

Overlapping

According to modern concept, the covalent bonds are formed by overlapping of atomic orbitals. Here, two half-filled atomic orbitals having electrons with opposite spins, come close together, share some common space and their unpaired electrons get paired up in the shared space. Whole this process is called overlapping. Thus, "The inter-penetration of atomic orbitals to share common space is called overlapping of the atomic orbitals."

Types of Overlapping

Depending upon the type of orbitals involved, the overlapping may be of following types-

(1) s-s Overlapping- when s-orbital of one atom overlaps with that of another atom, then it is called s-s overlapping.

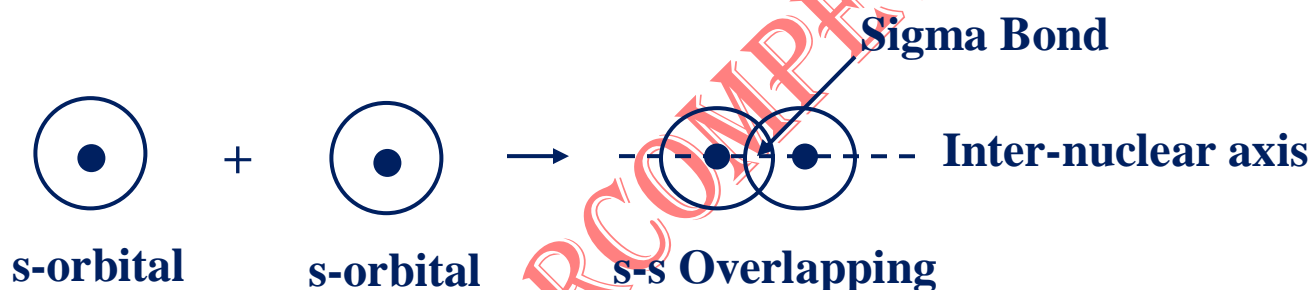


Fig.- s-s Overlapping

The covalent bonds formed in s-s overlapping have maximum electron density between two nuclei and are symmetrical about inter-nuclear axis. Such covalent bonds are called sigma bonds (σ - bonds).

Example - Formation of H₂ molecule

During formation of H₂ molecule, half-filled 1s-orbital of both the hydrogen atoms overlap together to form H-H sigma bond. Here, shared electron pair lies in shared space and provides stability to both the atoms.

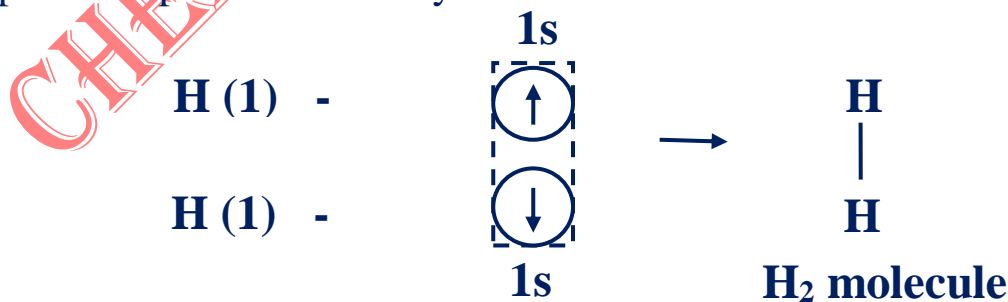


Fig.-Formation of H₂ molecule (schematic)

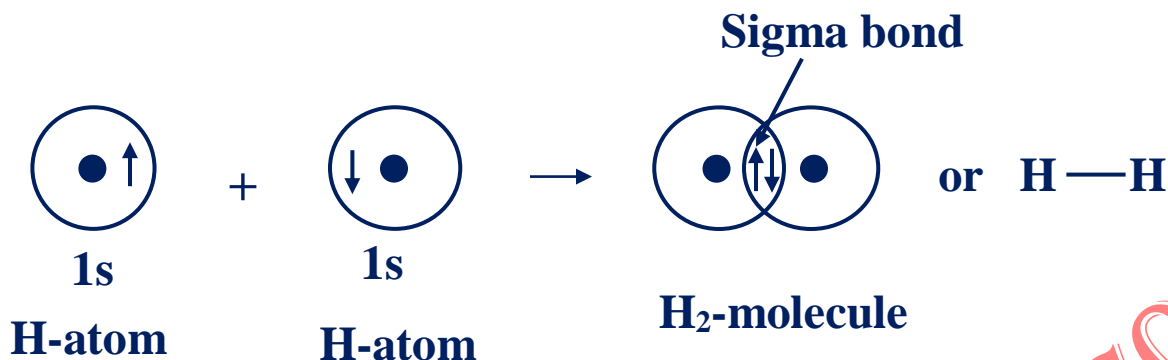


Fig.- Formation of H₂ molecule (diagrammatic)

(2) s-p Overlapping- when s-orbital of one atom overlaps with p-orbital of another atom, then it is called s-p Overlapping.

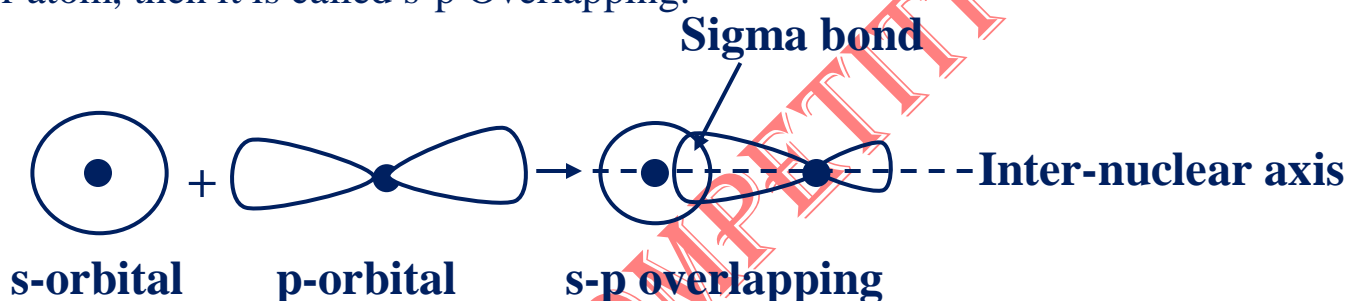


Fig.- s-p overlapping

The covalent bonds formed in s-p overlapping have maximum electron density in between two nuclei and are symmetrical about inter-nuclear axis. Such covalent bonds are called sigma bonds (σ - bonds).

Example- Formation of HF molecule

During formation of HF molecule, half-filled 1s-orbital of hydrogen atom overlaps with half-filled 2p_z-orbital of fluorine atom to form H-F sigma bond. Here, shared electron pair lies in shared space and provides stability to both the atoms.

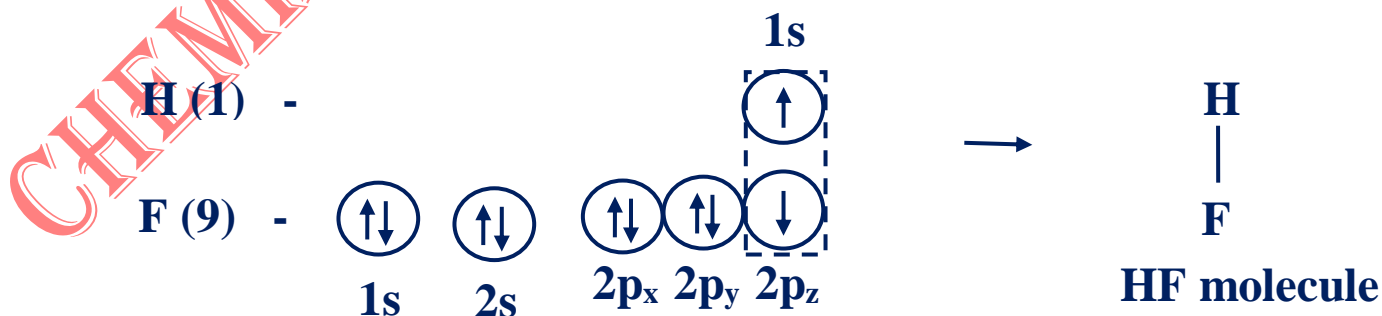


Fig.-Formation of HF molecule (schematic)

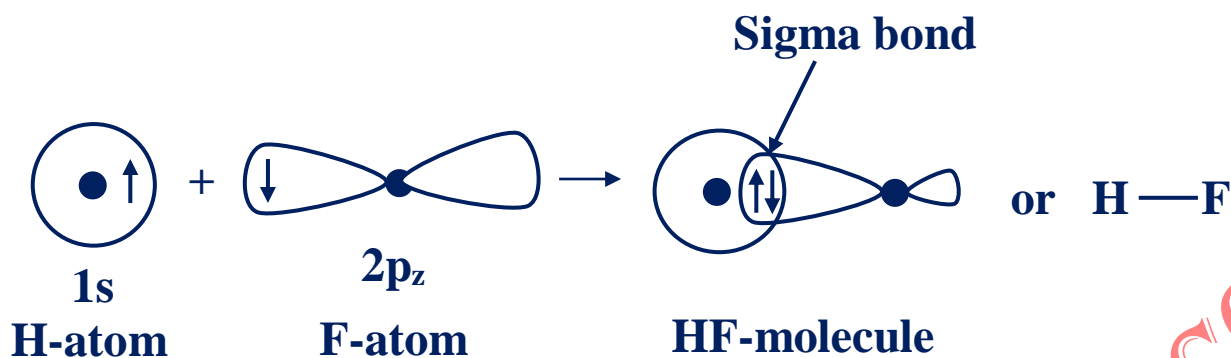


Fig.- Formation of HF molecule (diagrammatic).

(3) p-p Overlapping- when p-orbital of one atom overlaps with that of another atom, then it is called p-p overlapping.

p-p overlapping may be of following two types-

(A) Head-wise or axial p-p overlapping- When two p-orbitals come close together in head-wise manner and overlap, then it is called head-wise or axial p-p overlapping.

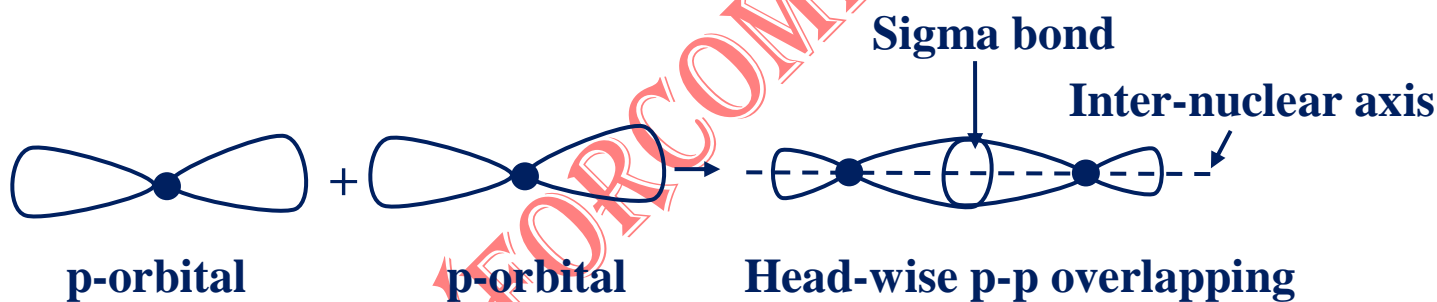


Fig.- Head wise or axial p-p overlapping

The covalent bonds formed in head-wise or axial p-p overlapping have maximum electron density in between two nuclei and are symmetrical about inter-nuclear axis. Such covalent bonds are called sigma bonds (σ - bonds).

Example- Formation of F_2 molecule

During formation of F_2 molecule, half-filled $2p_z$ - orbital of both the fluorine atoms overlap together in head-wise manner to form F-F sigma bond. Here, shared electron pair lies in shared space and provides stability to both the atoms.

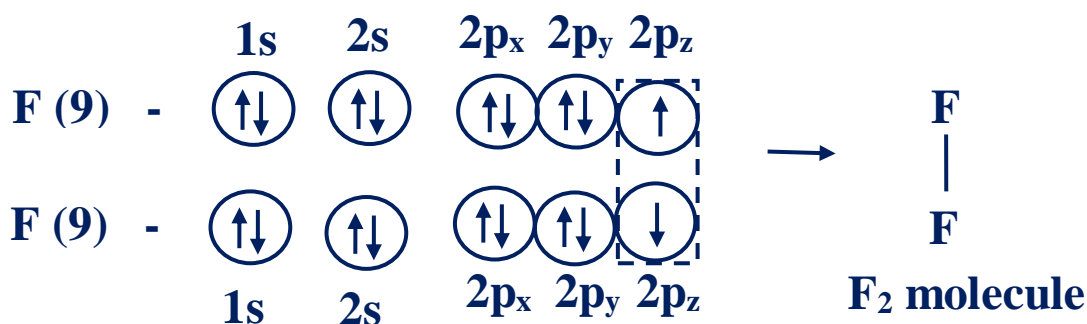


Fig.-Formation of HF molecule (schematic)

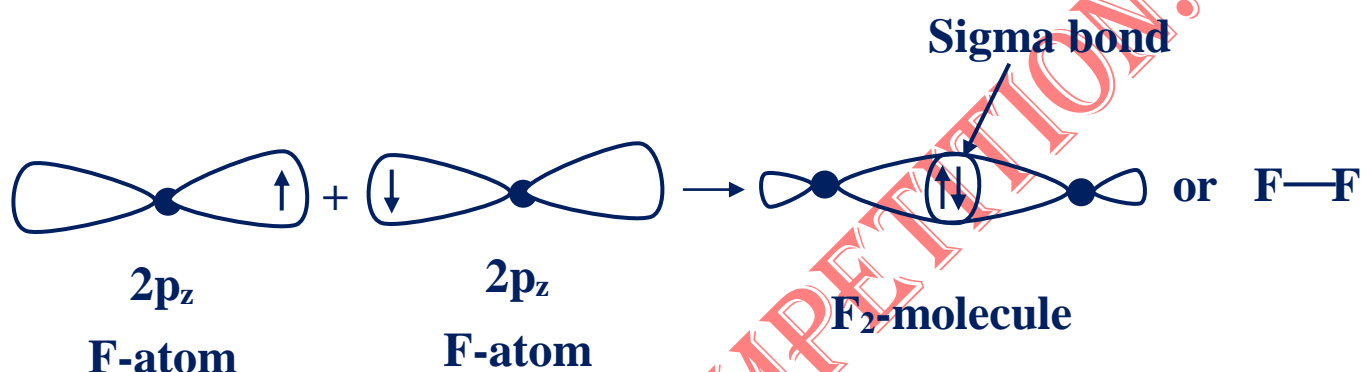


Fig.- Formation of F₂ molecule (diagrammatic)

(B) Side-wise or lateral p-p overlapping- When two p-orbitals come close together in side-wise manner and overlap, then it is called side-wise or lateral p-p overlapping.

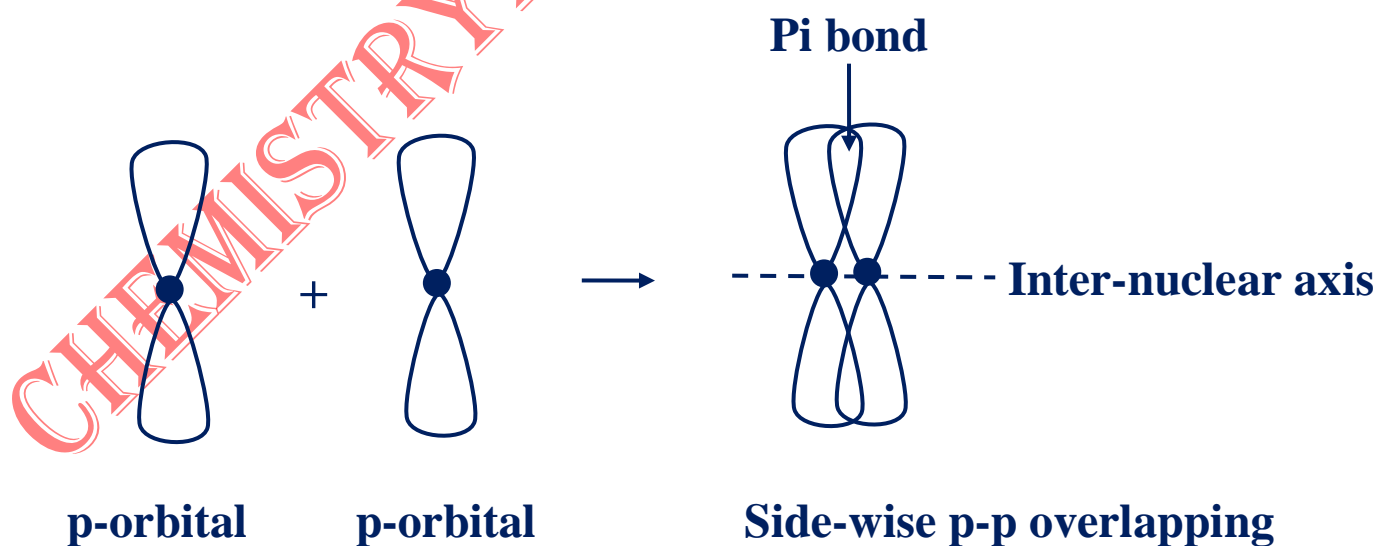


Fig.- Side wise or lateral p-p overlapping

The covalent bond formed in side-wise or lateral p-p overlapping has maximum electron density above and below the inter-nuclear axis and are not symmetrical about inter-nuclear axis. Such covalent bonds are called pi bonds (π - bonds).

Side-wise p-p overlapping never occurs alone, but always occurs along with head-wise p-p overlapping. Thus, pi bonds have no free existence, but are always formed along with sigma bond.

Example- Formation of O_2 molecule

During formation of O_2 molecule, half-filled $2p_z$ - orbital of both the oxygen atoms overlap together to form O-O sigma bond while half-filled $2p_y$ - orbital of both the atoms overlap together in side-wise manner to form pi bond.

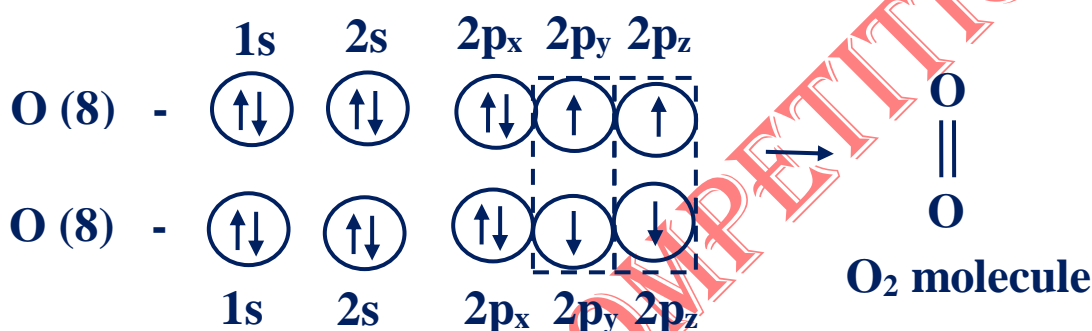


Fig.-Formation of O_2 molecule (schematic)

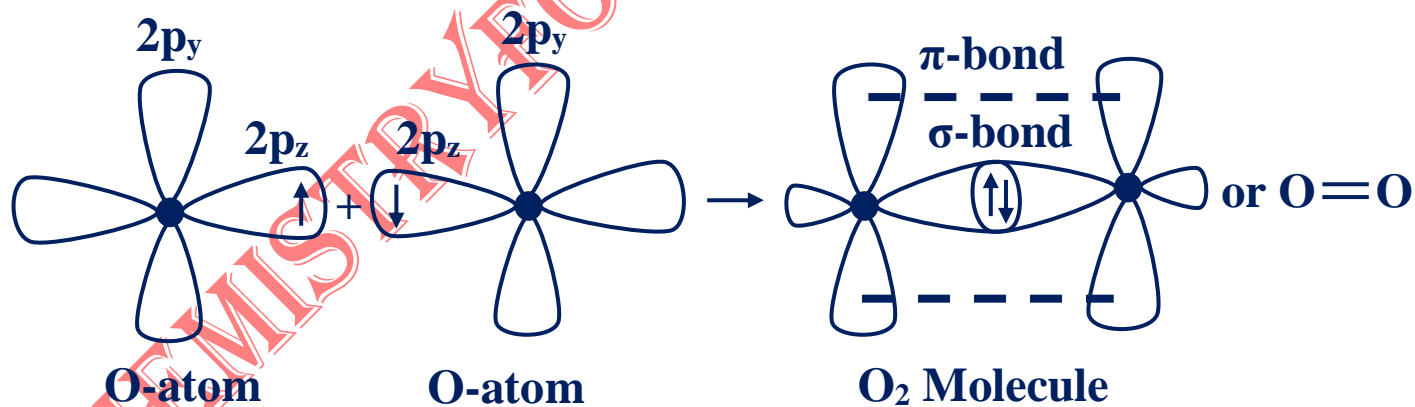


Fig.-Formation of O_2 molecule (diagrammatic)

Thus, $O = O$ of O_2 molecule consist of one sigma and one pi bonds. Similarly, $N \equiv N$ of N_2 molecule consist of one sigma and two pi bonds.