoms involved in a molecule. The bond will be highly polar if the difference in electronegativities between two atoms is large. An ionic bond is formed when an electron is completely transferred from one atom to another.
The following formula can be used to calculate the percentage of ionic character:

$$\% of ionic character = \frac{(v) observed}{(v) calculated} \times 100$$

(c) It is beneficial to understand the symmetry of the molecule. Despite having two or more polar bonds, symmetrical molecules have zero dipole moment.
In the case of BeF_2, for example, the dipole moment is zero. This is due to the fact that the two equal bond dipoles point in opposite directions and cancel each other out.
(d) Differentiate between cis- and trans-isomers. Dipole moment measurements aid in the differentiation of cis- and trans-isomers because the ds-isomer has a higher dipole moment than the trans isomer.
(e) Distinguish between ortho, meta and para isomers. Dipole moment measurements aid in the differentiation of o-, m-, and p-isomers because the dipole moment of the p-isomer is zero and that of the o-isomers is greater than that of the m-isomer.

(ii) The bond moments and the resultant dipole moment in CO_2, NF_3 and $CHCl_3$.

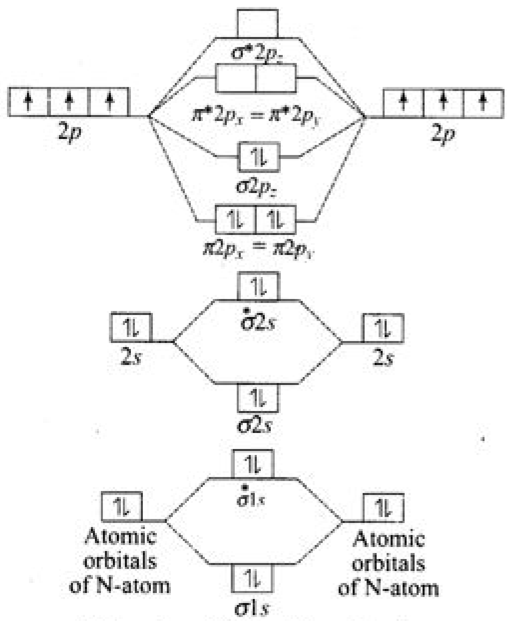


2. Use the molecular orbital energy level diagram to show that N_2 would be expected to have a triple bond, F_2, a single bond and Ne_2, no bond.

Answer.

Formation of N_2 molecule:

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



Molecular orbitals of N_2 molecule

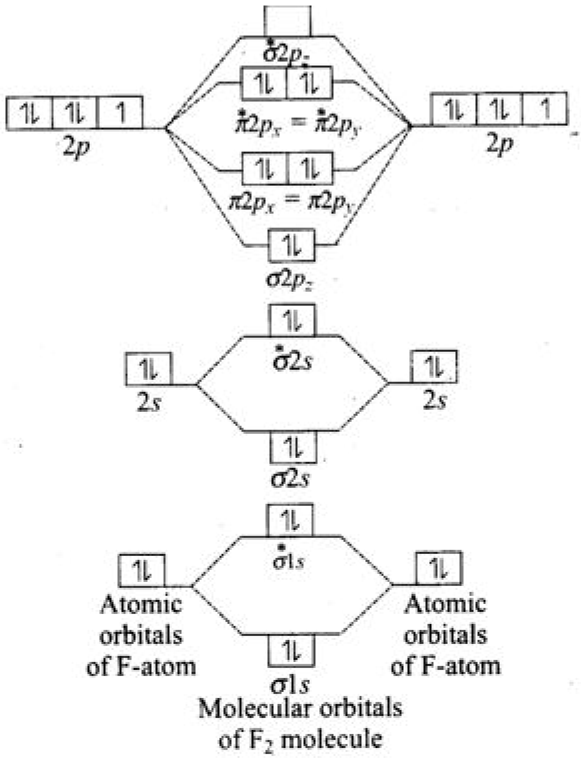
Here, N_b = 10, N_a = 4

Hence, Bond Order = ½ (N_b – N_a) = ½ (10 – 4) = 3

Bond order indicates the number of bonds in diatomic molecule is 3. Hence, the molecule has TripleBond.

Formation of F_2 molecule:

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



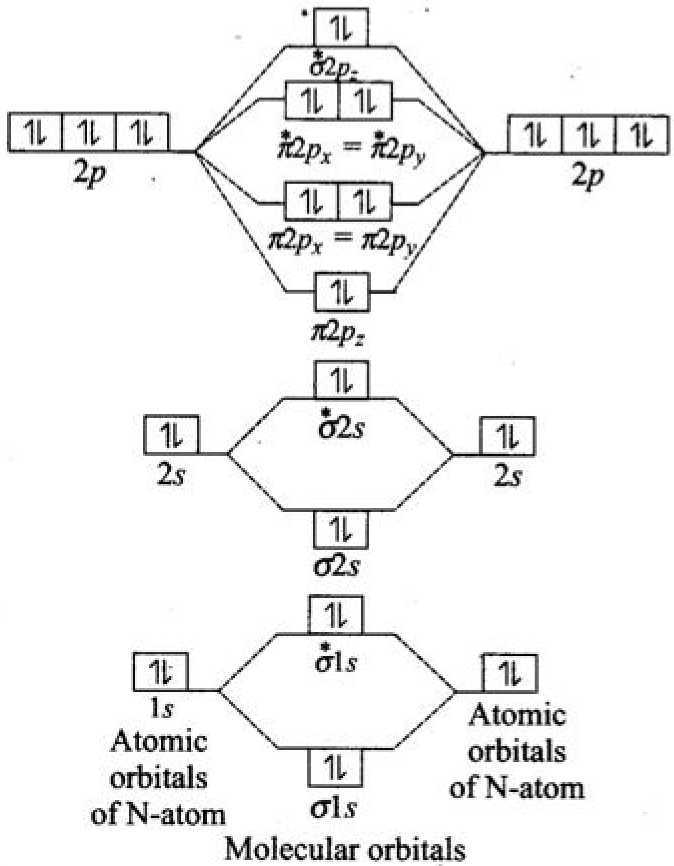
Here, $N_b = 10$, $N_a = 8$

Hence, Bond Order = $\frac{1}{2}(N_b - N_a) = \frac{1}{2}(10 - 8) = 1$

Bond order indicates the number of bonds in diatomic molecule is 1. Hence, the molecule has a Single Bond.

Formation of Ne_2 molecule:

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



Here, N_b = 10, N_a = 10
Hence, Bond Order = ½ (N_b – N_a) = ½ (10 – 10) = 0
Bond order indicates the number of bonds in diatomic molecule is 0. Hence, the molecule has no bond.

3. Briefly describe the valence bond theory of covalent bond formation by taking an example of hydrogen. How can you interpret energy changes taking place in the formation of dihydrogen?

Answer.
Heitler and London proposed the valence bond theory in 1927. Later, in 1931, L. Pauling and J.C. Slater improved and developed it. The valence bond theory is based on knowledge of atomic orbitals and electronic configurations of elements, atomic orbital overlap criteria, and molecule stability.

The key concepts of valence bond theory are as follows:
(i) Atoms retain their identity even after the molecule is formed.
(ii) As the two atoms approach each other, the bond is formed by the interaction of only the valence electrons. The inner electrons are not involved in the formation of the bond.

(iii) Only the valence electrons of each bonded atom lose their identity during bond formation remain unaffected.
(iv) Bond stability is explained by the fact that bond formation is accompanied by the release of energy. At a certain distance between the atoms, the molecule has the least amount of energy. This is known as intemuclear distance. The stronger the bond formed, the greater the decrease in energy.

Consider the following two hydrogen atoms: A and B. Assume they are approaching each other, and their nuclei are N_A and N_B, respectively, and their electrons are e_A and e_B.
Assume that the two atoms are at a great distance from each other and that there is no interaction between them. They are now thought to be approaching each other, and new attractive and repulsive forces begin to operate.

We now understand that attractive forces exist between:

- Nucleus of one atom and its own electron, i.e., $N_A – e_A$ and $N_B – e_B$.
- Nucleus of one atom and electron of another atom $N_A – e_B$ and $N_B – e_A$.

Similarly, repulsive forces emerge between
- two atoms' electrons $e_A – e_B$
- two atoms' nuclei $N_A – N_B$

It has been discovered that the magnitude of the new attractive force is greater than the magnitude of the new repulsive forces. As a result, two atoms approach each other, reducing potential energy. Eventually, the net force of attraction equals the net force of repulsion, and the system acquires the least amount of energy. Two hydrogen atoms are said to be bonded together at this point to form a stable molecule with a bond length of 74pm.

Since the energy is released when the bond between two hydrogen atoms is formed, the hydrogen molecule is more stable than isolated hydrogen atoms. The energy released in this way is known as the bond enthalpy, and it corresponds to the minimum in the figure's curve. In contrast, it takes 435.8kJ of energy to dissociate one mole of H_2 molecule.

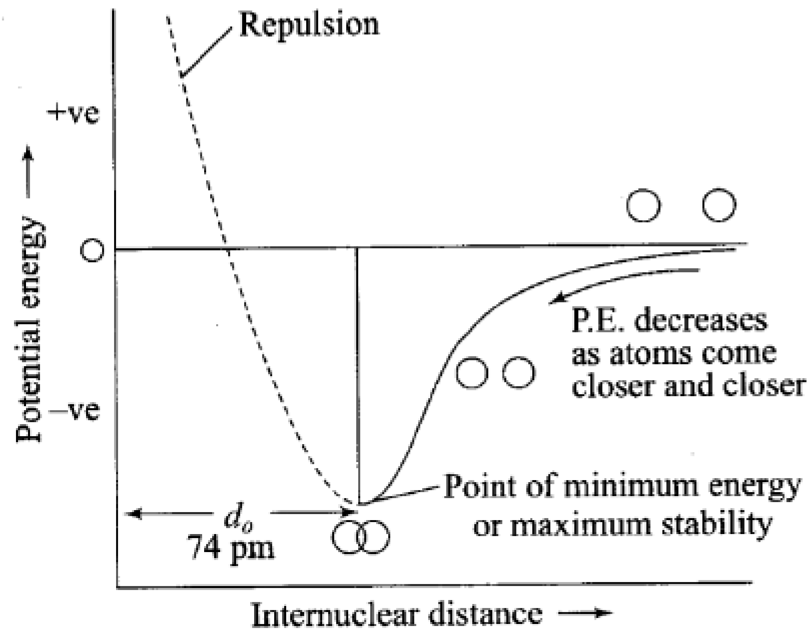


Fig. Variation of potential energy of interaction between two hydrogen atoms

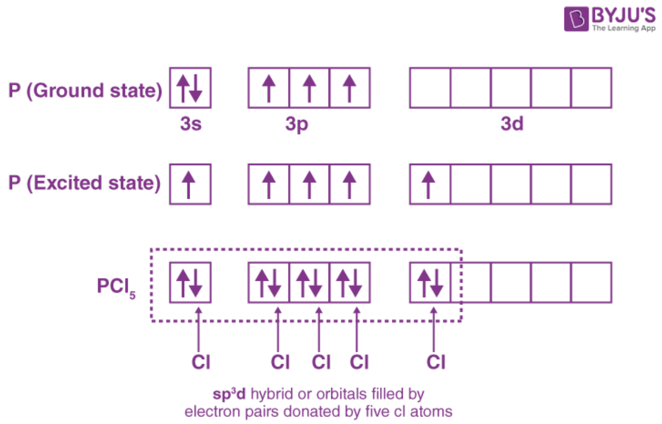
Potential energy curve for the formation of an H_2 molecule as a function of H atom internuclear distance. The curve's minimum corresponds to the most stable state of H_2.

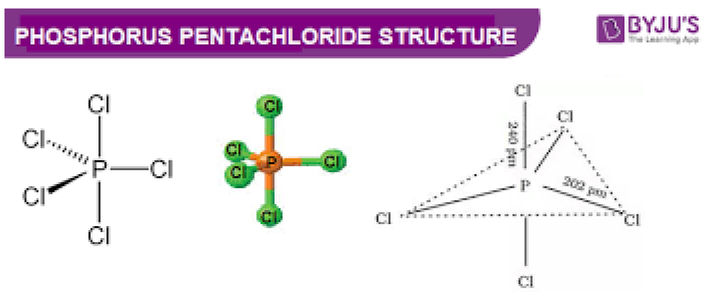
4. Describe hybridization in the case of PCl_5 and SF_6. The axial bonds are longer as compared to equatorial bonds in PCl_5 whereas in SF_6, both axial bonds and equatorial bonds have the same bond length. Explain.

Answer.

The ground state electronic configuration of P (15)- $1s^2\ 2s^2\ 3s^2\ 3p^3\ 3d^0$

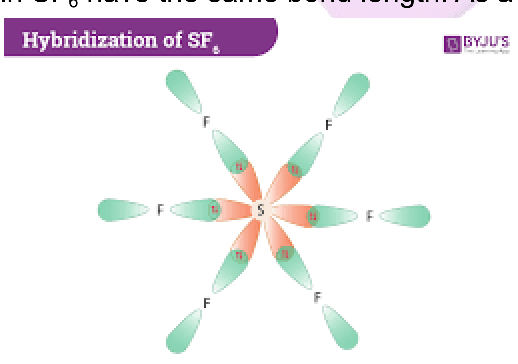
The excited state outer electronic configuration- $1s^2\ 2s^2\ 3s^1\ 3p^3\ 3d^1$





Three P – Cl bonds are equatorial bonds because they are in the same plane and form a 120° angle with each other. The remaining two P – Cl bonds, one above and one below the equatorial plane, form a 90° angle with the plane. These are known as axial bonds. Because axial bond pairs experience more repulsive interaction than equatorial bond pairs, axial bonds have been found to be slightly longer and thus slightly weaker than equatorial bonds, making PCl_5 molecules more reactive.

Since SF_6 has (sp^3d^2) hybridization and an octahedral shape with bonds at 90° angles, all of the bonds in SF_6 have the same bond length. As a result, the repulsion between all of the bonds is equal.



Octahedral structure of sulphur hexafluoride

5. (i) Discuss the concept of hybridization. What are its different types in a carbon atom?

(ii) What is the type of hybridization of carbon atoms marked with stars?

(i) $\overset{*}{C}H_2 = CH - \overset{O}{\overset{*||}{C}} - O - H$ (ii) $CH_3 - \overset{*}{C}H_2 - OH$

(iii) $CH_3 - CH_2 - \overset{O}{\overset{||}{C^*}} - H$ (iv) $\overset{*}{C}H_3 - CH = CH - CH_3$

(v) $CH_3 - \overset{*}{C} \equiv CH$

Answer.

(i) The term "hybridization" was introduced by Pauling. The atomic orbitals, according to him, combine to form a new set of equivalent orbitals known as hybrid orbitals. In contrast to pure orbitals, hybrid orbitals are used in bond formation. The phenomenon is known as hybridization, which is defined as the process of intermixing orbitals with slightly different energies in order to redistribute their energies, resulting in the formation of a new set of orbitals with equivalent energies and shape.

For example, when one 2s and three 2p-orbitals of carbon hybridise, four new sp3 hybrid orbitals are formed.

The following are the main characteristics of hybridization:

1. The number of hybrid orbitals equals the number of atomic orbitals hybridised.
2. The hybridised orbitals are always energy and shape equivalent.
3. Hybrid orbitals are more effective than pure atomic orbitals at forming stable bonds.
4. These hybrid orbitals are oriented in space in a preferred direction to achieve the least amount of repulsion between electron pairs and thus a stable arrangement.

As a result, the type of hybridization indicates the molecule's geometry.

- In carbon compounds, if carbon is linked to carbon via a triple bond, such as alkynes, triple bonded carbon is sp hybridised.
- In carbon compounds, if carbon is linked to carbon via a double bond (C=C), such as in alkenes, the double-bonded carbon is sp^2 hybridised.
- In carbon compounds, if carbon is linked to carbon via a single bond (C - C), such as alkanes, the carbon is sp^3 hybridised.

(ii) Type of hybridization in the figure:

1. Both atoms have sp^2 hybridization.
2. The marked atom is sp^3 hybridised.
3. The marked atom is sp^2 hybridised.
4. The marked atom is sp^3 hybridised.
5. The marked atom is sp hybridised.

Comprehension given below is followed by some multiple choice questions. Each question has one correct option. Choose the correct option.

Molecular orbitals are formed by the overlap of atomic orbitals. Two atomic orbitals combine to form two molecular orbitals called bonding molecular orbital (BMO) and antibonding molecular orbital (ABMO). Energy of antibonding orbital is raised above the parent atomic orbitals that have combined and the energy of the bonding orbital is lowered than the parent atomic orbitals. Energies of various molecular orbitals for elements hydrogen to nitrogen increase in the order :

σ1s < σ*1s < 1σ2s < σ*2s <(π2px≈π2py > <σ2p$_2$<(π*2px-π*2p,)<σ*2p, and for oxygen and fluorine order of energy of molecular orbitals is given below: σ1s < σ*1s < σ2sσ*2s < σp,(π2px≈π2py) <(π*2px≈π2py)<σ*2pz

Different atomic orbitals of one atom combine with those atomic orbitals of the second atom which have comparable energies and proper orientation. Further, if the overlapping is head on, the molecular orbital is called 'Sigma', (σ) and if the overlap is lateral, the molecular orbital is called 'pi', (π). The molecular orbitals are filled with electrons according to the same rules as followed for filling of atomic orbitals. However, the order for filling is not the same for all molecules or their ions. Bond order is one of the most important parameters to compare the strength of bonds.

6. Which of the following statements is correct?
(i) In the formation of dioxygen from oxygen atoms 10 molecular orbitals will be formed.
(ii) All the molecular orbitals in the dioxygen will be completely filled.
(iii) Total number of bonding molecular orbitals will not be same as total number of antibonding orbitals in dioxygen.
(iv) Number of filled bonding orbitals will be same as number of filled antibonding orbitals.

Answer.
The correct answer is (i) In the formation of dioxygen from oxygen atoms 10 molecular orbitals will be formed.
Oxygen has atomic configuration $1s^2$, $2s^2$, $2p_x^2$ $2p_y^1$ $2p_z^1$, which means 5 orbitals. Two oxygen atoms overlap five atomic orbitals each and thus, forming ten molecular orbitals.

7. Which of the following molecular orbitals has maximum number of nodal planes?
(i) σ∗1s
(ii) σ∗$2p_x$
(iii) π$2p_x$
(iv) π∗$2p_y$

Answer.

The correct answer is (iv) $\pi * 2p_y$

8. Which of the following pair is expected to have the same bond order?
(i) O_2, N_2
(ii) O_2^+, N_2^-
(iii) O_2^-, N_2^+
(iv) O_2^-, N_2^-

Answer.
The correct answer is (ii) O_2^+, N_2^-

9. In which of the following molecules, $\sigma 2p_z$ molecular orbital is filled after $\pi 2p_x$ and $\pi 2p_y$ molecular orbitals?
(i) O_2
(ii) F_2
(iii) N_2
(iv) None of these

Answer.
The correct answer is (iii) N_2.