

Hybridization

التفجيج

it is mixing of two atomic orbitals different in energy to form new hybrid orbitals have the same energy

* Condition of hybridization:

شروط التفجيج

- ① Hybridization occur in the Central atom
- ② Hybridization occur between two orbitals which near to each other in energy
- ③ The no. of atomic orbital inter in the hybridization equal to the no. of hybrid orbital

* Steps of hybridization:

① Excitation or promotion:

عالية الاثارة

- electron transfe from lower energy level to higher energy level

② Re-orientation:

إعادة ترتيب الأوربيتالات

* Types of orbitals:

① Atomic orbital:

S $\rightarrow$ 1 orbitalP $\rightarrow$ 3 orbitald $\rightarrow$ 5 orbitalf $\rightarrow$ 7 orbital

② molecular orbital:

S + S $\rightarrow$ S — S $\rightarrow$ (σ) bond

Linear overlap

axial overlap

تقاطع بالخط

P_x + P_x $\rightarrow$ P_x — P_x $\rightarrow$ (σ) bond

P_y + P_y $\rightarrow$ CS (π) bond
P_z + P_z $\rightarrow$ lateral overlap



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③ Hybrid orbital:

Combination between two different atomic orbital to give hybrid orbitals

- $sp \rightarrow 2$ hybrid orbitals
- $sp^2 \rightarrow 3$ hybrid orbitals
- $sp^3 \rightarrow 4$ hybrid orbitals

👉 Note if sp^3 combine with $sp^3 \rightarrow$ Linear
 sp^2 " " $sp^2 \rightarrow$ Linear
 sp " " $sp \rightarrow$ Linear

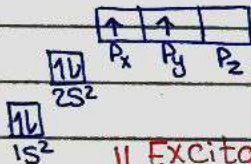
* Types of hybridization:

sp^3

تكوين 4 روابط سيجما

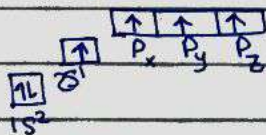
• mixing of $2s, 2p_x, 2p_y, 2p_z$

ground state C_6

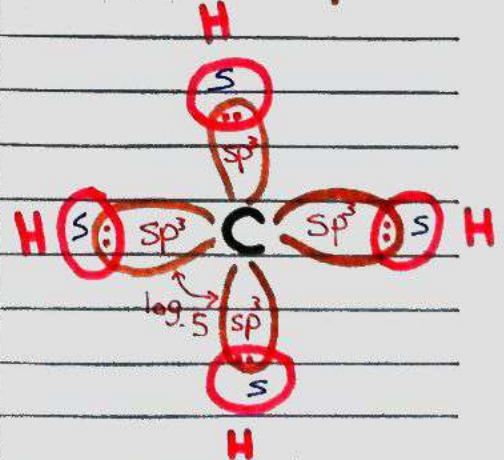
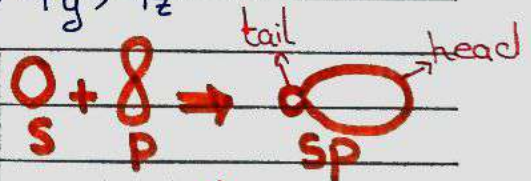
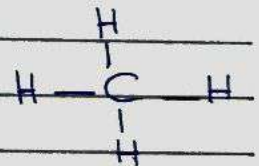
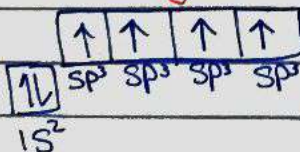


Excitation or promotion

excited state



hybridization



Example: Alkanes

• sp^3 properties: → تنطبق على استادم رب التوجيه فيه من النوع sp^3

* Shape: Tetrahedral "pyramindal" شكل هرمي

* Bond angle: 109.5°

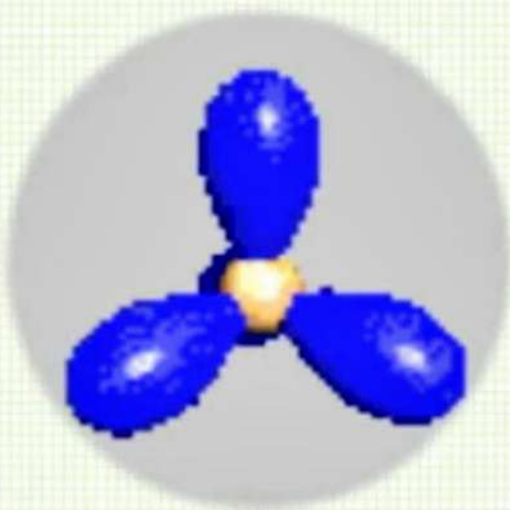
* Bond length: $1.5 \text{ \AA}$

* (s) character: 25%

* (p) character: 75%

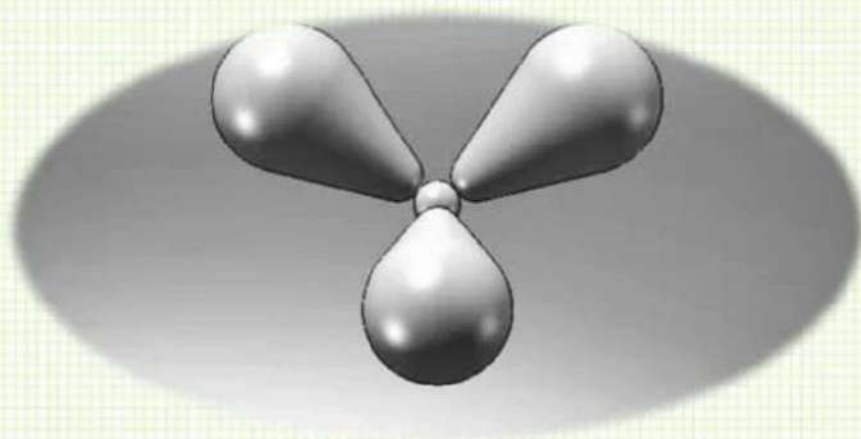
* Example: → $CH_4 \Rightarrow 4(s)$ bond between C-H

sp^3 Hybridization



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sp^3 Hybridization



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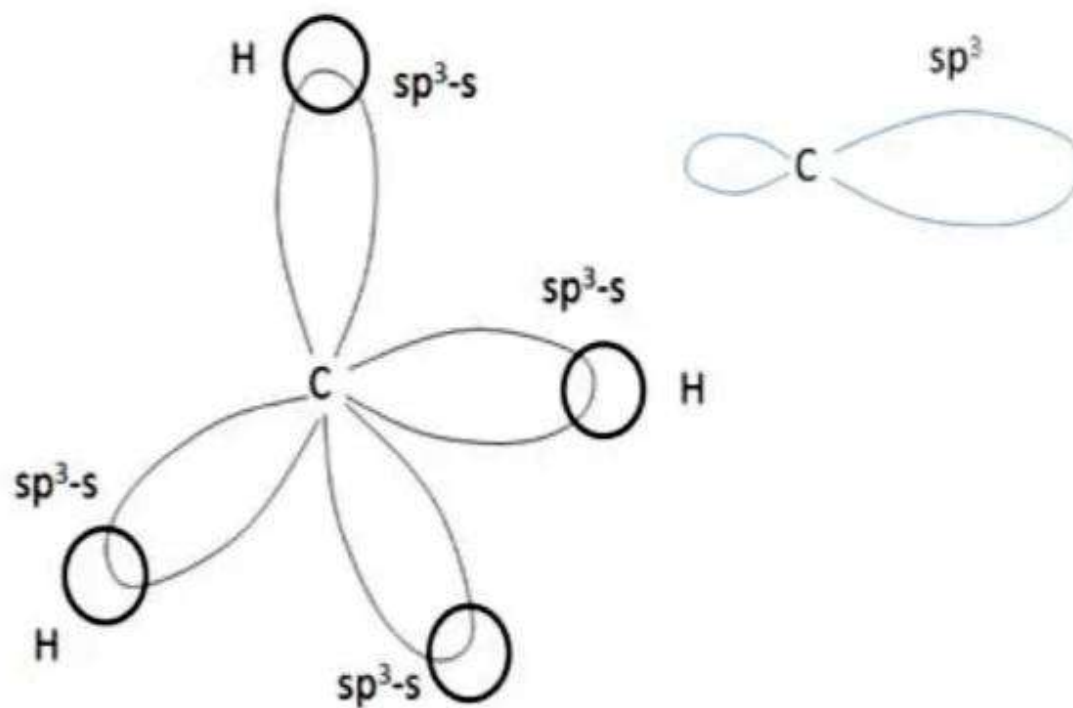
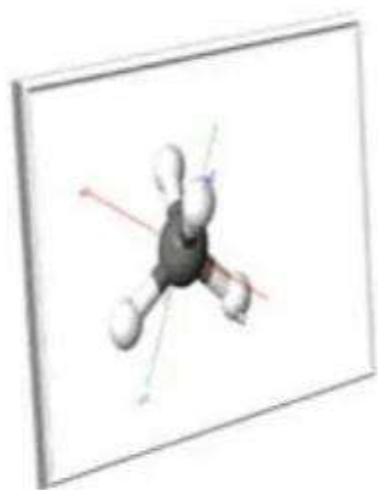


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Bonding in Methane (CH_4)



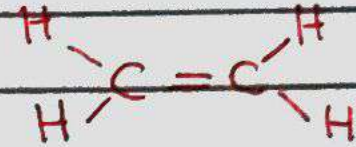
Bonding in Methane : Carbon uses sp^3 hybridized orbital to form 4 covalent bond with hydrogen in methane.



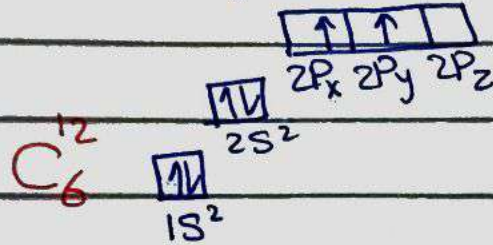
sp²

تكون 3 روابط سيجما

• mixing of 2s, 2p_x, 2p_y

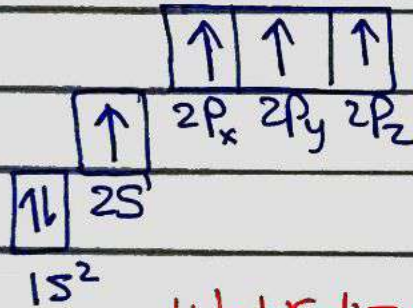


ground state

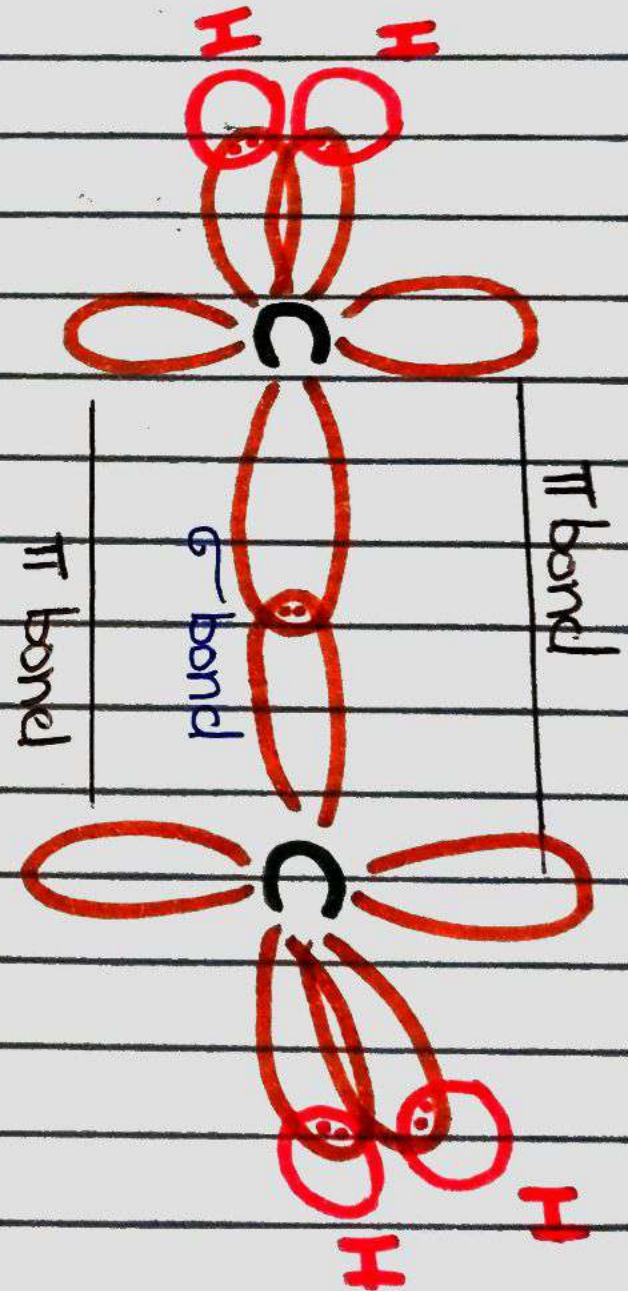
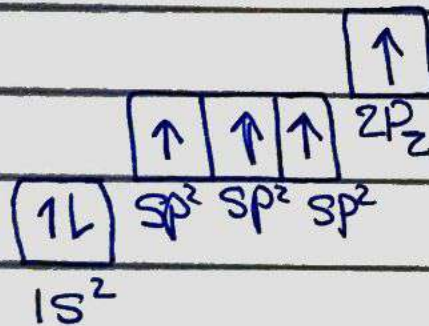


Excitation or promotion

excited state



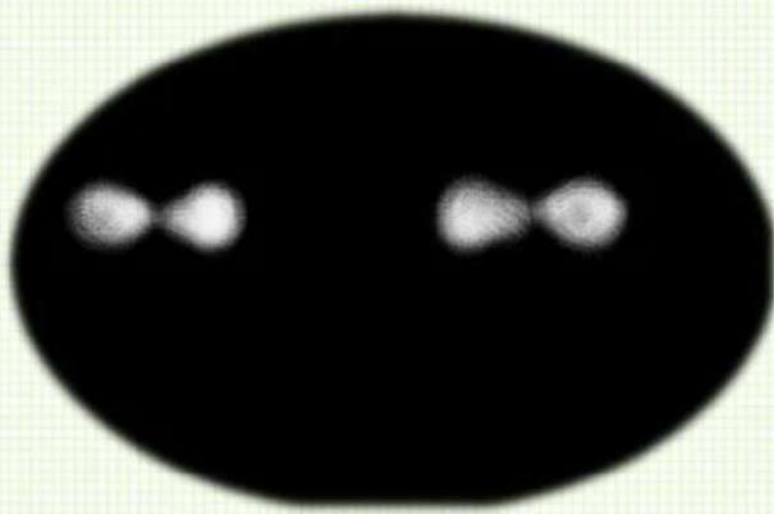
hybridization



• sp^2 hybridization properties:

- * Shape: Trigonal "planar" ترباعي
- * Bond angle: 120°
- * Bond length: $1.3 \text{ \AA}$
- * s character: 33.3%
- * p character: 66.7%
- * Example: Alkenes $\Rightarrow$ 3 σ bond between C-H, C-C
1 π bond between C-C

Formation of Sigma Bond



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hybrid orbitals - sp , sp^2 , or sp^3



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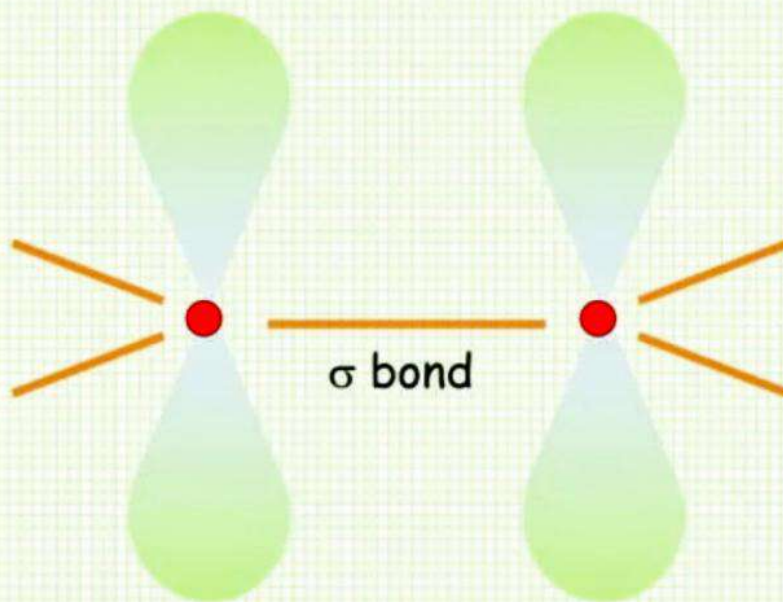


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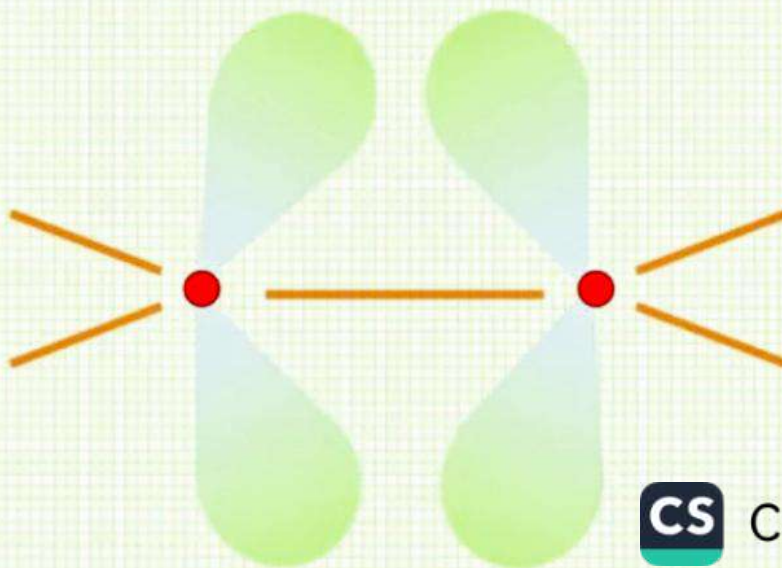


Formation of σ bond

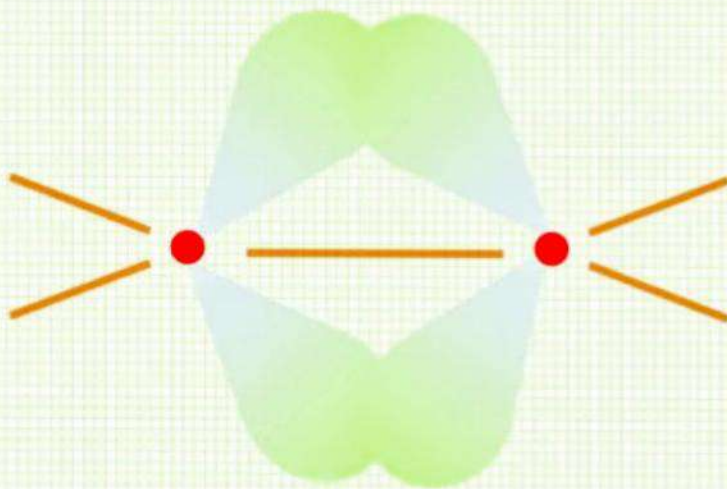


Remaining **p** orbitals from sp or sp^2

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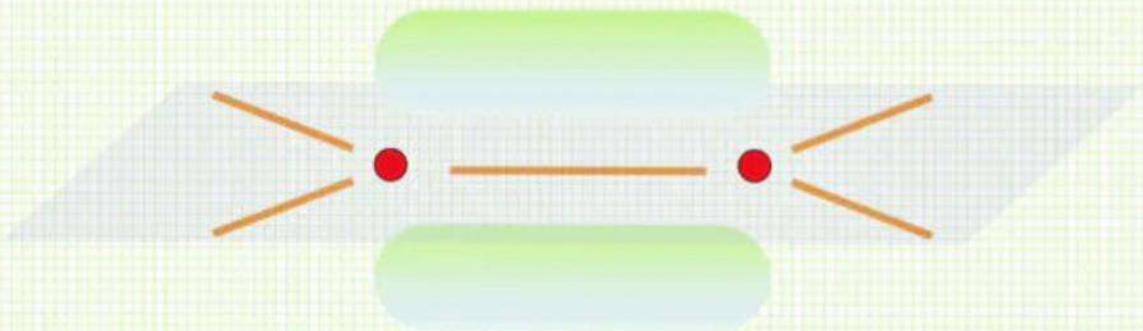


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Planar molecule (each carbon is trigonal planar)
with π cloud **above** and **below** the plane



π bond hinders free rotation about the carbon-to-carbon bond



Formation of π bond



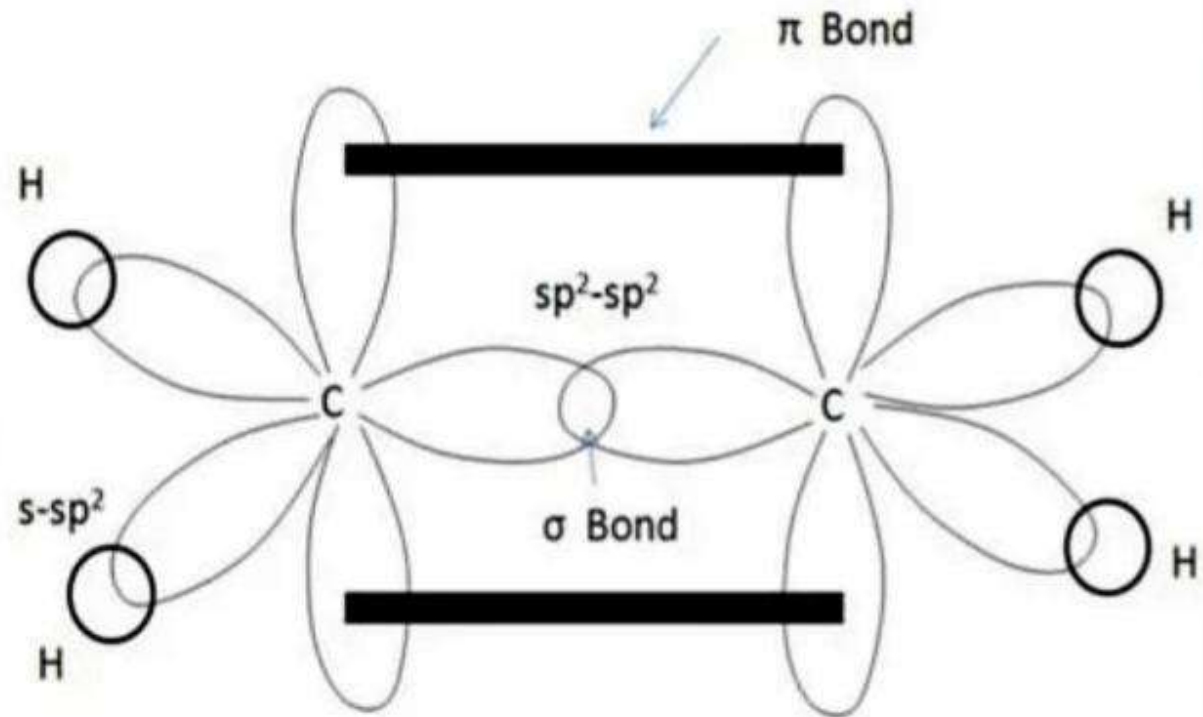
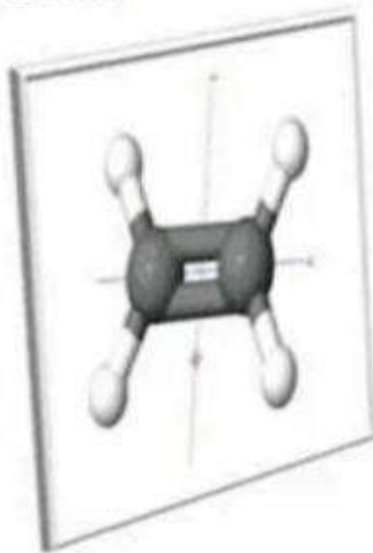
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Bonding in Ethene ($\text{H}_2\text{C}=\text{CH}_2$)



Each carbon uses sp^2 hybridized orbital to form 2 sigma bonds with hydrogen and 1 sigma bond with other carbon. Pure p-orbital of C forms Pi bond.

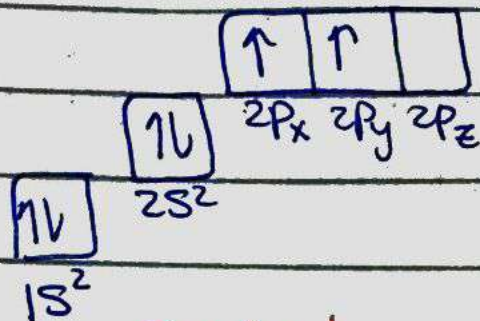


SP

* mixing of 2 atomic orbitals
* mixing of S, P_x

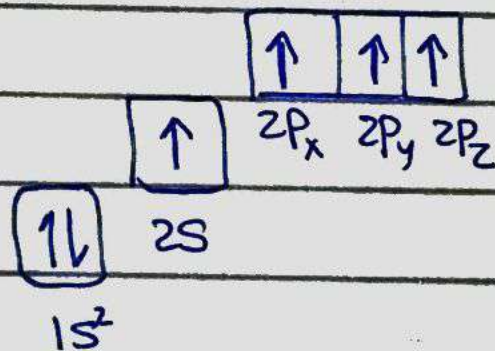
Ground
State

C₆

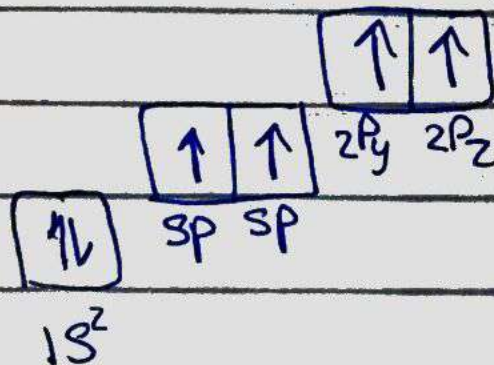


Excited
or promotion

excited
State



hybridization



• sp hybridization properties:

* Shape: linear

* Bond angle 180°

* Bond length $1.2 \text{ \AA}$

* s character 50%

* p character 50%

* Example: Alkyne $\Rightarrow$ 2π bond between C - C

2σ bond between



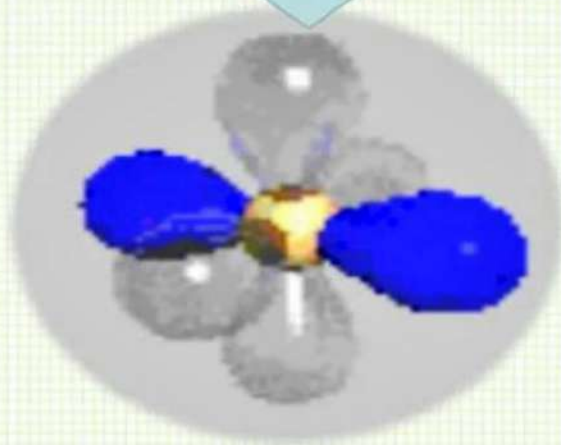
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sp Hybridization



Pure p orbital

Sp hybrid orbital

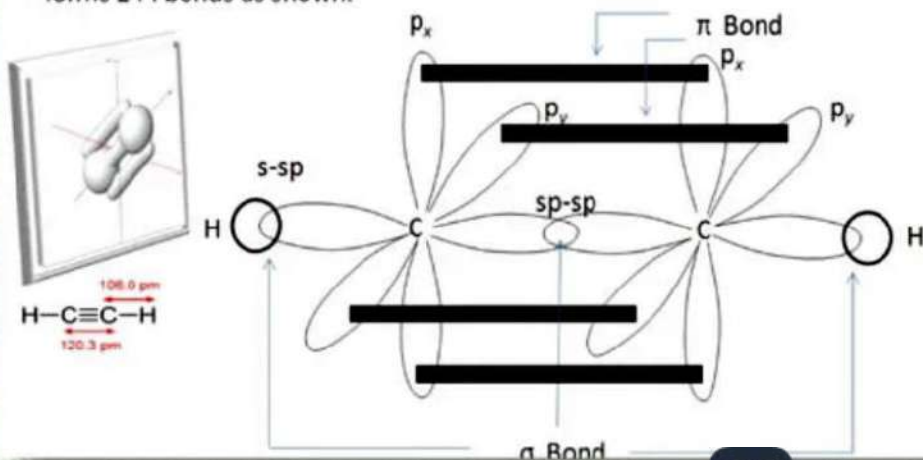


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Bonding in Acetylene



Each Carbon atom in acetylene uses sp hybridized orbital's to form 2 sigma bonds with neighbouring Hydrogen and 1 Carbon atom. 2 pure orbital's forms 2 Pi bonds as shown.

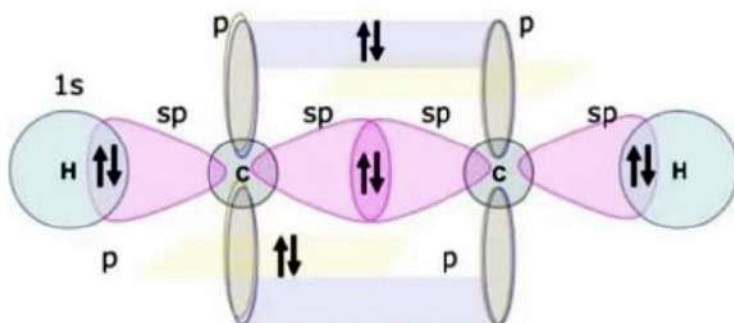


sp Hybridization



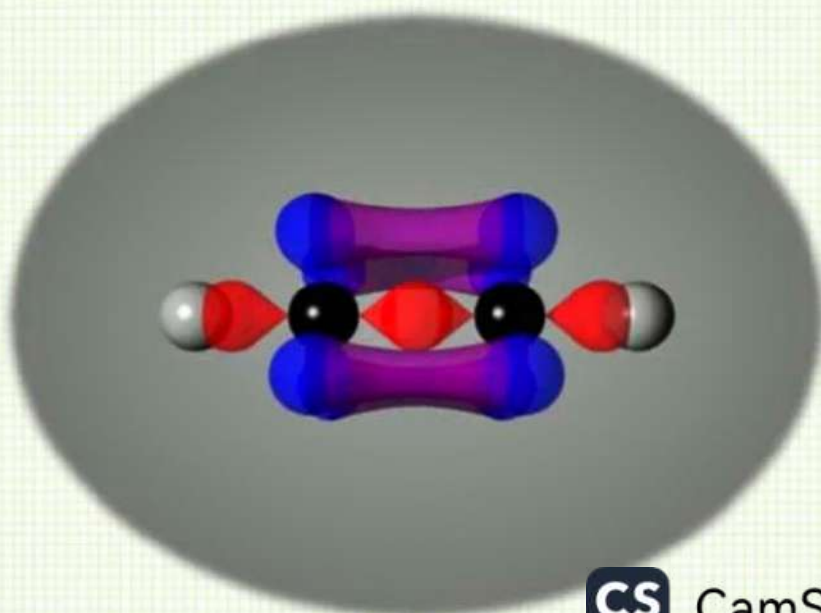
HYBRIDIZATION

Example: **Ethyne** (C_2H_2)



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Bonding in **Acetylene**



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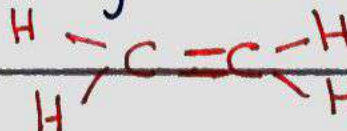
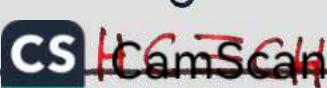
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* Bond formation from hybridization:

* Single bond $\Rightarrow$ Sigma bond

* double bond $\Rightarrow$ Sigma bond + pi bond

* Triple bond $\Rightarrow$ Sigma bond + 2 pi bond

	sp^3	sp^2	sp
shape	tetrahedral	Trigonal	Linear
Bond angle	109.5°	120°	180°
Bond length	$1.5 \text{ \AA}$	$1.3 \text{ \AA}$	$1.2 \text{ \AA}$
Example	methane CH_4	Ethylene 	Acetylene 

σ	π
Formed by linear overlap تنشأ نتيجة التداخل بالرأس	formed by lateral overlap تنشأ نتيجة التداخل بالجانب
Strong bond	Weak bond
Formed in..	formed in..
① S-S	① $P_z - P_z \Rightarrow H_2C=CH_2$
② 2 hybrid orbital	② $P_y - P_y, P_z - P_z \Rightarrow HC \equiv CH$
③ hybrid orbital + S	
has independent excess يمكن أن توجد وحدها في المركب	has dependent excess لا يمكن أن توجد وحدها في المركب
Free rotation	Restricted rotation

* To indicate the type of hybridization...
You have to know: → Number of "sigma bond + lone pair"

* O → have two lone pair

N → have one lone pair

$\left. \begin{array}{c} F \\ Cl \\ Br \\ I \end{array} \right\} \Rightarrow \text{have 3 lone pair}$

Example: H_2O

• 2 sigma bond between O-H

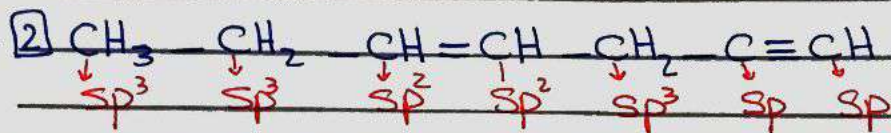
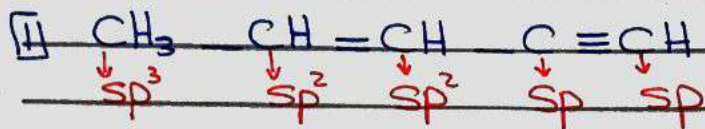
• O → have 2 lone pair

} = 4

∴ sp^3

Examples:

indicate the type of hybridization.



1) what is the hybridization of oxygen atom in water?

(a) sp

(b) sp^2

(c) sp^3

2) bond that formed by axial overlap

(a) σ

(b) π

3) percentage of s in sp

(a) 25%

(b) 75%

(c) 50%

4) The geometry of Alkyne

(a) Linear

(b) Trigonal planner

(c) tetrahedral

5) The hybridization of lined carbon in $\text{H}_2\text{C}=\overset{*}{\text{C}}-\text{CH}_2$

(a) sp

(b) sp^2

(c) sp^3