

2. Explain the formation of co-ordinate covalent bond?
3. Explain s-p overlap with examples?
4. Explain the formation of triple bond in Nitrogen molecule?

(or)

Explain the formation of multiple bond with an example?

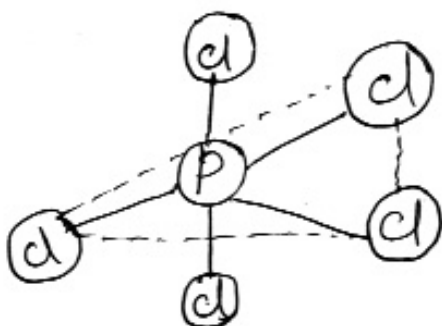
5. Discuss the type of overlaps that are possible with s and p orbitals.

SECTION - IV DIAGRAMS (5 Marks Each)

1. Draw the bond formation of Hydrogen Chloride and Nitrogen molecules in a diagram.
2. Draw the diagram showing the formation of a double bond (oxygen molecule)?
3. Draw the diagram showing the formation of p-p overlap in fluorine molecule.

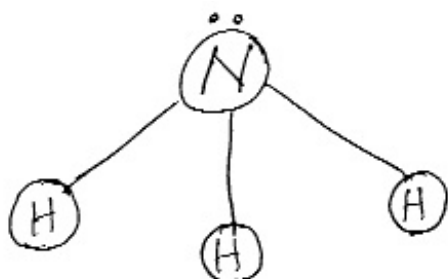
KEY PART - A SECTION - I

1.A (a) Phosphorus Penta Chloride (PCl_5):



- 1) In the vapour state PCl_5 molecule has a "trigonal bi-pyramid" structure.
- 2) Three chlorines and phosphorus lie in one plane.
- 3) One chlorine above the plane and one chlorine below the plane are present.

(b) Ammonia molecule (NH_3):



- 1) Ammonia has a "pyramidal" shape.
- 2) The three hydrogens in one plane and nitrogen above the plane, as shown in the figure.
- 3) Nitrogen has one lone pair of electrons in ammonia.

2.A The strength of the bond depends on extent of overlap. The extent of overlap is maximum in sigma bond and minimum in pi-bond. Hence sigma bond is stronger than

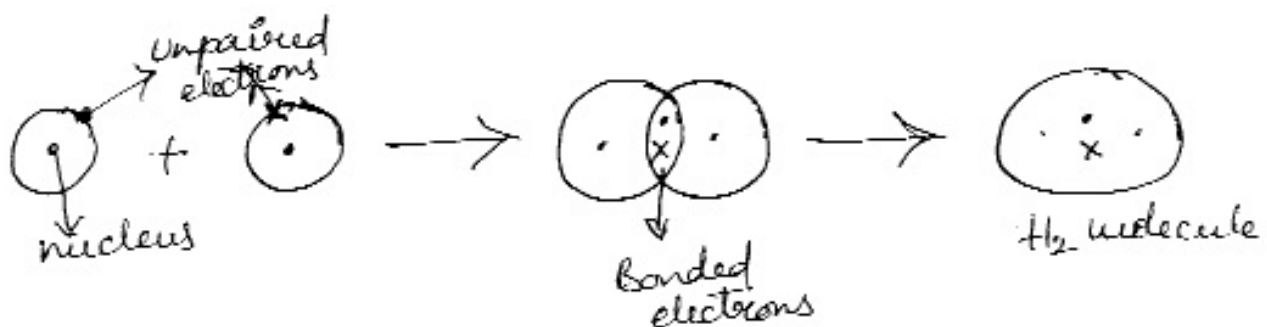
pi-bond.

3.A

Sl.No.	Sigma Bond	Pi - Bond
1	The bond formed by the end-on-end overlap of orbitals of atoms is called sigma bond.	The bond formed by the side-on-overlap of orbitals of atoms is called pi-bond.
2	It has independent existence.	It has no independent existence.
3	It is the strongest bond.	It is the weakest bond.
4	It is formed by the overlapping of i) s-s ii) s-p and iii) p-p orbitals.	It is formed by the overlapping of i) p-p and ii) p-d orbitals.

4.A Bond Formation of H₂ Molecule:

Consider two hydrogen atoms having one unpaired electron, approaching each other. Each atom has one unpaired electron in '1s' orbital. As these two atoms approach each other, 's' orbital gets overlap at the internuclear distance as shown in the figure and thus a hydrogen molecule is formed due to 's-s' overlap.

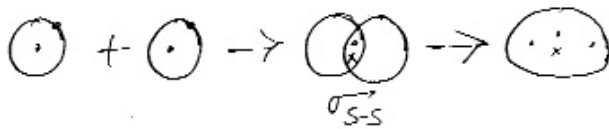


5.A (a) Sigma Bond:

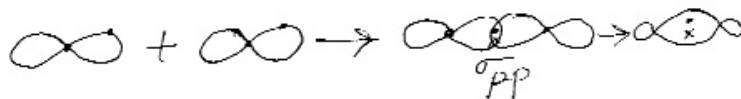
- (1) A strong bond formed by end-on-end overlap of two orbitals is called a "sigma-bond".
- (2) In this type of bond, maximum overlap of orbitals takes place and therefore the bond formed is strong.
- (3) Sigma bond can exist independently.
Eg: Molecules having σ bonds are H₂, HCl, Cl₂ etc.,
- (4) Sigma bond is formed by
 - (i) s-s overlap
 - (ii) s-p overlap and

(iii) p-p overlap.

(i) s-s overlap :



(ii) p-p overlap :



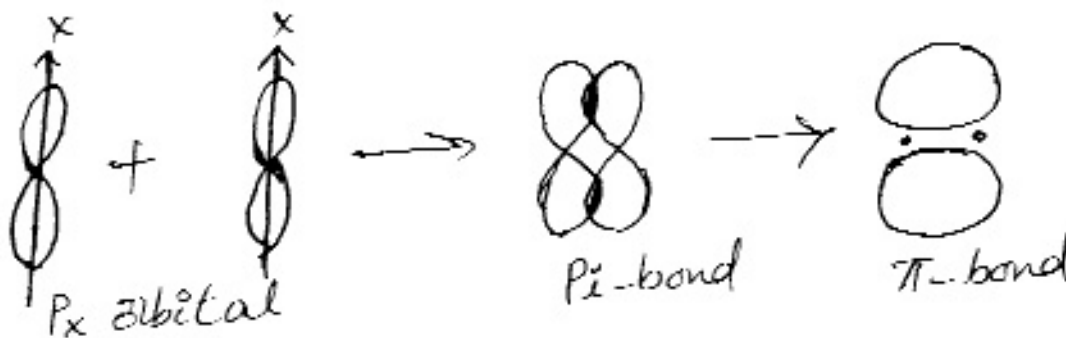
(iii) s-p overlap :



(b) Pi-Bond:

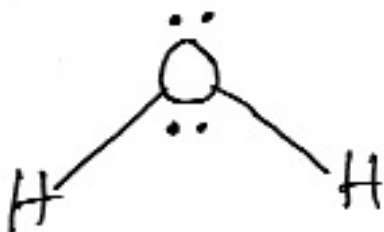
- 1) A weak-bond formed by lateral overlap of two orbitals is called a pi-bond.
- 2) The extent of overlap is much less than in σ -bond.
- 3) It always exists along with a σ -bond.
- 4) It can not exist independently.

Eg: Molecules having π -bond are C_2H_4 , CO_2 , N_4O_2 etc.,

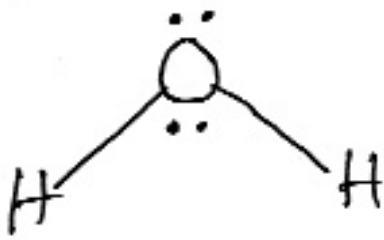


6.A 1. Water Molecule:

- (1) Water molecule is non-linear and has "V"-shape.
- (2) In water molecule, two lone pairs of electrons are present on oxygen atom.



2. PCl_3 molecule:

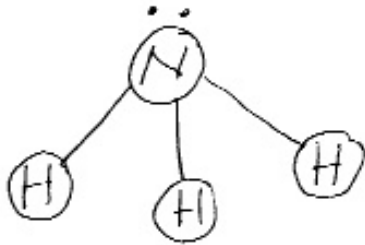


2.A Molecules having pyramidal shape are

- i) ammonia (NH_3)
- ii) phosphorus trichloride (PCl_3)
- iii) phosphine (PH_3)

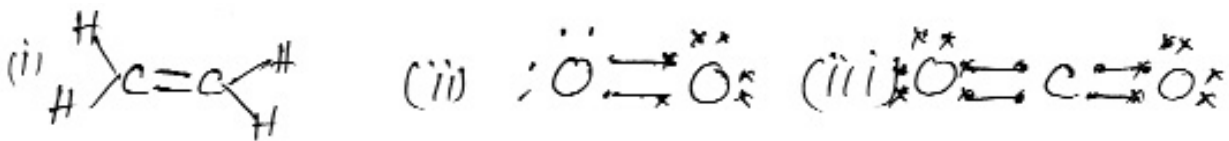
3.A Ammonia molecule:

- 1) NH_3 molecule has a pyramidal structure.
- 2) Three Hydrogens in one plane and nitrogen is above the plane.
- 3) Nitrogen has one lone pair of electrons in ammonia.



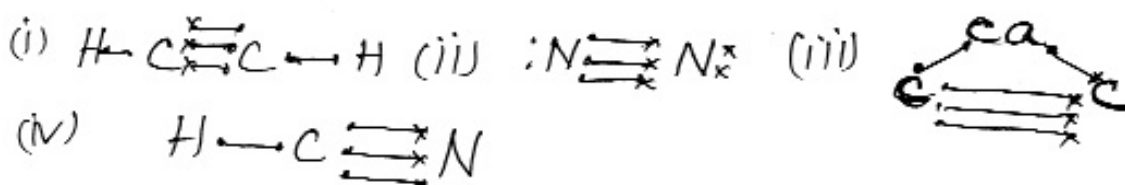
4.A Molecules having a double bond are

- i) ethylene (C_2H_4)
- ii) oxygen (O_2)
- iii) carbon dioxide (CO_2)



5.A Molecules having a triple bond are

- i) acetylene (C_2H_2)
- ii) Nitrogen (N_2)
- iii) Calcium Carbide (CaC_2)
- iv) Hydrogen Cyanide (HCN)



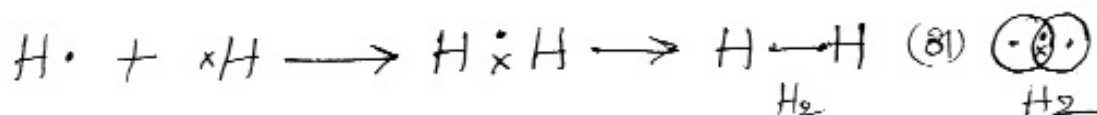
6.A Molecules having p-p overlap are

- (1) Bromine (Br_2)
- (2) Chlorine (Cl_2)
- (3) Fluorine (F_2)
- (4) Oxygen (O_2)

7.A 'p' and 'd' orbitals can form pi-bonds.

8.A The shape of carbon-di-oxide molecule is linear.

9.A The electron dot structure of H_2 molecule is



10.A "Molecules having double and triple covalent bonds are" called as "multiple covalent bonds".

- Eg:**
- 1) Nitrogen molecule ($\text{N} \equiv \text{N}$)
 - 2) Oxygen molecule ($\text{O} = \text{O}$)
 - 3) Hydrogen cyanide molecule ($\text{H} - \text{C} \equiv \text{N}$)

SECTION - III Long Answers

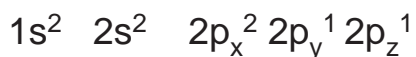
1.A Double Bond:

"The bond formed by sharing of two pairs of electrons between two atoms" is called a "double bond".

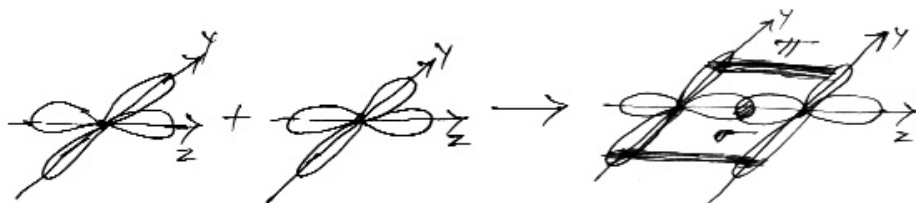
Eg: O_2 , CO_2 , C_2H_4 , etc.,

Formation of Double bond in oxygen molecule:

- (1) Consider the formation of oxygen molecule (O_2)
- (2) The electronic configuration of oxygen is $1s^2 2s^2 2p^4$ ie.



- (3) Oxygen has two unpaired electrons one each in $2p_y$ and $2p_z$ orbitals.
- (4) The $2p_z$ orbital of one oxygen atom overlap with the ' $2p_z$ ' orbital of another oxygen by end-on-end overlap resulting in the formation of a ' σ ' bond.
- (5) Two ' $2p_y$ ' orbitals of two oxygen atoms are parallel to each other, and perpendicular to $2p_z$. So ' $2p_y$ ' orbitals overlap side-ways and form a ' π '-bond.
- (6) Thus oxygen molecule is formed by one sigma bond and one pi-bond and having a double bond.



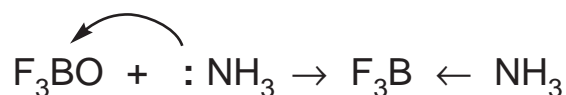
2.A Co-ordinate Covalent Bond:

A chemical bond formed by the sharing of an electron pair, contributed by one of the two combining atoms is called "co-ordinate covalent bond".

Eg: $\text{NH}_3 \text{BF}_3$, NH_4^+ , H_3O^+ etc.,

Formation of Ammonia-Boron Trifluoride molecule:

- (1) Ammonia molecule has pyramidal shape and has a lone pair of electrons on nitrogen.
- (2) Boron Trifluoride (BF_3) molecule has an empty orbital.
- (3) NH_3 molecule donates an electron pair to BF_3 and forms a "co-ordinate covalent bond".
- (4) Co-ordinate covalent bond is designate as " \rightarrow " from donor to acceptor.
- (5) Nitrogen donates its lone pair of electrons and Boron accepts. Thus Ammonia Boron Tri-fluoride molecule is formed by the formation of a "co-ordinate covalent bond".



3.A s-p overlap:

"The overlap of 's' orbital of one atom and 'p' orbital of another atom" is called "s-p overlap".

Eg: HCl , HF , HBr

Formation of HCl molecule:

- (1) Consider the formation of HCl molecule.
- (2) The electronic configuration of hydrogen is ' $1s$ ' and the the electronic configuration of chlorine is $1s^2 2s^2 2p^5 3s^2 3p^5$

Hydrogen : $1s^1$ $\boxed{\uparrow}$

Chlorine : $1s^2 2s^2 2p^6 3s^2 3p^5$

$1s^2$ $2s^2$ $2p^6$



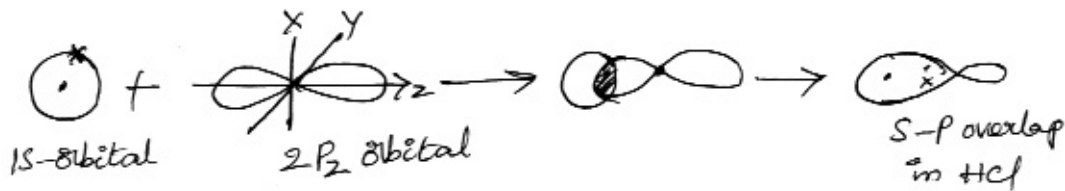
$3s^2$ $3p_x^2$ $3p_y^2$ $3p_z^1$



- (3) Hydrogen atom has one unpaired electron in ' $1s$ ' orbital and chlorine has one unpaired electron in ' $3p_z$ ' orbital.
- (4) When the two atoms approach other, overlap takes place between s and p orbitals at

inter nuclear distance.

- (5) Thus HCl molecules is formed due to s-p overlap.



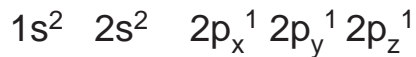
4.A Triple Bond:

"The bond formed by sharing of three pairs of electrons between two atoms", is called "Triple covalent bond".

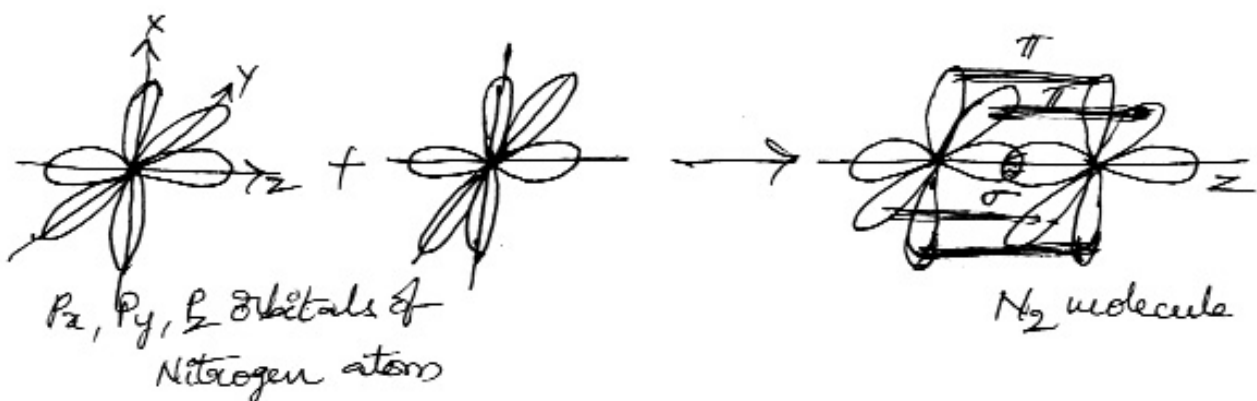
Eg: N_2 , C_2H_2 , HCN etc.,

Formation of a Triple Bond in Nitrogen Molecule:

- (1) The electronic configuration of nitrogen is $N = 7 = 1s^2 2s^2 2p^3 =$



- (2) There are three unpaired electrons, one each in $2p_x$, $2p_y$, $2p_z$ orbitals.
- (3) The two $2p_z$ orbitals of two nitrogen atoms overlap end-on-end to form a sigma (σ) bond.
- (4) The remaining two orbitals $2p_y$ and $2p_x$ are perpendicular to each other, hence these orbitals overlap sideways to give rise to two π -bonds.
- (5) Thus, in nitrogen a triple bond is formed.
- (6) In nitrogen molecule, one sigma bond and two pi bonds are present.



5.A Overlapping with 's' and 'p' orbitals:

Three types of overlaps are possible with 's' and 'p' orbitals. They are

- (i) s-s overlap
- (ii) p-p overlap
- (iii) s-p overlap

- (i) **s-s overlap:** The overlap of 's' orbitals of two atoms is called 's-s' overlap.

Eg: H_2

Formation of H₂ molecule:

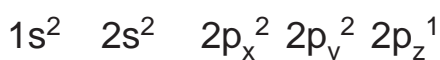
- (1) Consider two hydrogen atoms having one unpaired electron each in '1s' orbital.
- (2) As two hydrogen atoms approach each other, '1s' orbitals of two atoms overlap by end-on-end manner and forms a sigma bond.



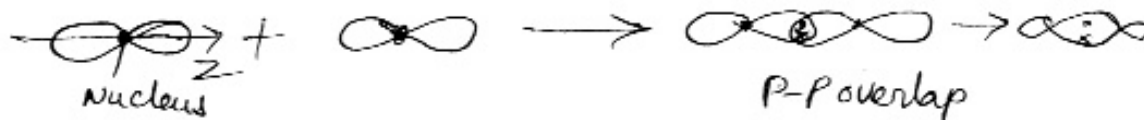
- (ii) **p-p overlap:** The overlap of 'p' orbitals of two atoms is called "p-p overlap".
Eg: F₂, Cl₂, Br₂...

Formation of F₂ molecule:

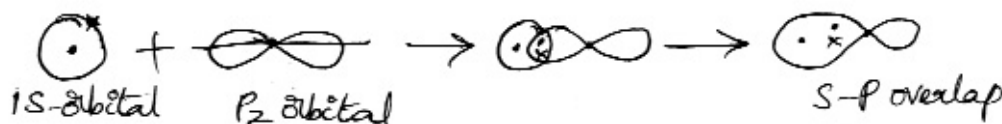
- (1) The electronic configuration of fluorine atom is F = 9 =



- (2) Fluorine atom has one unpaired electron in '2p_z' orbital.
- (3) So, when two fluorine atoms approach each other. Their 2p_z orbitals overlap by end-on-end manner and forms a sigma bond.



- (iii) **s-p overlap:** "The overlap of 's' orbital of one atom and 'p' orbital of another atom" is called "s-p" overlap.
Eg: HCl, HF, HBr



Formation of HCl molecule:

- (1) The electronic configuration of hydrogen and chlorine are 1s¹ and 1s² 2s² 2p⁶ 3s² 3p⁵ respectively.

