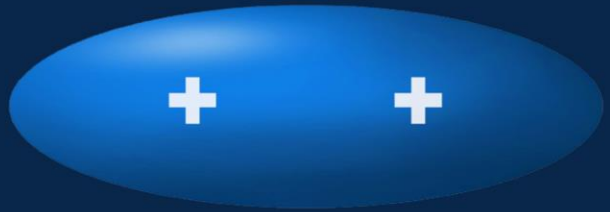
# CHEMICAL BONDING - L4



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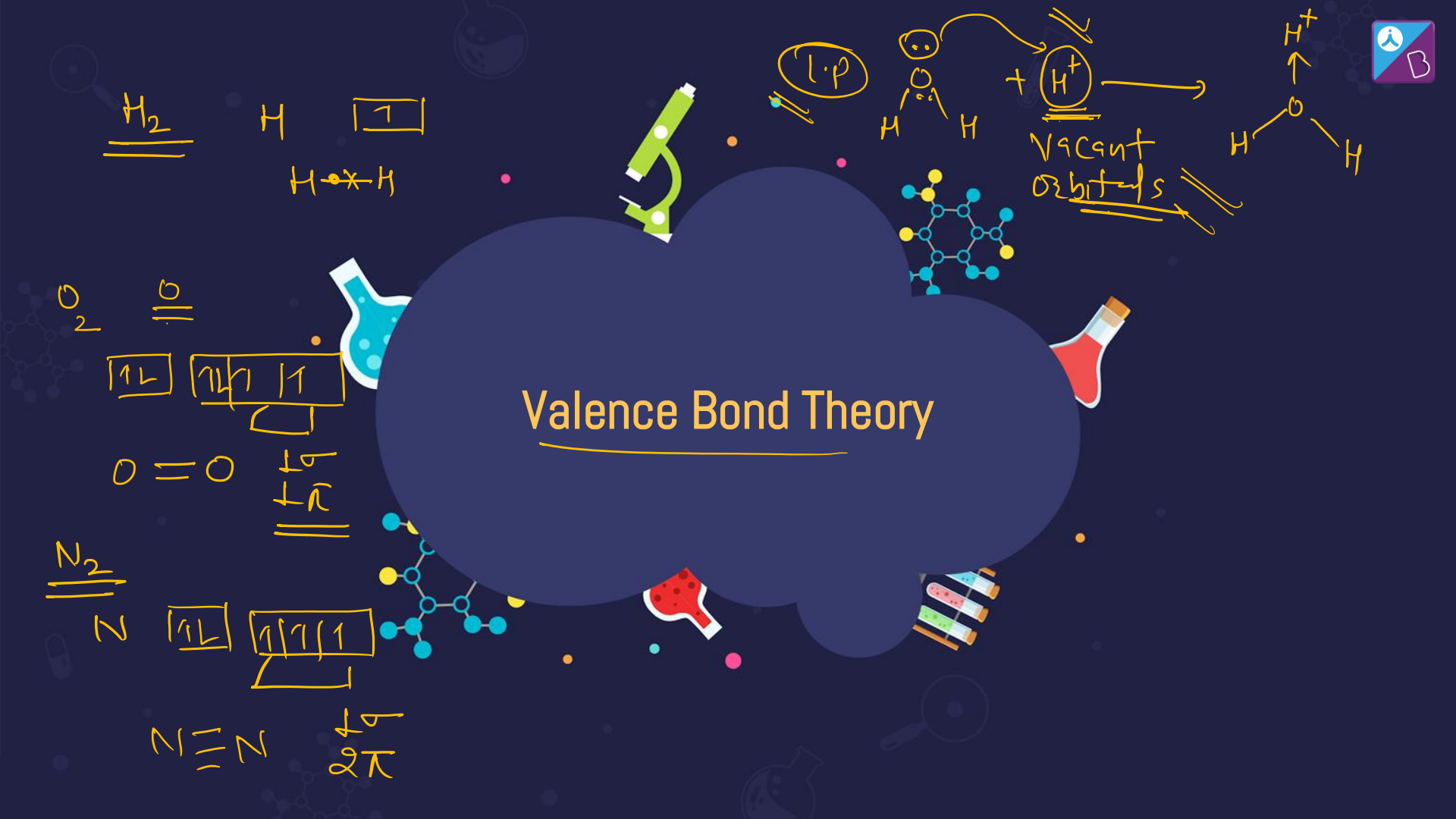
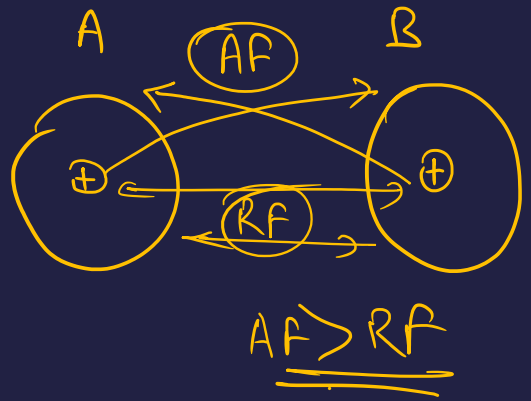

Valence Bond Theory
$H_2$
H
H–H
l.p
+ $H^+$
Vacant orbitals
$H^+$
$O_2$
O=O
$N_2$
N
N≡N

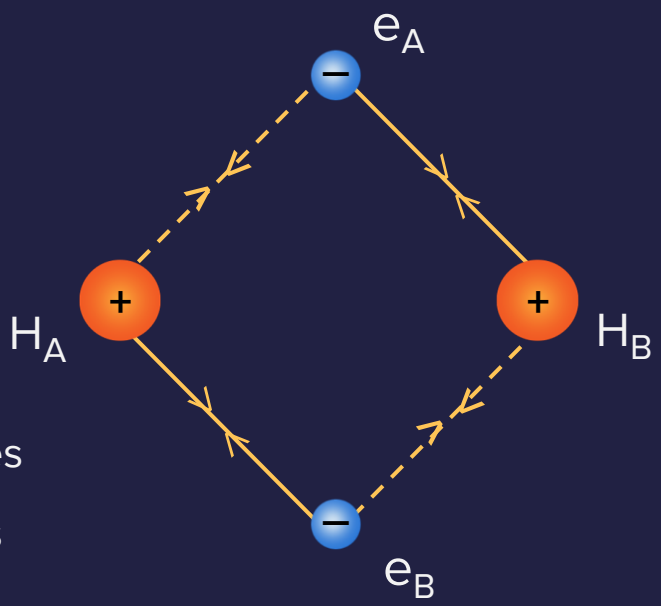
# Valence Bond Theory (V.B.T.)

Remember what happens when
two atoms approach each other?



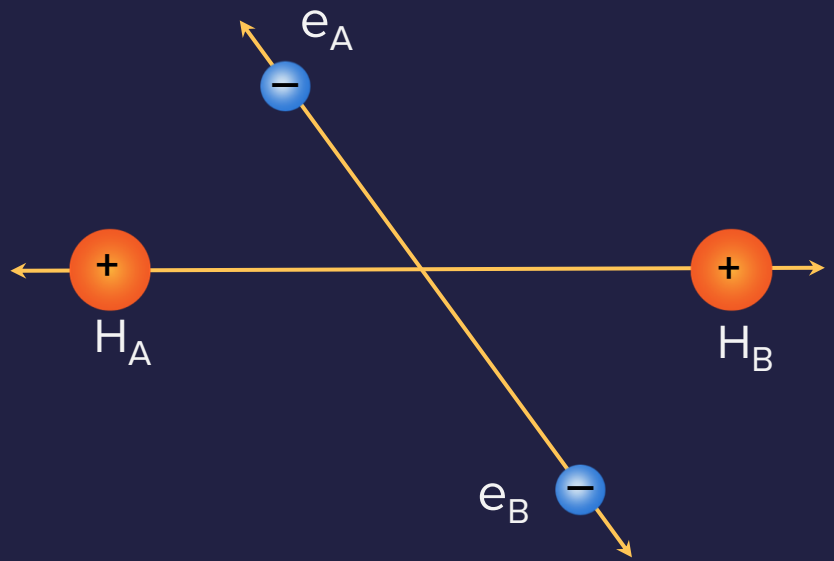
# Valence Bond Theory

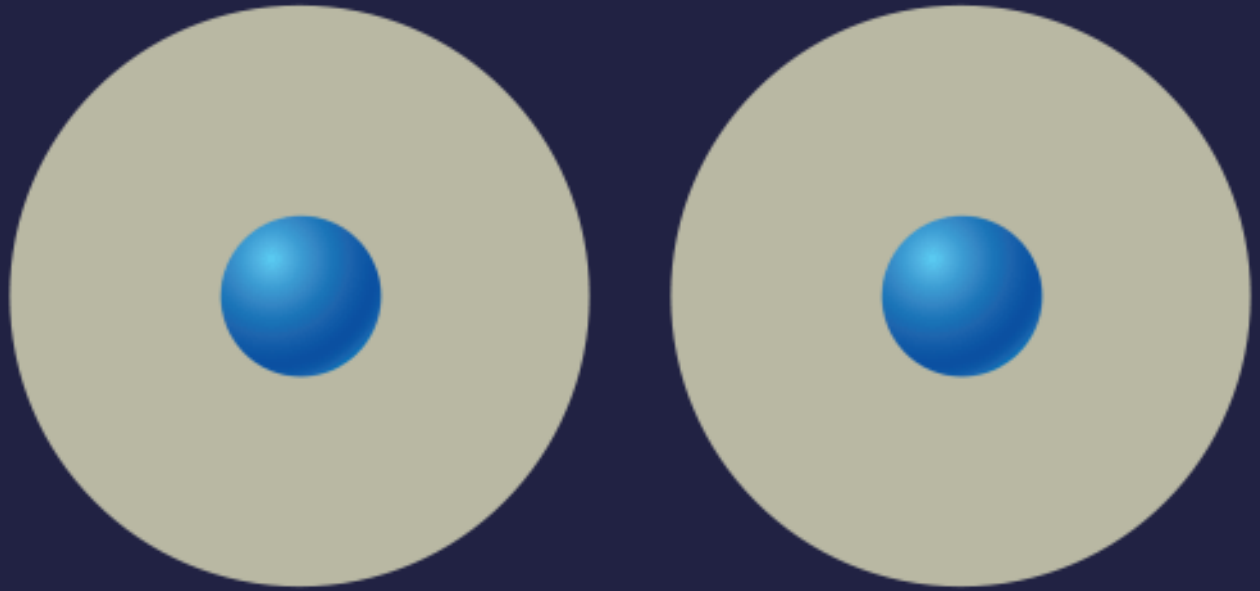
**Attractive forces** tend to bring the two atoms **close to each other**



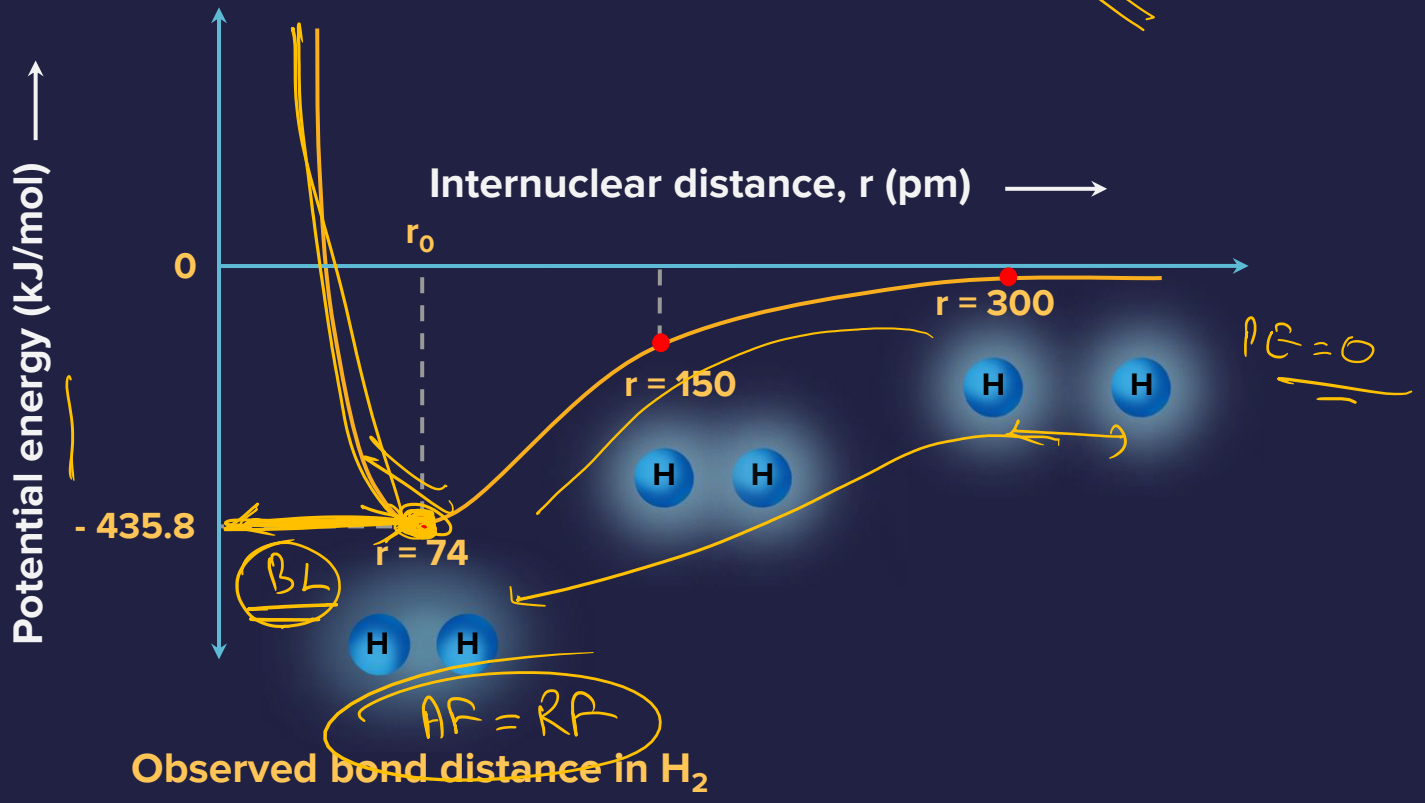
# Valence Bond Theory

**Repulsive** forces tend to **push them apart**





# Potential Energy Curve



# Orbital Overlap Concept

**Partial interpenetration** of atomic orbitals

Orbital overlapping

Electron pair is **shared**

# Valence Bond Theory

**Covalent bond** formation occurs

When **appropriately oriented atomic orbitals** of the combining atoms undergo **overlapping**

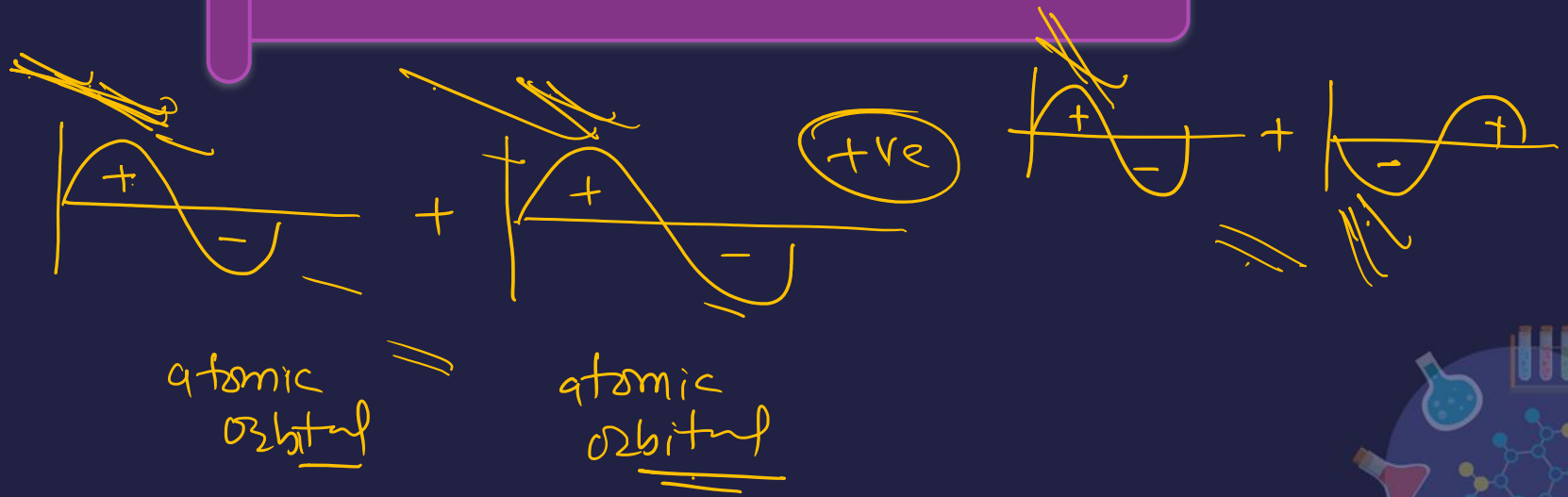
# Conditions for Overlap

Covalent Bond

Each orbital should have **one electron** with **opposite spin**

# Orbital Overlap

**All orbital** overlappings **do not** result in **bond formation.**

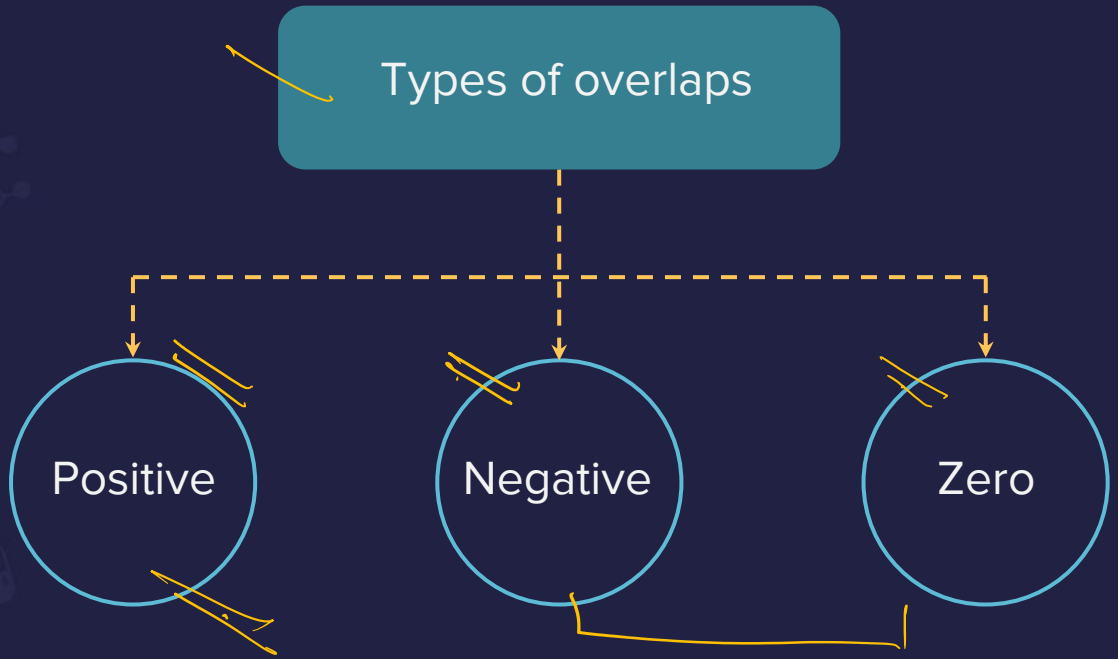


# Directional Properties of Bonds

Covalent bond → Directional bond

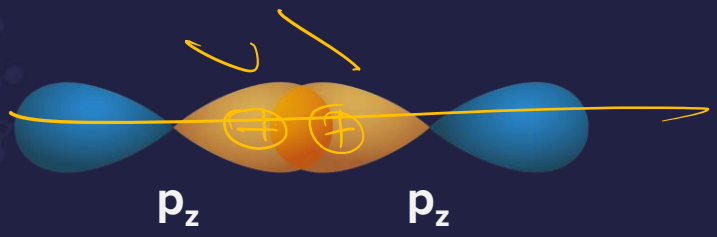
Ionic bond → Non-directional bond

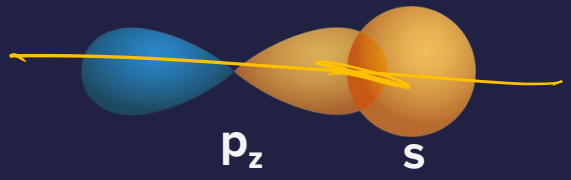
# Orbital Overlap

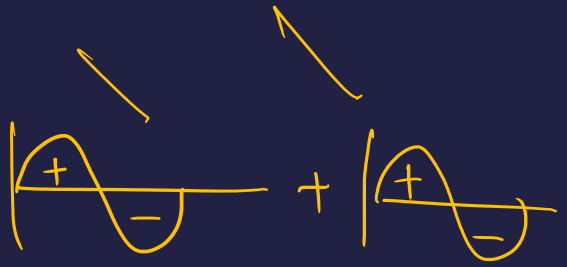


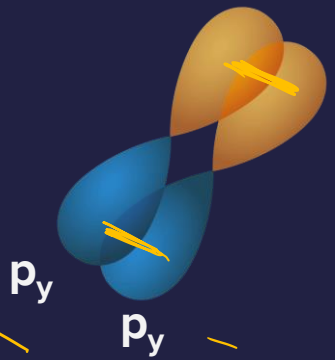
# Orbital Overlap

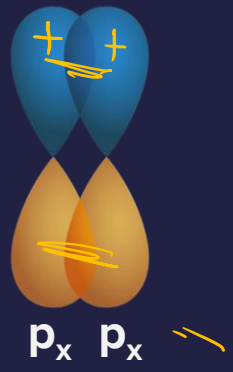
Positive Overlapping



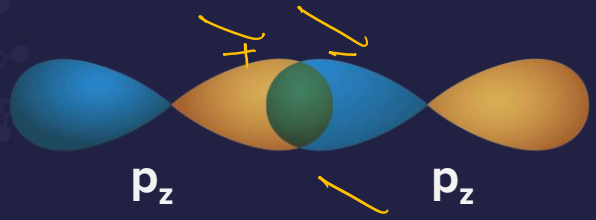



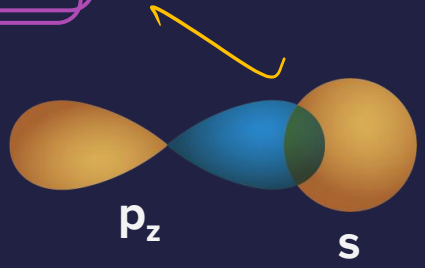


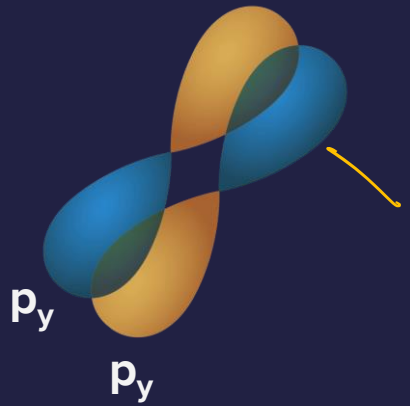



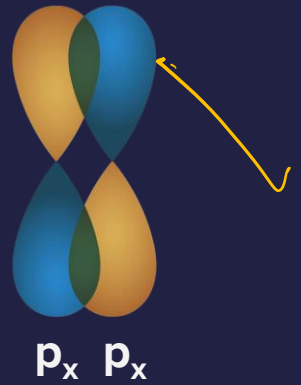
# Orbital Overlap

Negative Overlapping



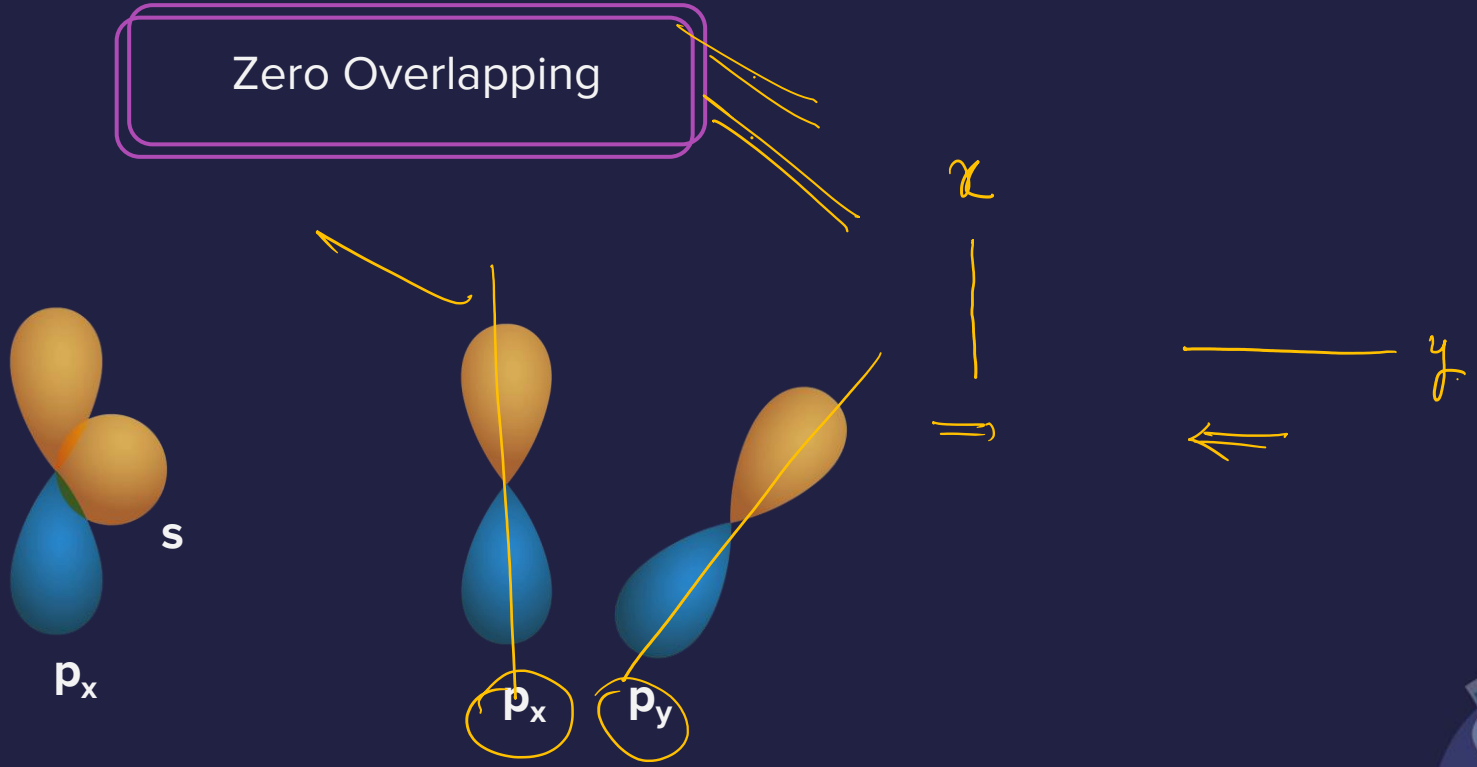



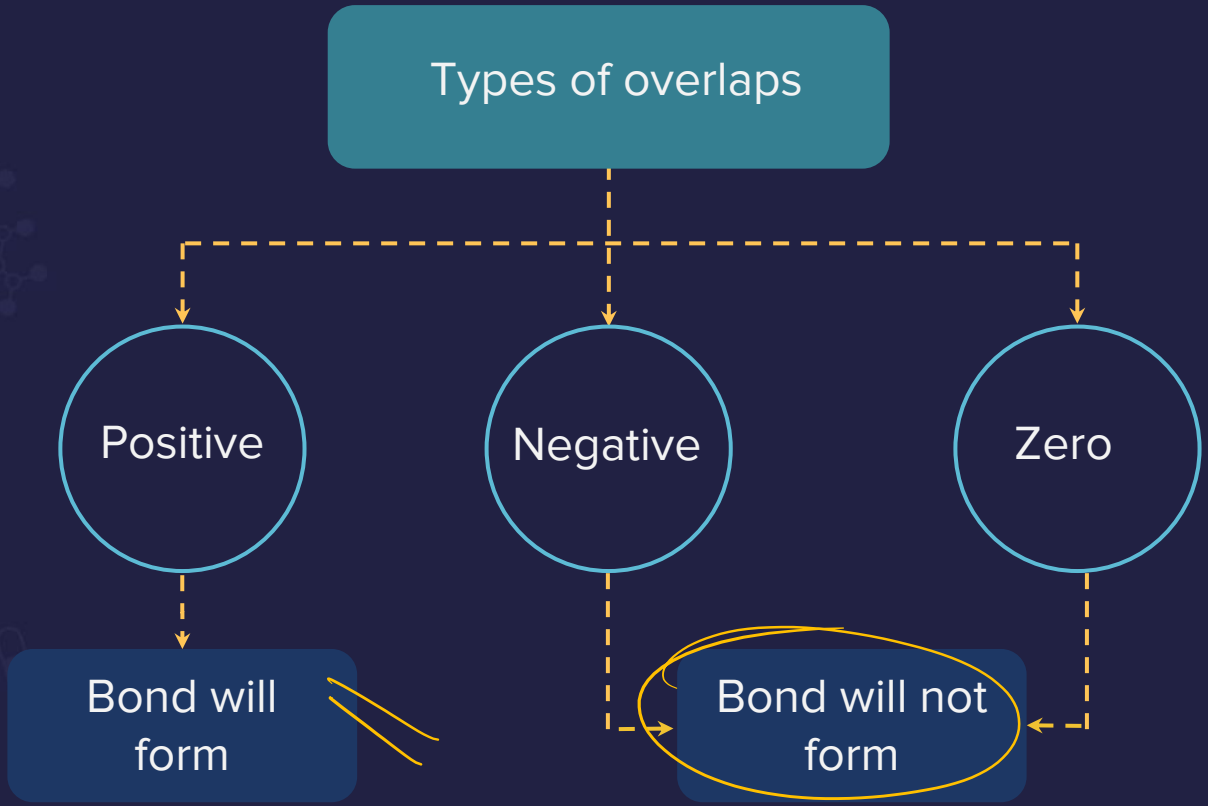



# Orbital Overlap

Zero Overlapping



# Orbital Overlap



# Co-ordinate Bond Or Dative Bond

Bond formed by **sharing of electrons** between two atoms

Shared pair of electrons is contributed by **only one of the two atoms**

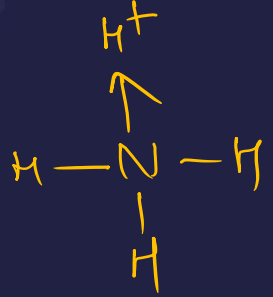
# Conditions for Overlap

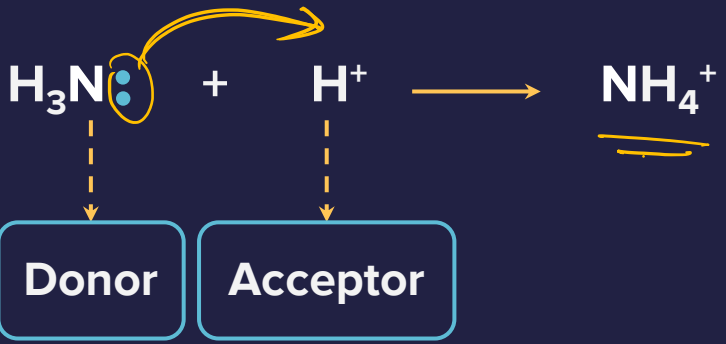
| | |
|---|---|
| Coordinate Bond | One orbital should have a **pair of electrons** and other must be **vacant.** |

# Lewis Acid & Lewis Base

**Lone pair donors** are also called as **Lewis base**

**Lone pair acceptors** are also called as **Lewis acid**



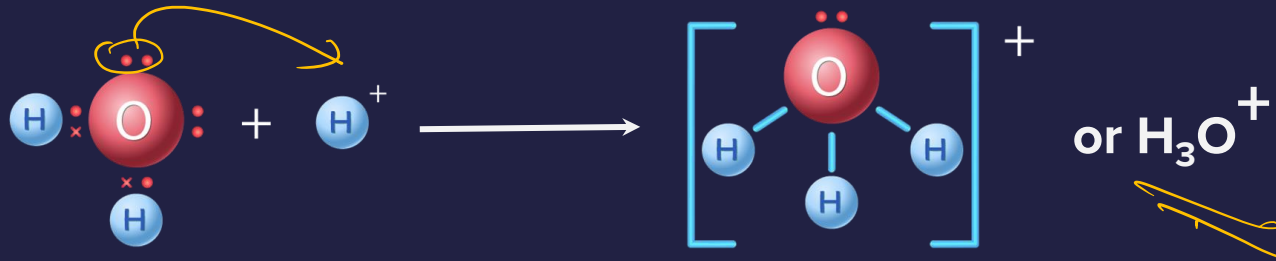


# Remember!!

Coordinate bond once formed **cannot be distinguished from covalent bond**

Covalent & coordination bond are **same w.r.t. bond properties**

# Co-ordinate Bond or Dative Bond

# Which of the following contains coordinate and covalent bonds?

a) $NH_3$

b) $H_3O^+$


c) HCl

d) $H_2O$

In coordinate bond, the acceptor atoms must essentially contain an orbital in its valence shell with:

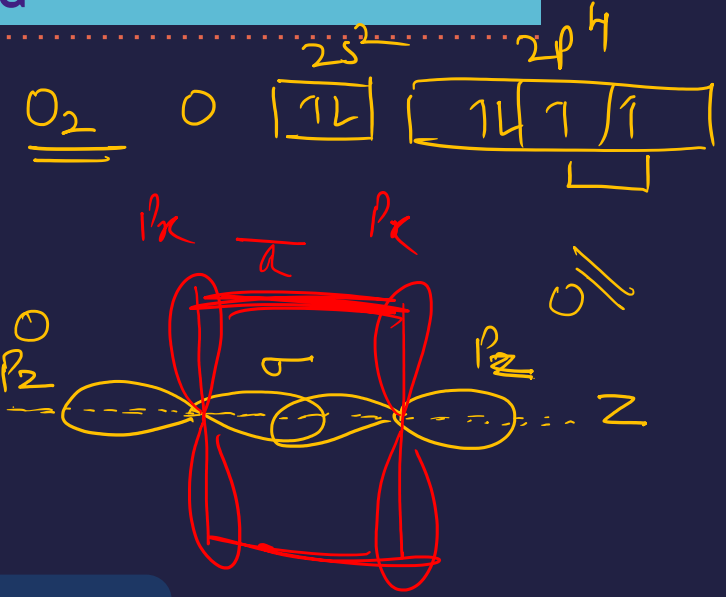
a) With paired electron

b) With single electron

c) With no electron

d) With three electron

# Covalent Bond



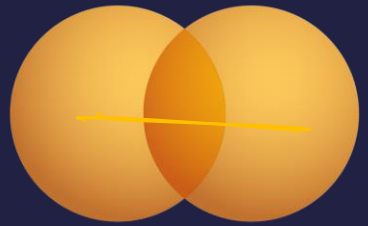
Covalent Bond

**Sigma (σ)** bond

**Pi (π)** bond

# Sigma ($\sigma$) bond

Head-on overlapping or Axial overlapping



# Axial or head on overlapping

**Sigma** bond is formed

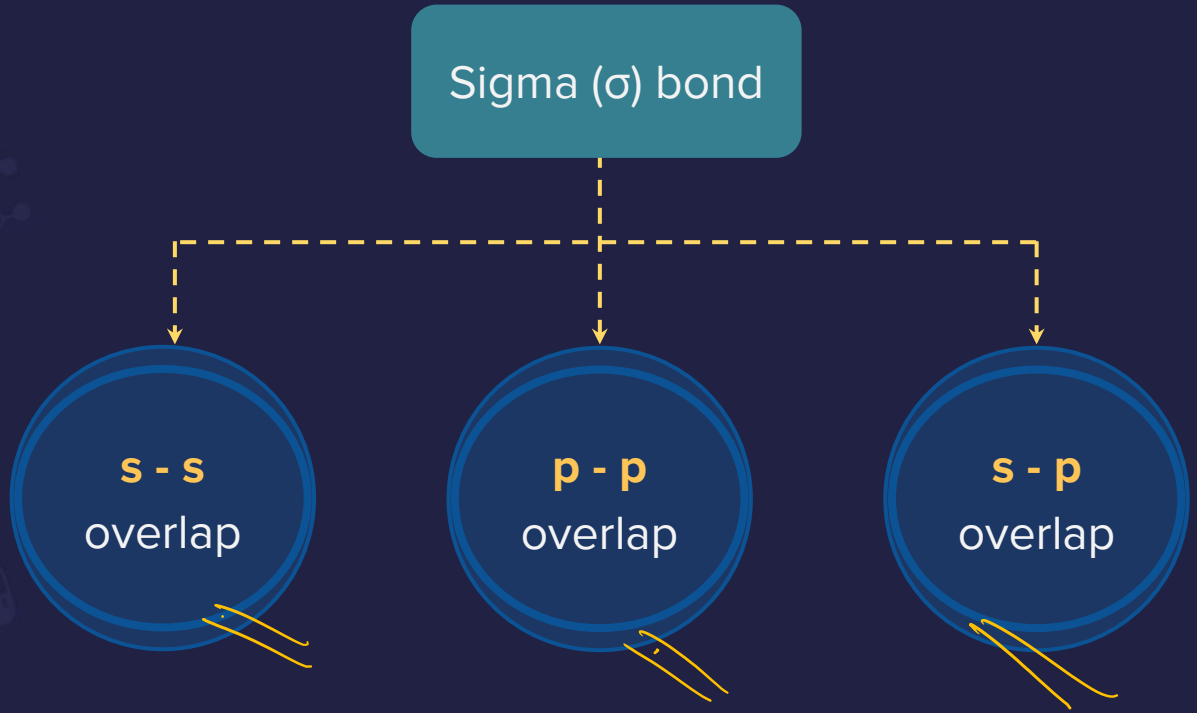
**Axis of orbitals** are **same** as their **combining axis**

# Axial or head on overlapping

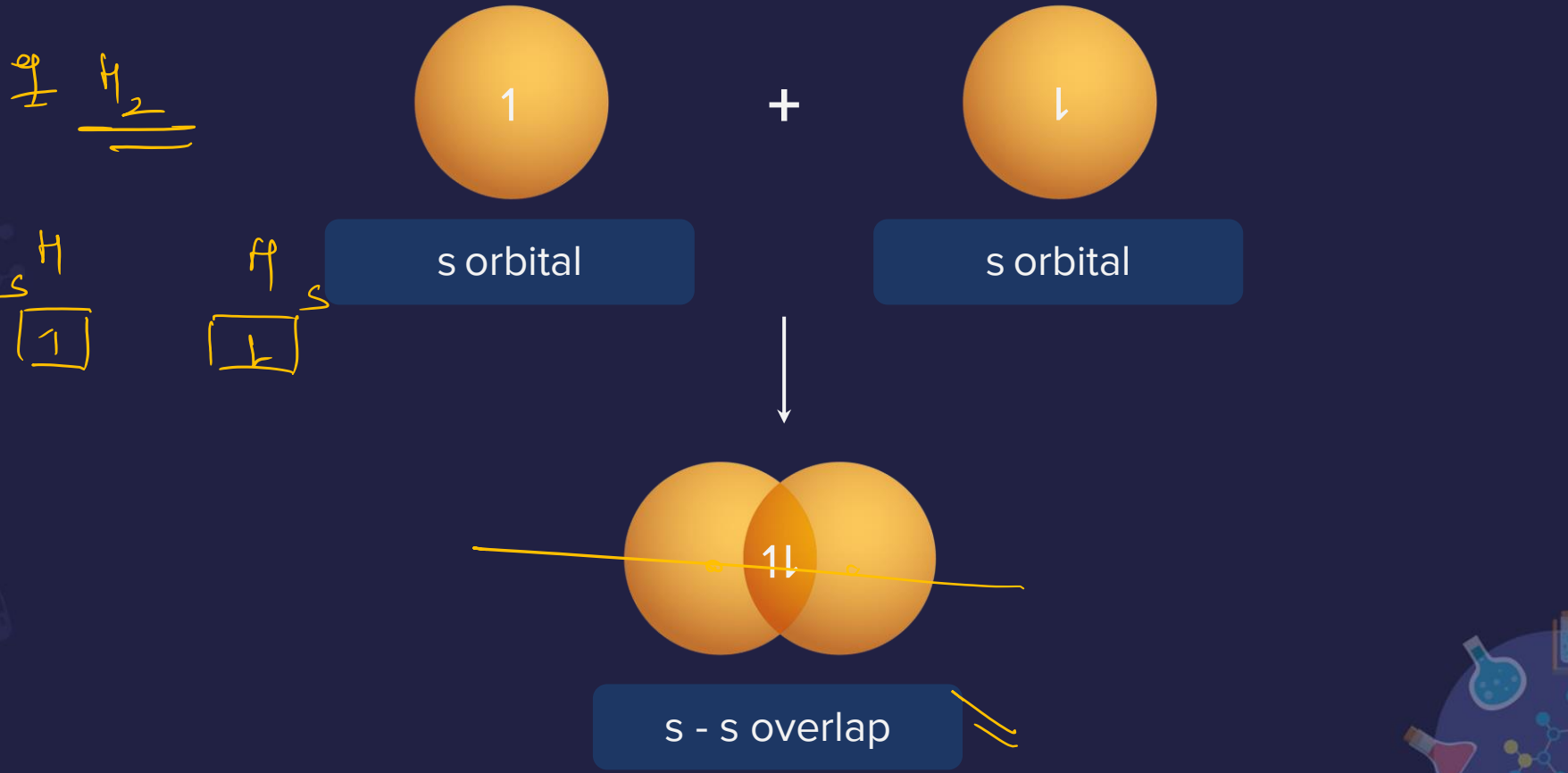
**Sigma** bond

Can **undergo rotation** about the internuclear axis

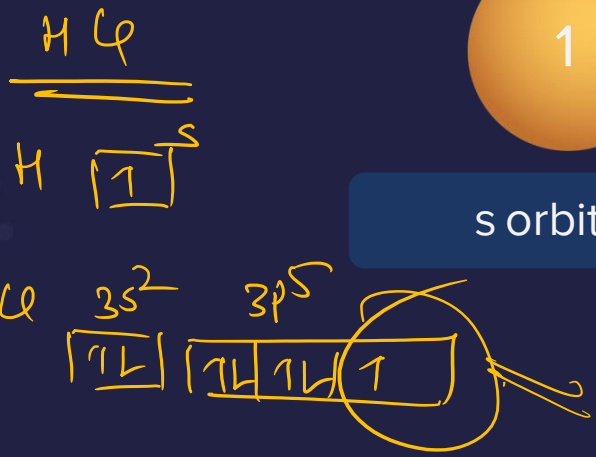
# Types of Head on overlap

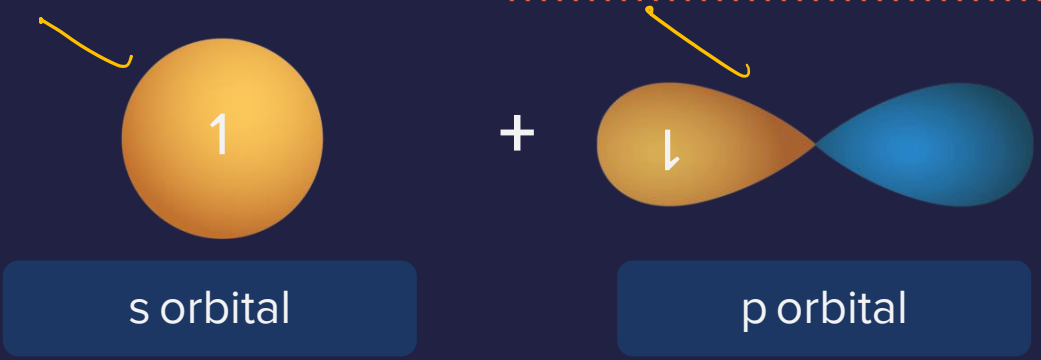


# Sigma Bond



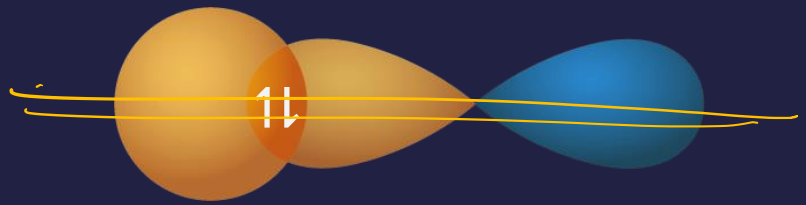
# Sigma Bond





s orbital

p orbital



s - p overlap

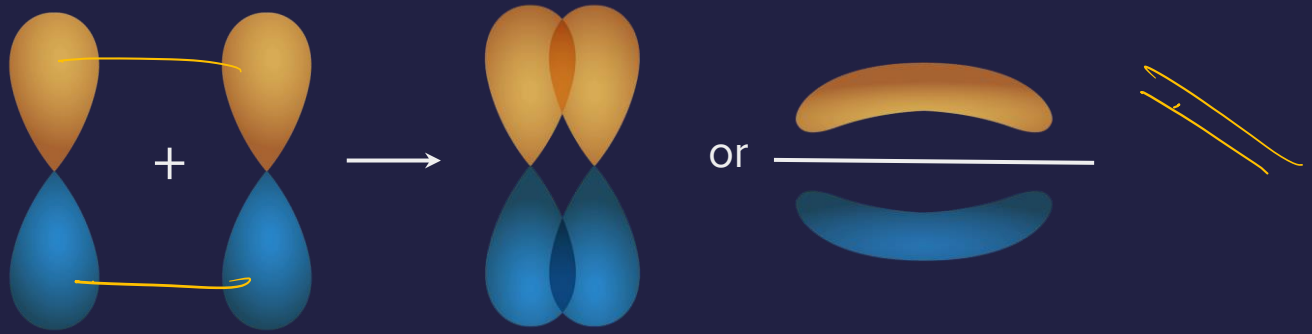
# Sigma Bond

p orbital + p orbital

p - p overlap

# Pi (π) Bond

Sideways Overlapping



# Lateral or sidewise overlapping

**π bond** is formed

Axes of the combining orbitals are **perpendicular** to the internuclear axis.

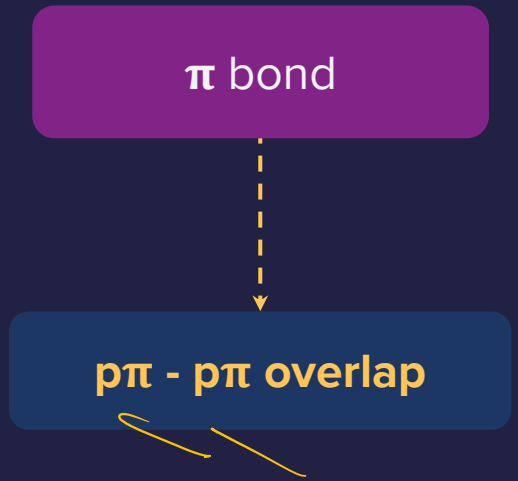
# Lateral or sidewise overlapping

**π bond**

**Cannot undergo rotation** about the internuclear axis

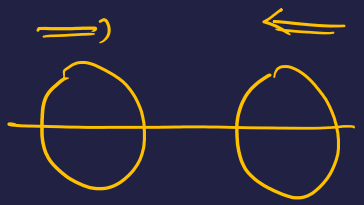
Generally, **π bond** between two atoms is formed in **addition** to a **σ bond**

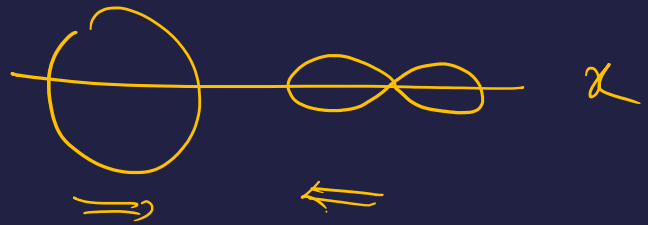
# π bonds



# pπ - pπ Overlap

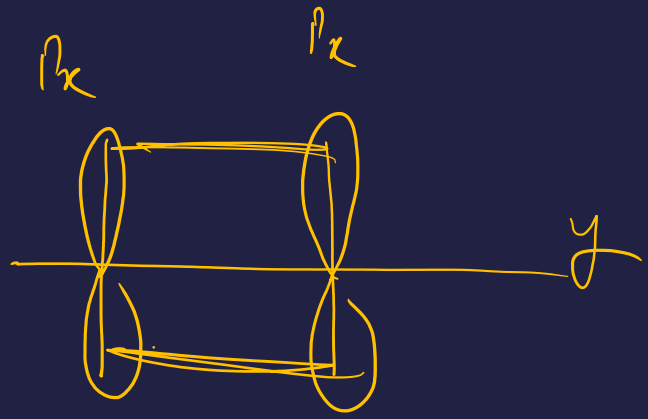
| Orbitals Interacting | Approaching Along | Bond Formed |
| --- | --- | --- |
| $s + s$ | Any axis | σ |
| $s + p_x$ | x-axis | σ |
| $s + p_y$ | y-axis | |
| $s + p_z$ | z-axis | |
| $p_x + p_x$ | x-axis | σ |






$p_x - p_x$

| Orbitals Interacting | Approaching Along | Bond Formed |
|---|---|---|
| $p_x + p_x$ | x-axis | |
| | y-axis | $\pi$ |
| | z-axis | |
| $p_y + p_y$ | x-axis | |
| | y-axis | |
| | z-axis | |



# Bond Strength

In general, order of strength of bond


Extent of Overlapping

# Extent of Overlapping

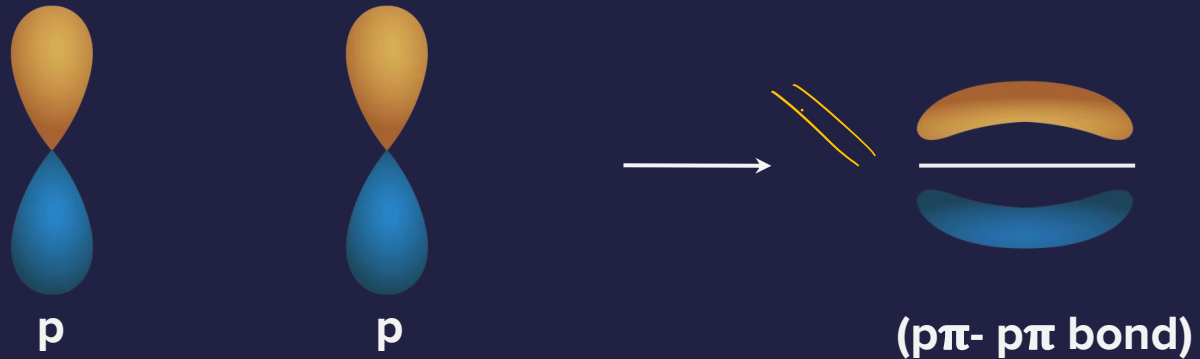
**Greater the extent of overlapping** between the two atomic orbital

**Stronger will be the bond**

# Comparison of Sigma and Pi Bonds

| Sigma bond | Pi bond |
| --- | --- |
| **Axial** overlap | **Sideways** overlap |
| **Larger** extent of **overlap** | **Lower** extent of **overlap** |

# Strength of σ and π Bonds

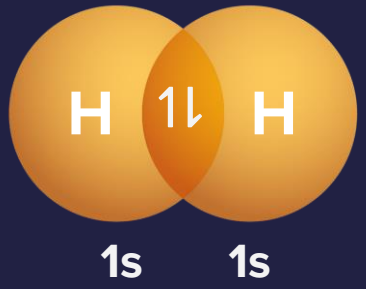
# Bonding in $H_2$ molecule

H 1

$1s^1$

H 1

$1s^1$




i.e., H $\overset{\sigma}{—}$ H

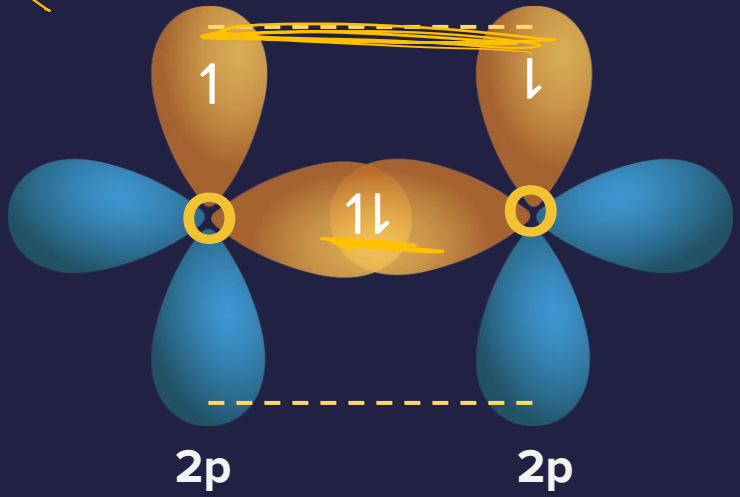
# Bonding in $O_2$ molecule

O

| $1\downarrow\uparrow$ | $1\downarrow\uparrow$ | $1\downarrow\uparrow$ | 1 | 1 |
|---|---|---|---|---|
| $1s^2$ | $2s^2$ | | $2p^4$ | |

O

| $1\downarrow\uparrow$ | $1\downarrow\uparrow$ | $1\downarrow\uparrow$ | 1 | 1 |
|---|---|---|---|---|
| $1s^2$ | $2s^2$ | | $2p^4$ | |



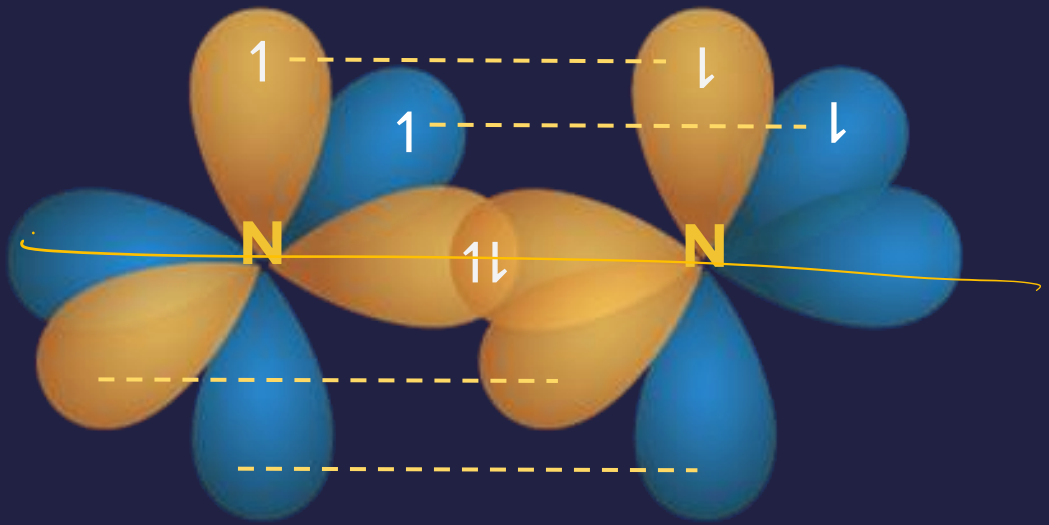

i.e., O $\overset{\sigma}{=\!=}_{\pi}$ O

# Bonding in $N_2$ molecule

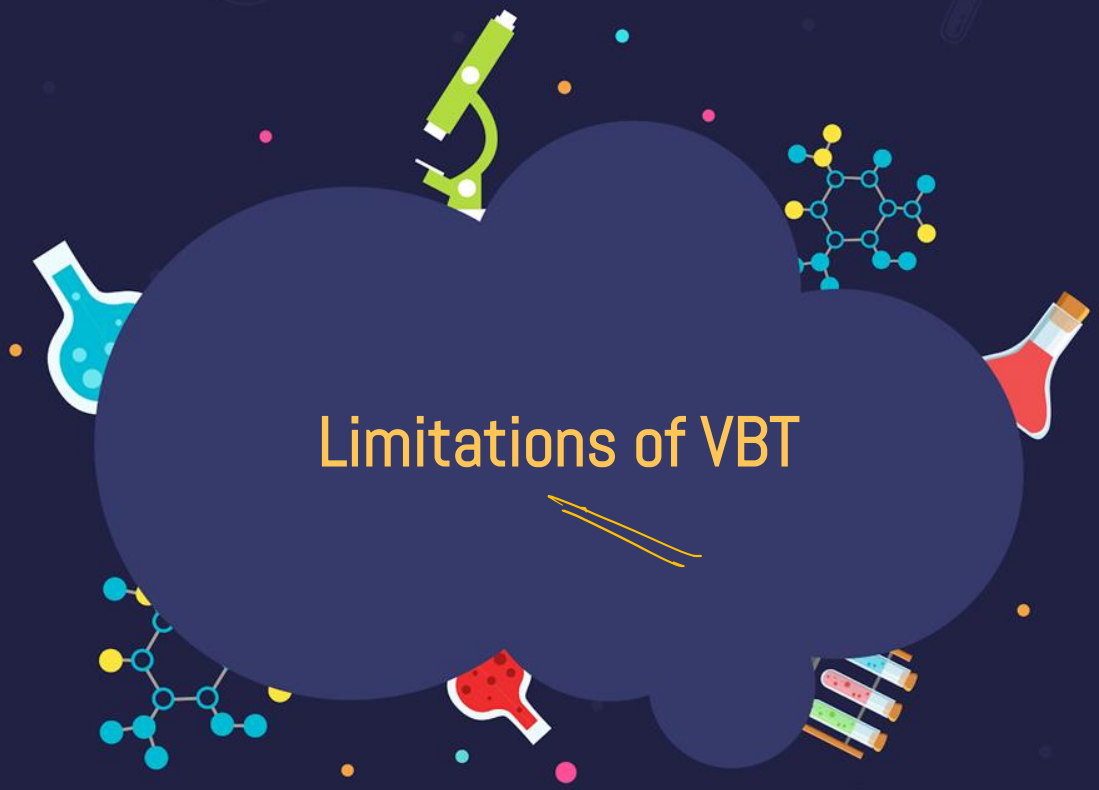


⇒ N ≡ N where, N $\begin{matrix}\sigma\\ \pi\\ \pi\end{matrix}$ N

# Bonding in $N_2$ molecule




N $\overline{\sigma}$ $\overline{\pi}$ $\overline{\pi}$ N


Limitations of VBT

# Limitations of VBT

**Paramagnetic** nature of $O_2$ could not be explained

# Limitations of VBT

**Fails** to account for the **geometry and shapes** of various molecules

# A π bond is formed by the overlap of:

a) s - s orbital

b) s - p orbital

c) p - p orbital in head on manner

d) p - p orbitals in sideways manner

Assertion: Sigma bonds are stronger than π bonds.
Reason: Sigma bonds are covalent bonds.
Choose the correct option:

a) Both Assertion and reason are true & reason is the correct explanation of assertion

b) Both assertion and reason are true & reason is not a correct explanation of the assertion

c) Assertion is true but the reason is false

d) Both assertion and reason are false

Which of the following overlaps is incorrect [assuming z-axis to be the internuclear axis]?

(i) $2p_y + 2p_y \rightarrow \pi 2p_y$

(ii) $2p_z + 2p_z \rightarrow \sigma 2p_z$

(iii) $2p_x + 2p_x \rightarrow \pi 2p_x$

(iv) $1s + 2p_y \rightarrow \pi(1s\text{-}2p_y)$

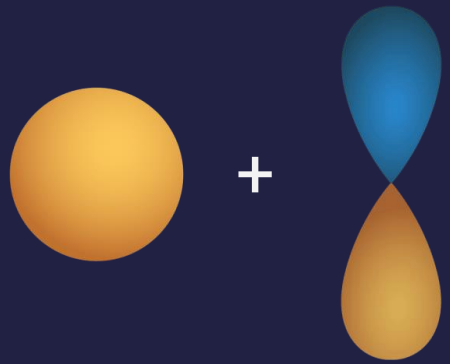
a) 'i' & 'ii'

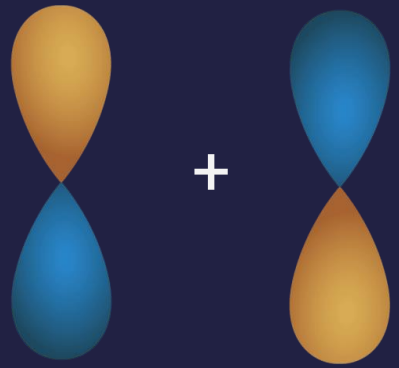
b) 'ii' & 'iv'

c) only 'iv'

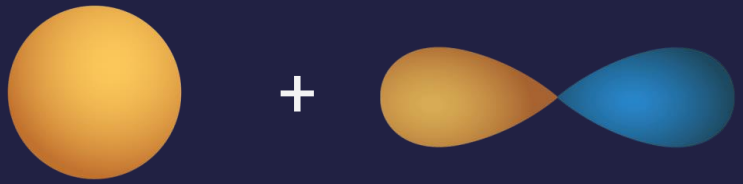
d) None of these

# Which of the following leads to bonding?

a) 

b) 

c)



d)


Keep Learning