Chemistry Study Materials for Class 11
(NCERT Questions -Answers of Chapter- 04)
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CHEMICAL BONDING AND MOLECULAR STRUCTURE

Question 4.37: Write the significance of a plus and a minus sign shown in representing the orbitals.

Answer

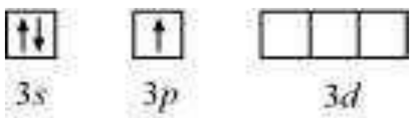
Molecular orbitals are represented by wave functions. A plus sign in an orbital indicates a positive wave function while a minus sign in an orbital represents a negative wave function.

Question 4.38: Describe the hybridisation in case of PCl_5. Why are the axial bonds longer as compared to equatorial bonds?

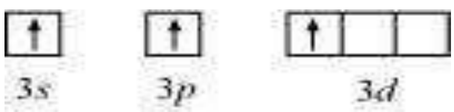
Answer

The ground state and excited state outer electronic configurations of phosphorus (Z = 15) are:

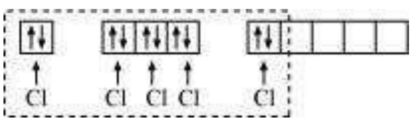
Ground state:



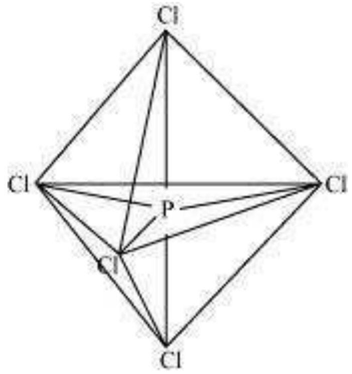
Excited state:



Phosphorus atom is sp^3d hybridized in the excited state. These orbitals are filled by the electron pairs donated by five Cl atoms as:



PCl_5 The five sp^3d hybrid orbitals are directed towards the five corners of the trigonal bipyramidals. Hence, the geometry of PCl_5 can be represented as:



There are five P–Cl sigma bonds in PCl_5. Three P–Cl bonds lie in one plane and make an angle of 120° with each other. These bonds are called equatorial bonds.

The remaining two P–Cl bonds lie above and below the equatorial plane and make an angle of 90° with the plane. These bonds are called axial bonds.

As the axial bond pairs suffer more repulsion from the equatorial bond pairs, axial bonds are slightly longer than equatorial bonds.

Question 4.39: Define hydrogen bond. Is it weaker or stronger than the Vander Waals forces?

Answer

A hydrogen bond is defined as an attractive force acting between the hydrogen attached to an electronegative atom of one molecule and an electronegative atom of a different molecule (may be of the same kind).

Due to a difference between electronegativities, the bond pair between hydrogen and the electronegative atom gets drifted far away from the hydrogen atom. As a result, a hydrogen atom becomes electropositive with respect to the other atom and acquires a positive charge.

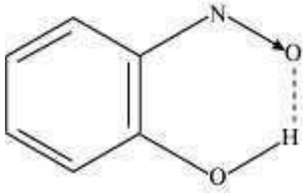
$$4^{\delta} - X^{\delta-} .... H^{\delta+} - X^{\delta-} .... H^{\delta+} - X^{\delta-}$$

The magnitude of H-bonding is maximum in the solid state and minimum in the gaseous state.

There are two types of H-bonds:

(i) Intermolecular H-bond e.g., HF, H_2O etc.

(ii) Intramolecular H-bond e.g., o-nitrophenol



Hydrogen bonds are stronger than Vander Walls forces since hydrogen bonds are regarded as an extreme form of dipole-dipole interaction.

Question 4.40: What is meant by the term bond order? Calculate the bond order of: N_2, O_2, O_2^+ and O_2^-

Answer

Bond order is defined as one half of the difference between the number of electrons present in the bonding and anti-bonding orbitals of a molecule.

If N_a is equal to the number of electrons in an anti-bonding orbital, then N_b is equal to the number of electrons in a bonding orbital.

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

If $N_b > N_a$, then the molecule is said be stable. However, if $N_b \leq N_a$, then the molecule is considered to be unstable.

Bond order of N_2 can be calculated from its electronic configuration as:

$$[\sigma(1s)]^2[\sigma^*(1s)]^2[\sigma(2s)]^2[\sigma^*(2s)]^2[\pi(2p_x)]^2[\pi(2p_y)]^2[\sigma(2p_z)]^2$$

Number of bonding electrons, N_b = 10 Number of anti-bonding electrons, N_a = 4

Bond order of nitrogen molecule $= \frac{1}{2}(10-4) = 3$

There are 16 electrons in a dioxygen molecule, 8 from each oxygen atom.

The electronic configuration of oxygen molecule can be written as:

$$[\sigma-(1s)]^2[\sigma^*(1s)]^2[\sigma(2s)]^2[\sigma^*(2s)]^2[\sigma(1p_z)]^2[\pi(2p_x)]^2[\pi(2p_y)]^2[\pi^*(2p_x)]^1[\pi^*(2p_y)]^1$$

Since the 1*s* orbital of each oxygen atom is not involved in boding, the number of bonding electrons N_b= 8 and the number of anti-bonding electrons N_a.= 4

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

$= \frac{1}{2}(8-4)$

= 2

Hence, the bond order of oxygen molecule is 2.

Similarly, the electronic configuration of O_2^+ can be written as:

$$KK[\sigma(2s)]^2[\sigma^*(2s)]^2[\sigma(2p_z)]^2[\pi(2p_x)]^2[\pi(2p_y)]^2[\pi^*(2p_x)]^1$$

$N_b = 8$ $N_a = 3$

Bond order of $O_2^+ = \frac{1}{2}(8-3)$ = 2.5

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