



Structure and Bonding in Organic Chemistry- Hybridization

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Hybridization

- The intermixing of orbitals and having slightly energies and the redistribution of their energies to form a new orbitals having identical shapes and equivalent energies is known as **hybridization**.
- New orbital thus formed are called **hybrid orbitals**.

Features of Hybridization

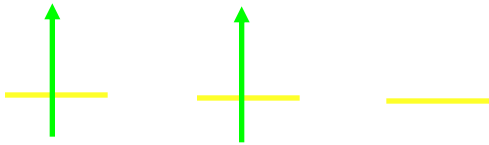
- Only those orbitals which have approximately equal energies and belong to the same atom undergo hybridization.
- Number of hybrid orbitals produced is equal to the number of atomic orbitals which undergo hybridization.
- The hybridization orbitals have equivalent energies and identical shapes.

Types of Hybridization

- Tetrahedral or sp^3 -hybridization.
- Trigonal or sp^2 -hybridization.
- Diagonal or sp -hybridization.

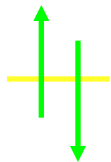
sp³ Orbital Hybridization

2p



Promote an electron from the 2s
to the 2p orbital

2s



sp³ Orbital Hybridization



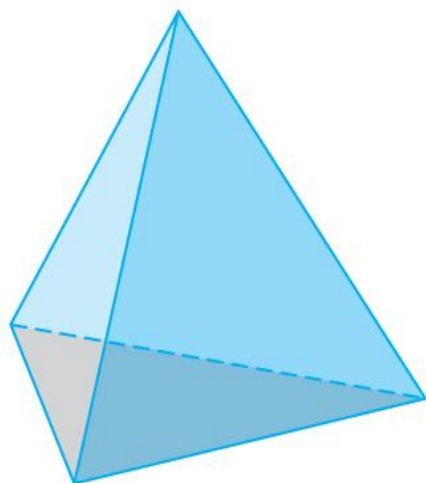
sp^3 Orbital Hybridization



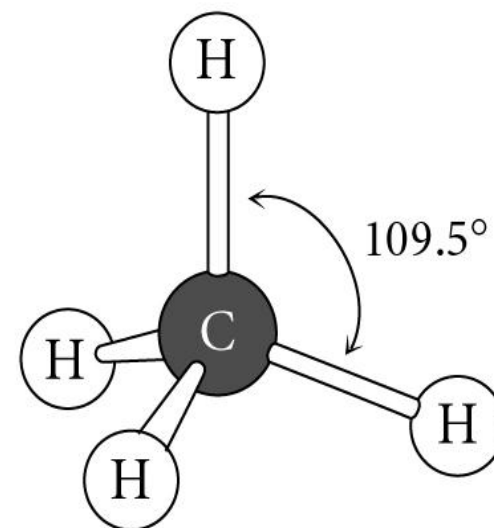
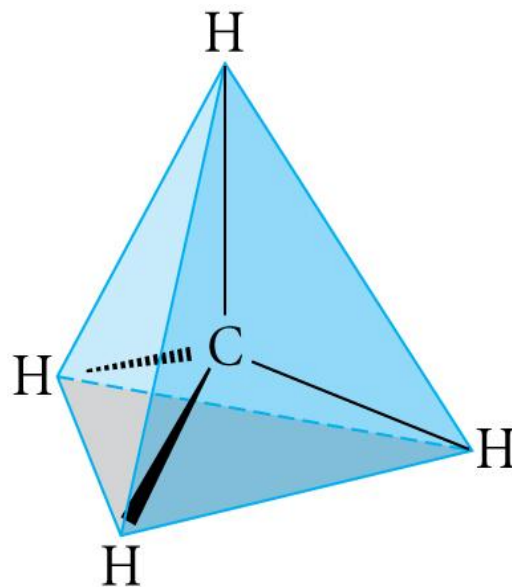
- Mix together (hybridize) the $2s$ orbital and the three $2p$ orbitals



Tetrahedral Geometry



a regular tetrahedron

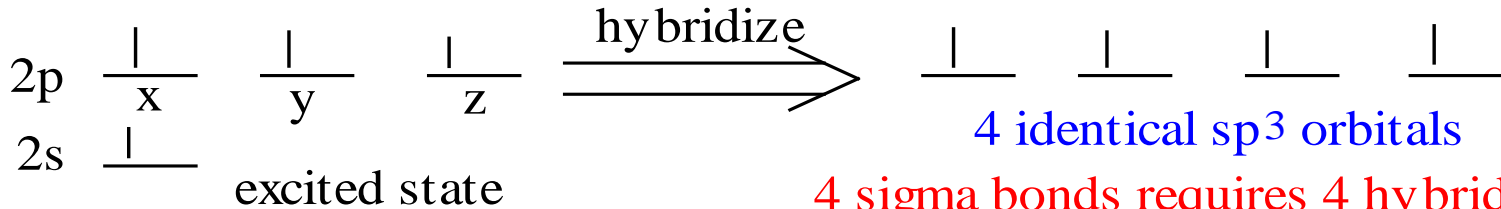
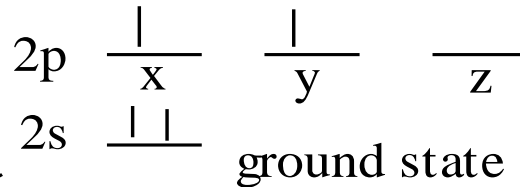
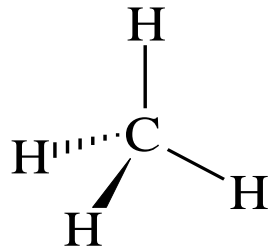


methane

sp³ Hybridization

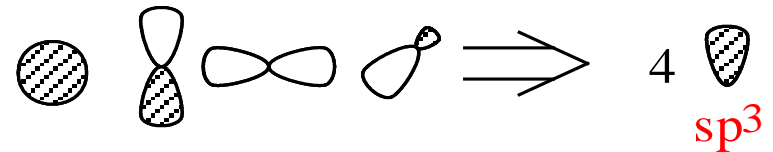
4 Regions of electron Density

CH₄

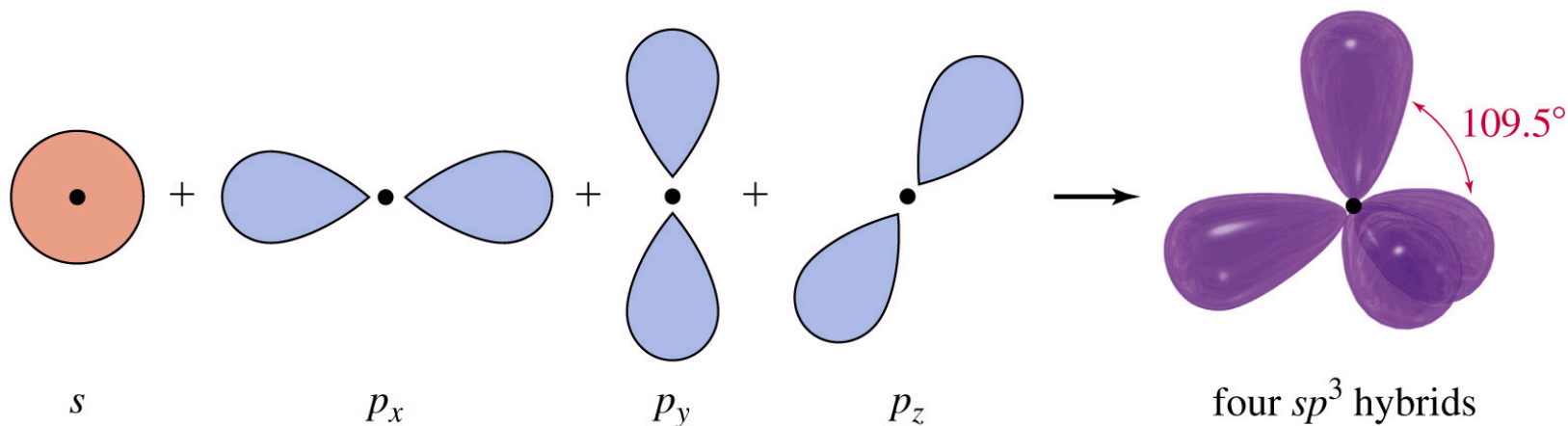


4 identical sp³ orbitals

4 sigma bonds requires 4 hybrid orbital:
tetrahedral geometry



Hybridization of 1 s and 3 p Orbitals – sp^3



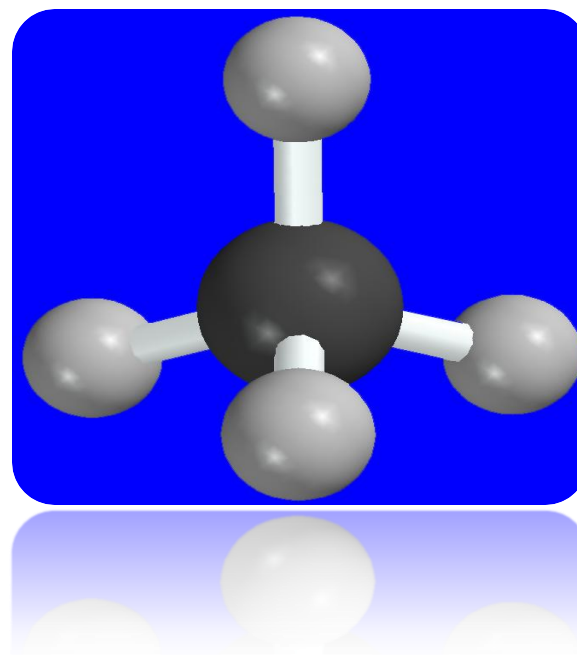
- Each of the four hybrid orbitals has **one-fourth** s-character and **three-fourth** p-character.
- This type of orbitals are formed when carbon atoms form only **single bonds** with other atoms.
- One of the lobes of an sp^3 orbital is larger than other, it can **overlap better** with another when it forms a bond therefore sp^3 hybrid orbitals forms **stronger bonds** then formed by unhybridised s or p orbitals.

Structure of Methane

tetrahedral

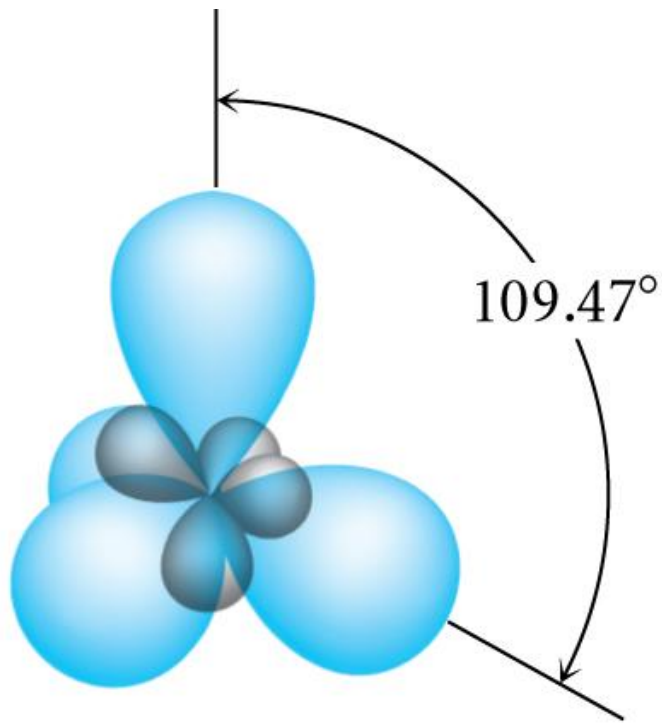
bond angles = 109.5°

bond distances = 110 pm

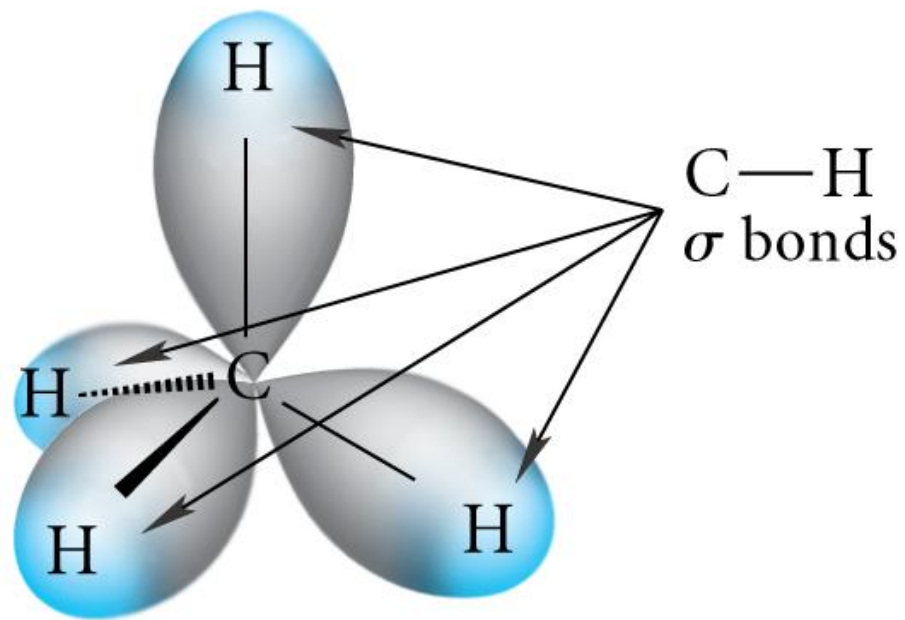


sp^3 is Tetrahedral Geometry

Methane



(c)



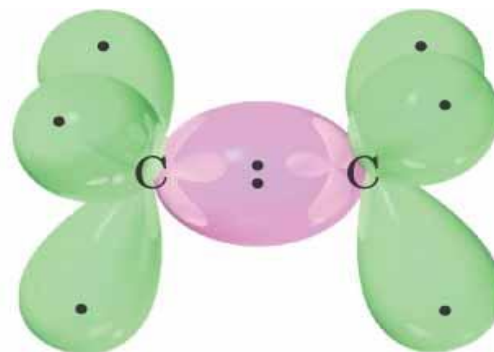
(d)



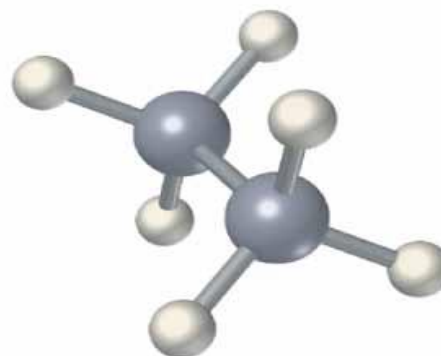
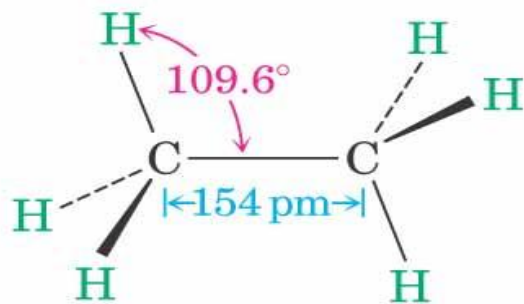
sp^3 carbon



sp^3 carbon

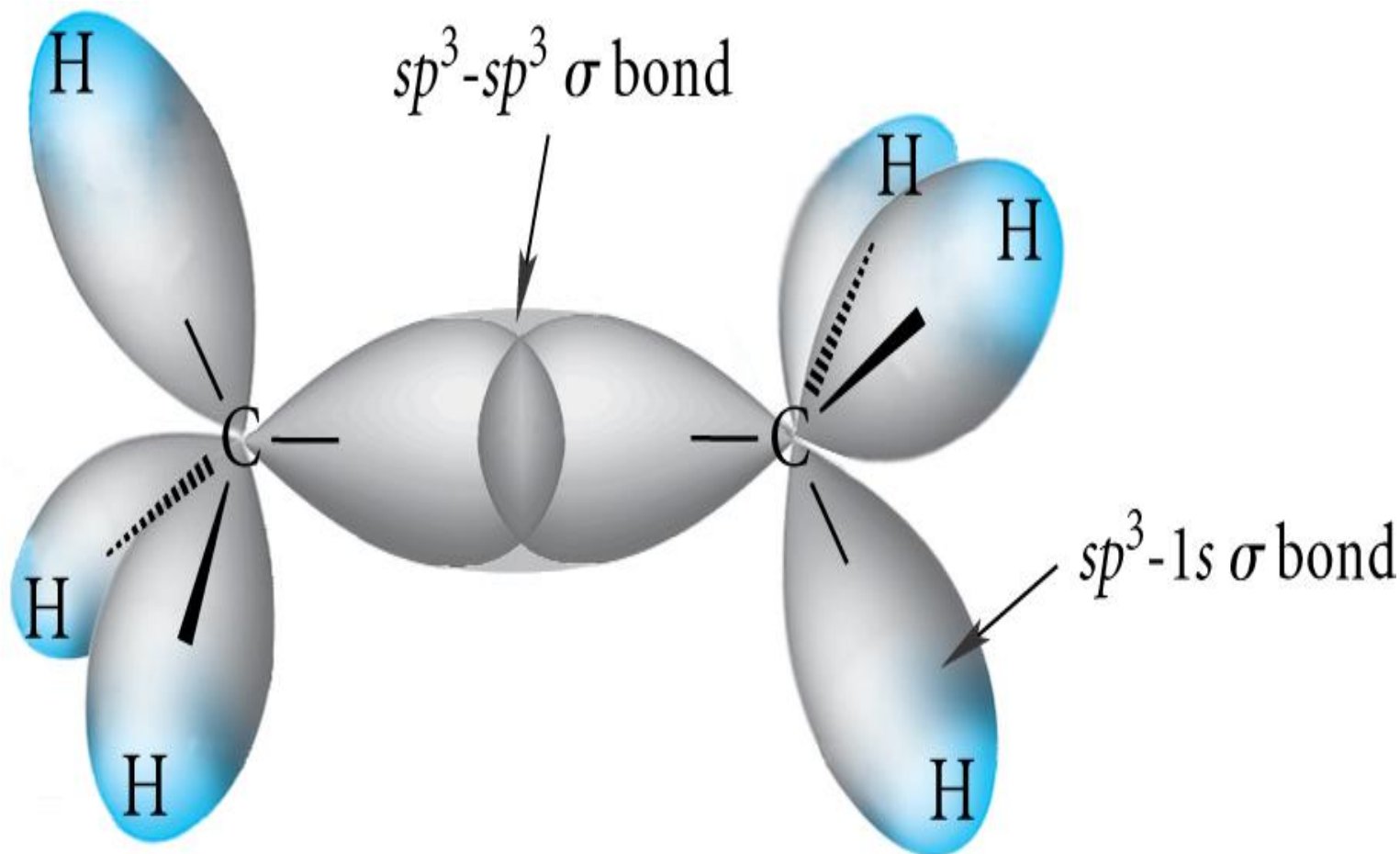


sp^3-sp^3 σ bond



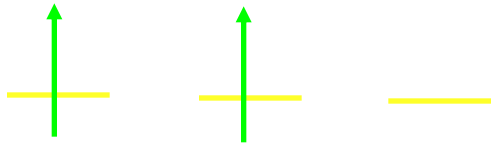
Orbital Depiction of Ethane, C_2H_6

the s bond



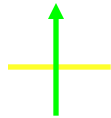
sp² Orbital Hybridization

2p

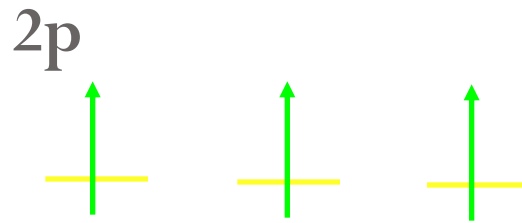
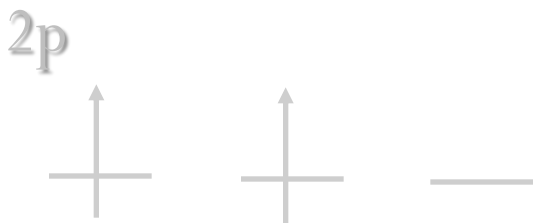


Promote an electron from the 2s
to the 2p orbital

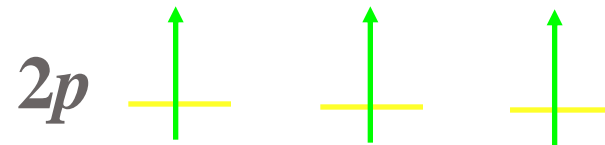
2s



sp² Orbital Hybridization



sp² Orbital Hybridization



Mix together (hybridize) the $2s$ orbital and two of the three $2p$ orbitals



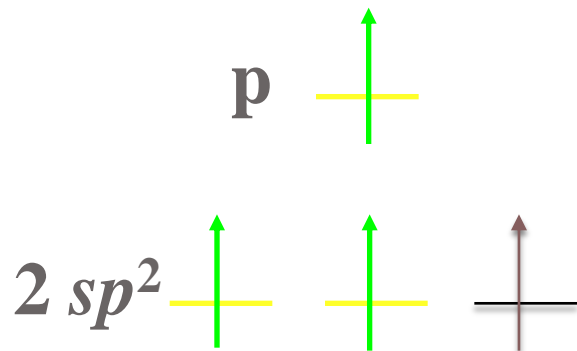
sp^2 Orbital Hybridization



3 equivalent half-filled sp^2 hybrid orbitals
plus 1 p orbital left unhybridized



sp² Orbital Hybridization



2 of the 3 sp^2 orbitals are involved in σ bond to hydrogen's; the other is involved in a σ bond in a σ bond to carbon

➤ The sp^2 hybrid orbitals has **one-third** s-character and **two-third** p-character.

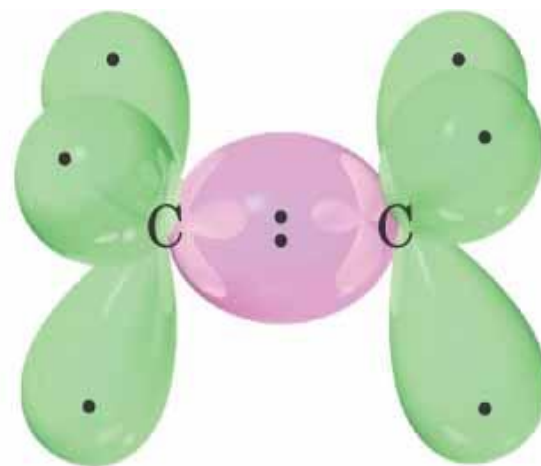
➤ This type of orbitals are formed when carbon atoms form only **double bonds** with other atoms.



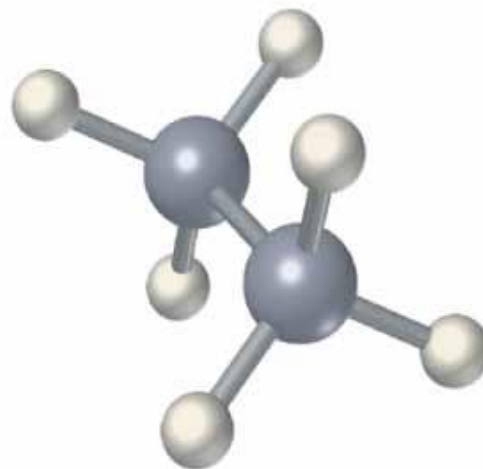
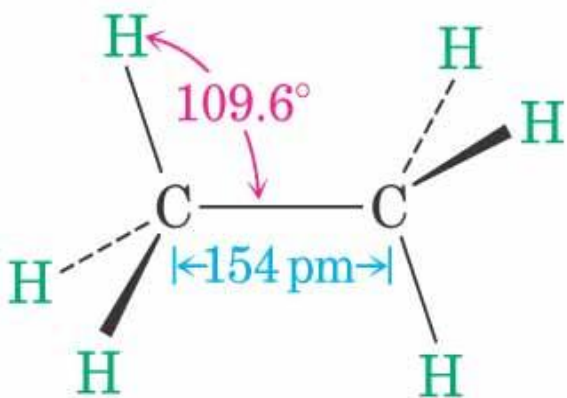
sp^3 carbon



sp^3 carbon

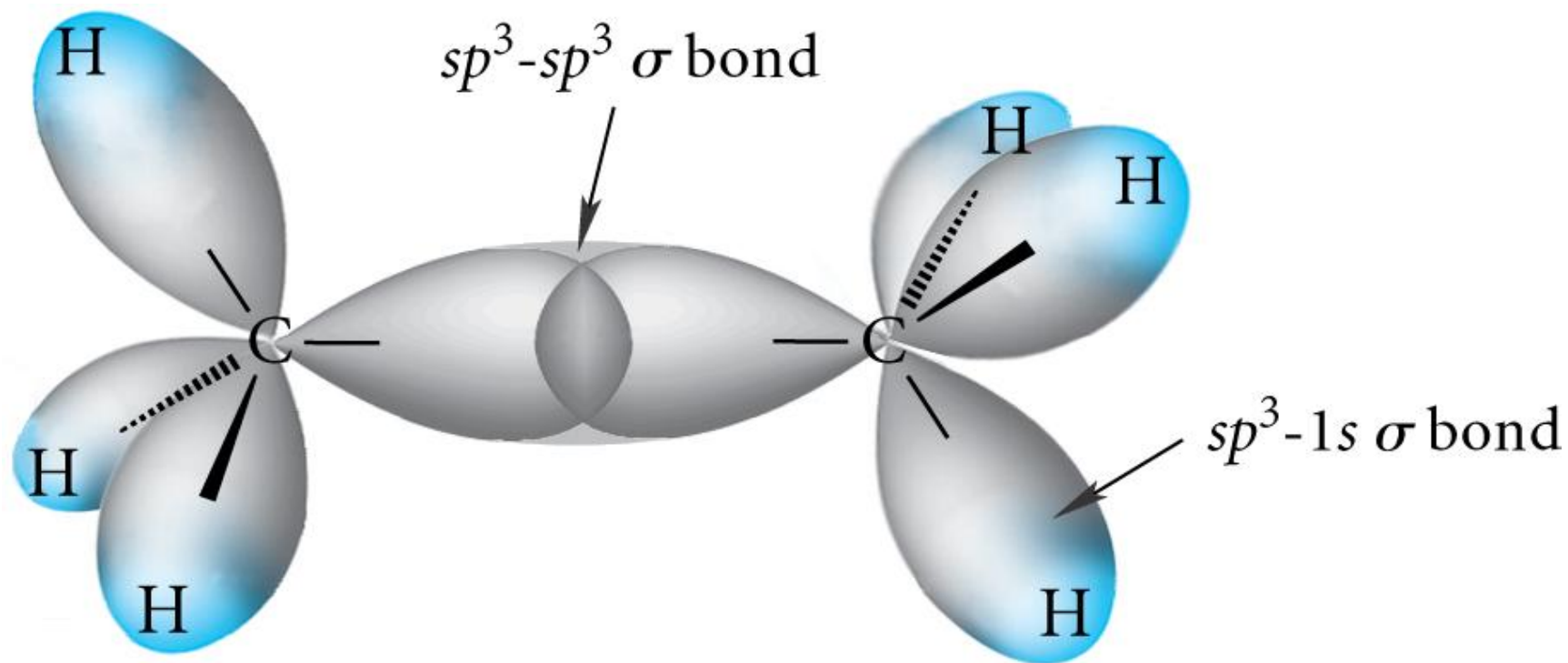


sp^3-sp^3 σ bond



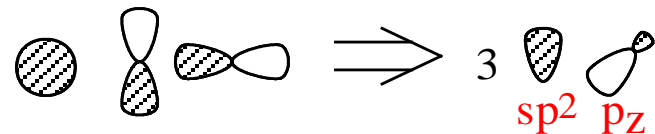
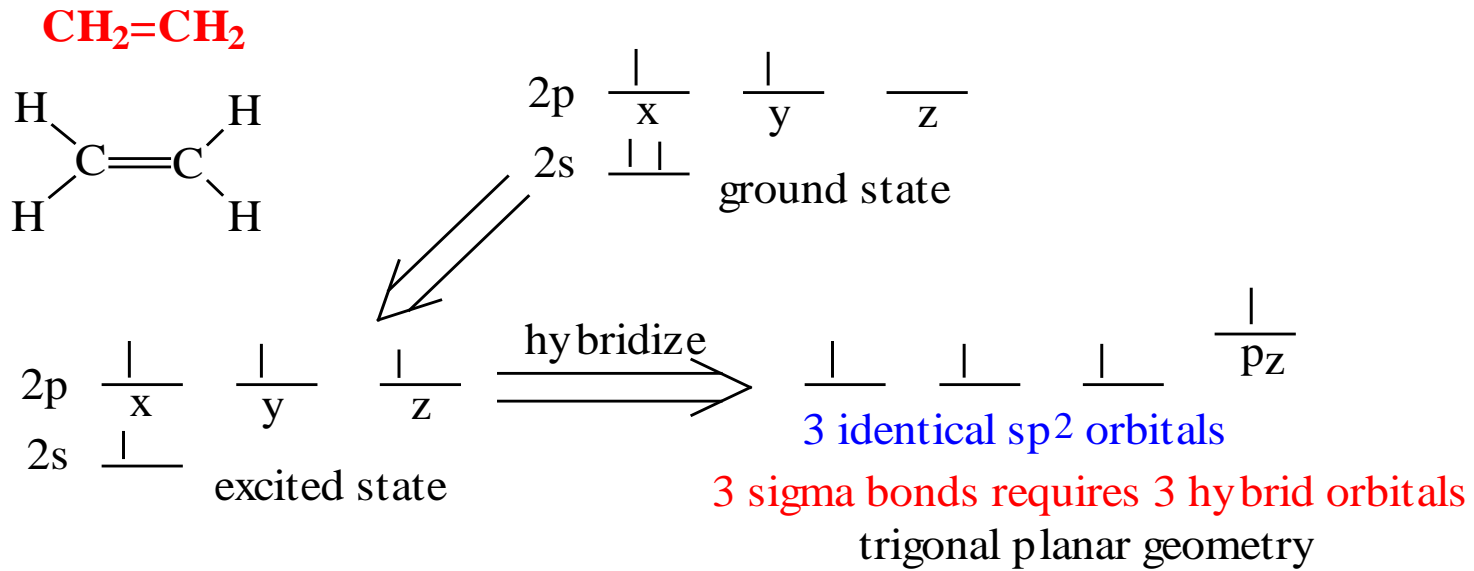
Orbital Depiction of Ethane, C_2H_6

the s bond

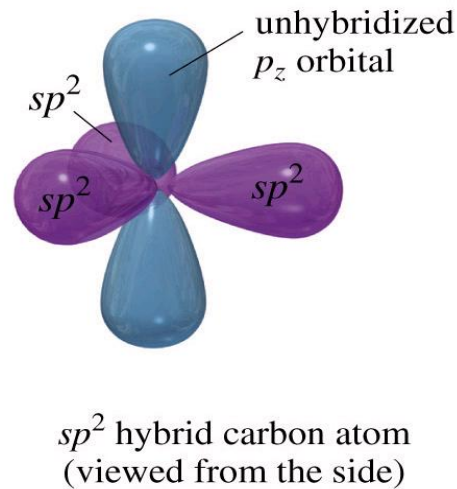
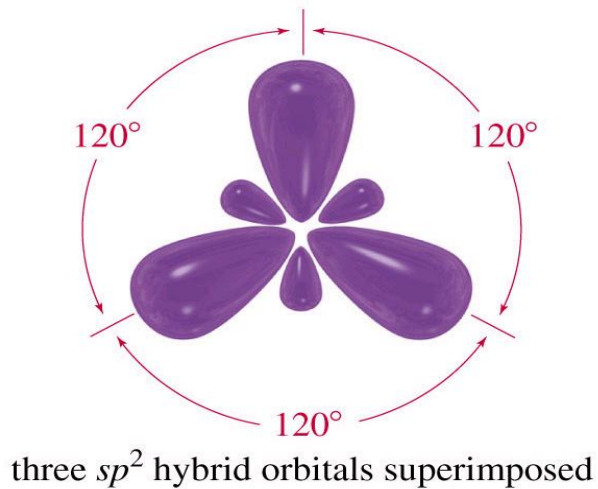
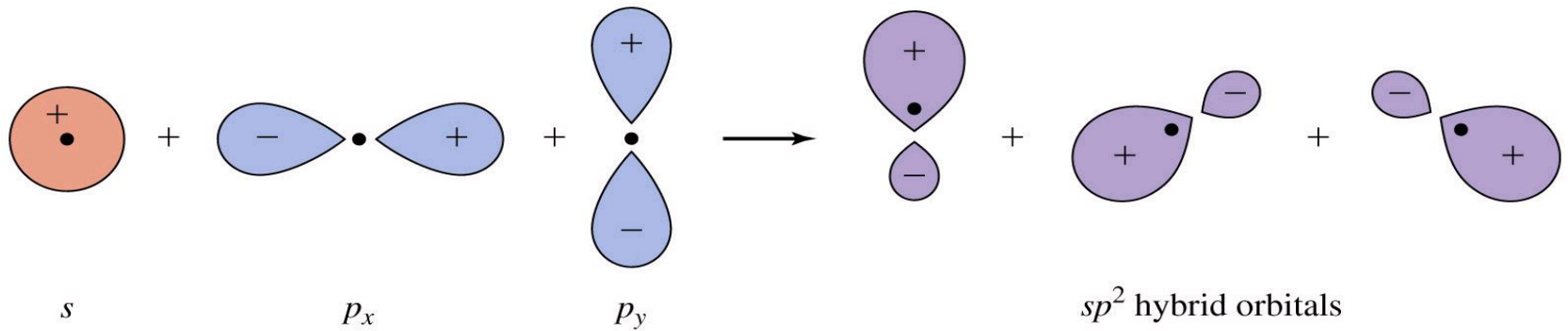


sp² Hybridization

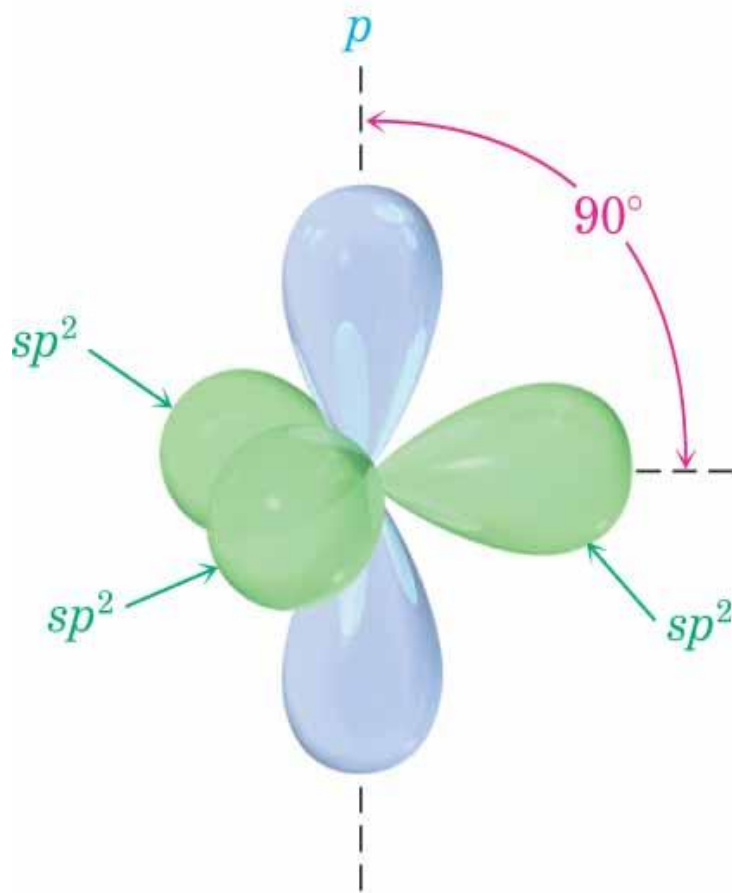
3 Regions of Electron Density



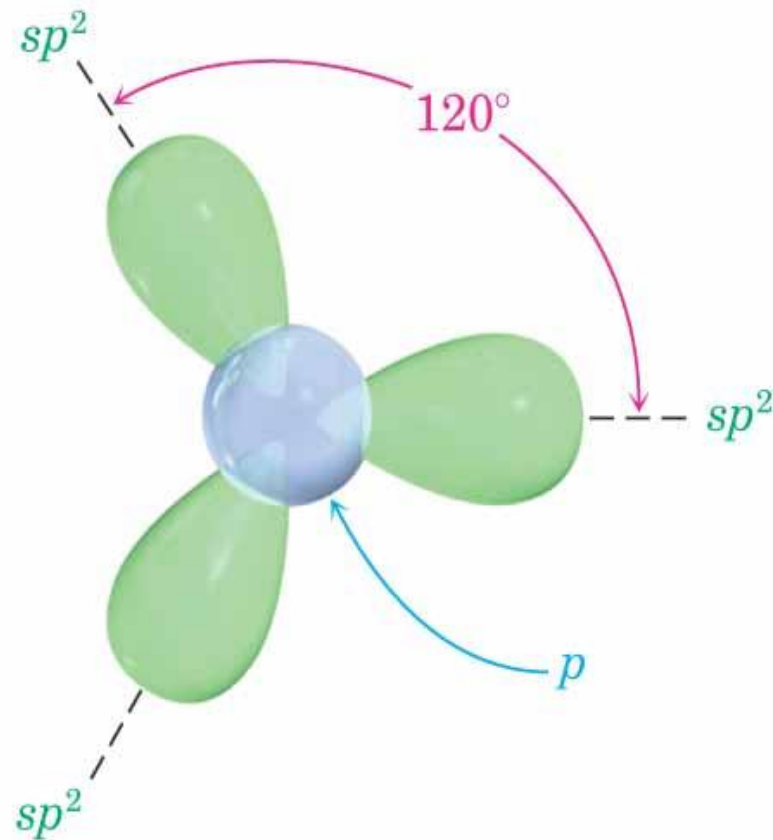
Hybridization of 1 s and 2 p Orbitals - sp^2



An sp^2 Hybridized Atom



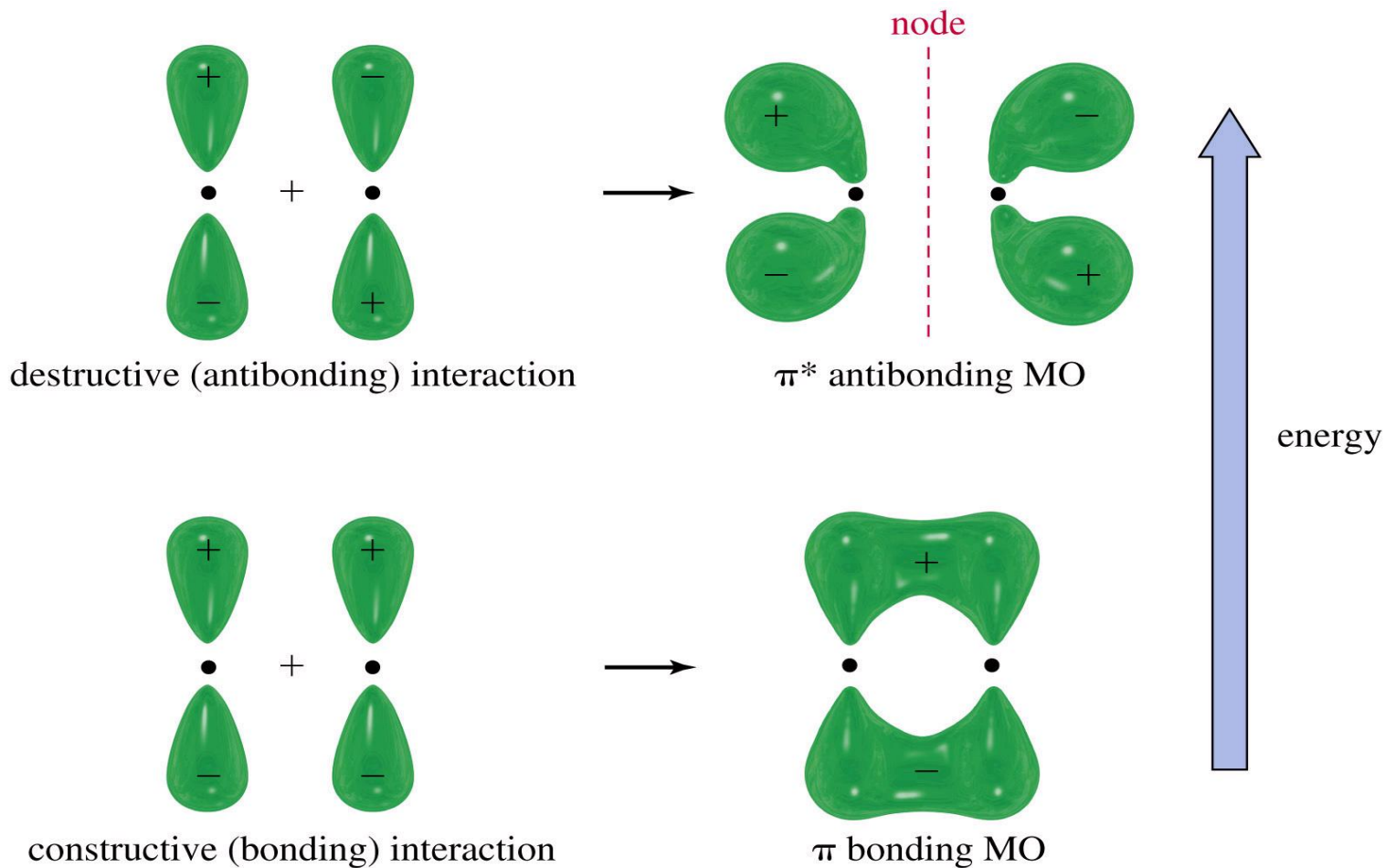
Side view



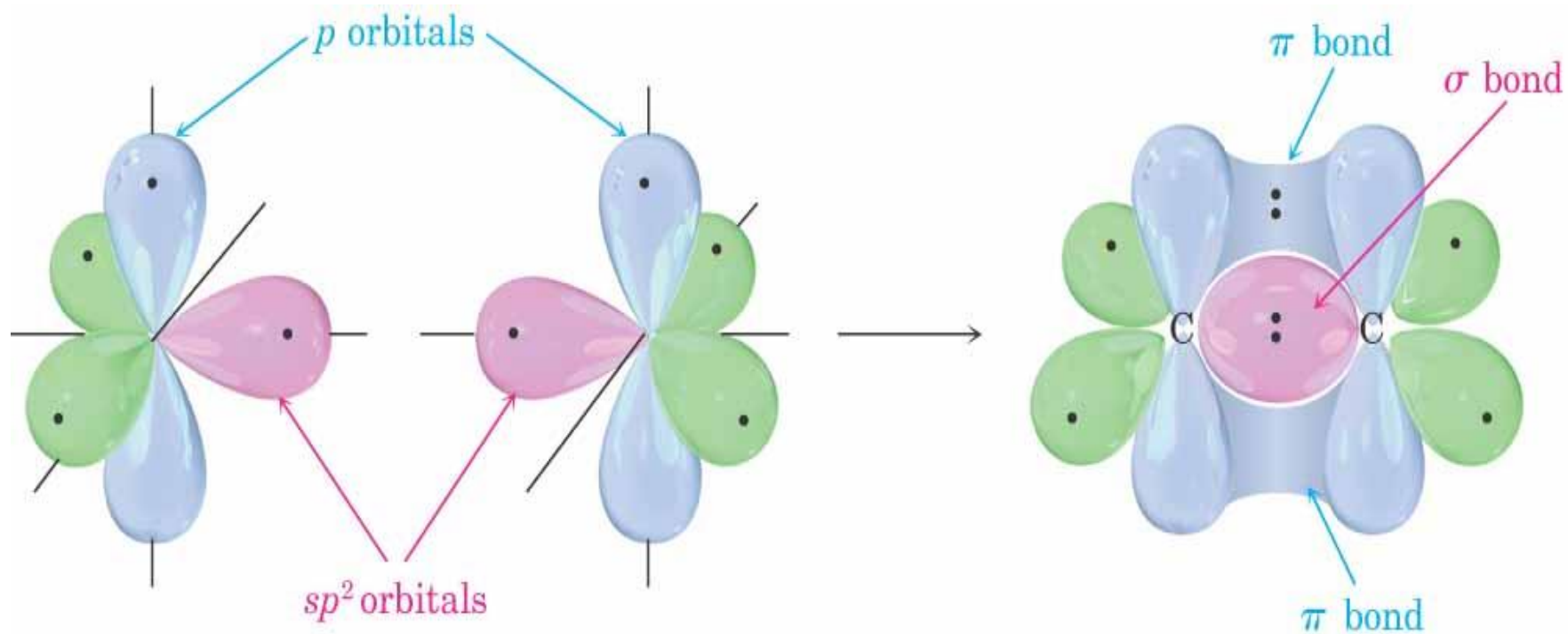
Top view

The p bond

Overlap of 2 parallel p Orbitals



Ethylene $\text{CH}_2=\text{CH}_2$

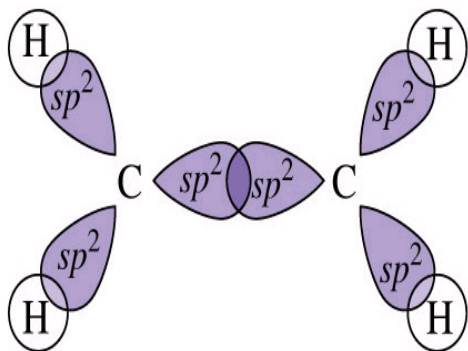


*sp*² carbon

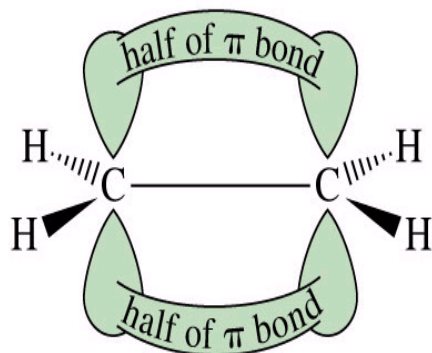
*sp*² carbon

Carbon-carbon double bond

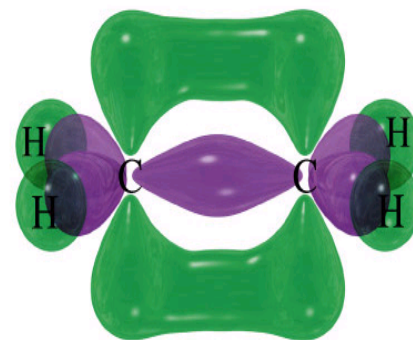
Views of Ethylene, C_2H_4



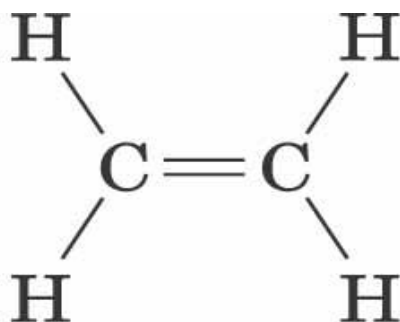
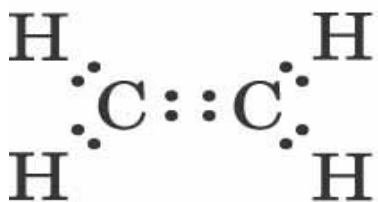
σ bond framework
(viewed from above the plane)



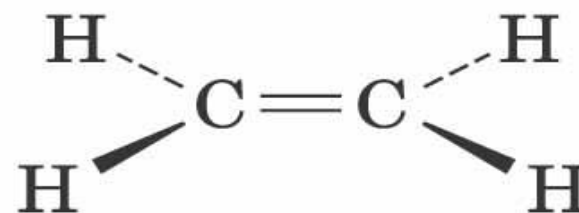
π bond
(viewed from alongside the plane)



ethylene



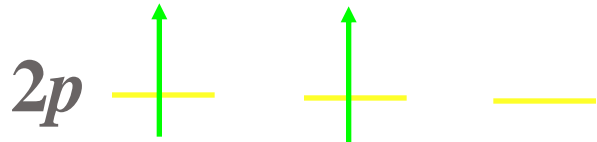
Top view



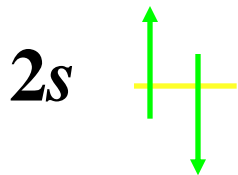
Side view

Ethylene

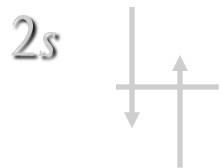
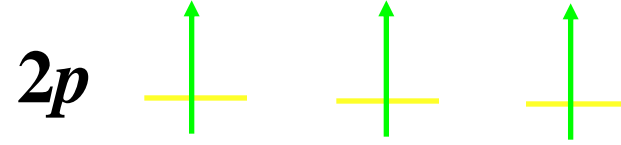
sp Orbital Hybridization



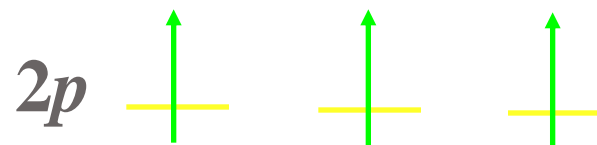
Promote an electron from the $2s$ to the $2p$ orbital



sp Orbital Hybridization



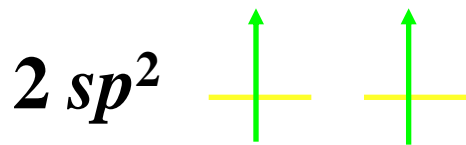
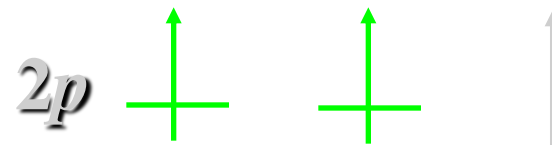
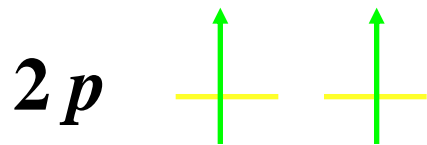
sp Orbital Hybridization



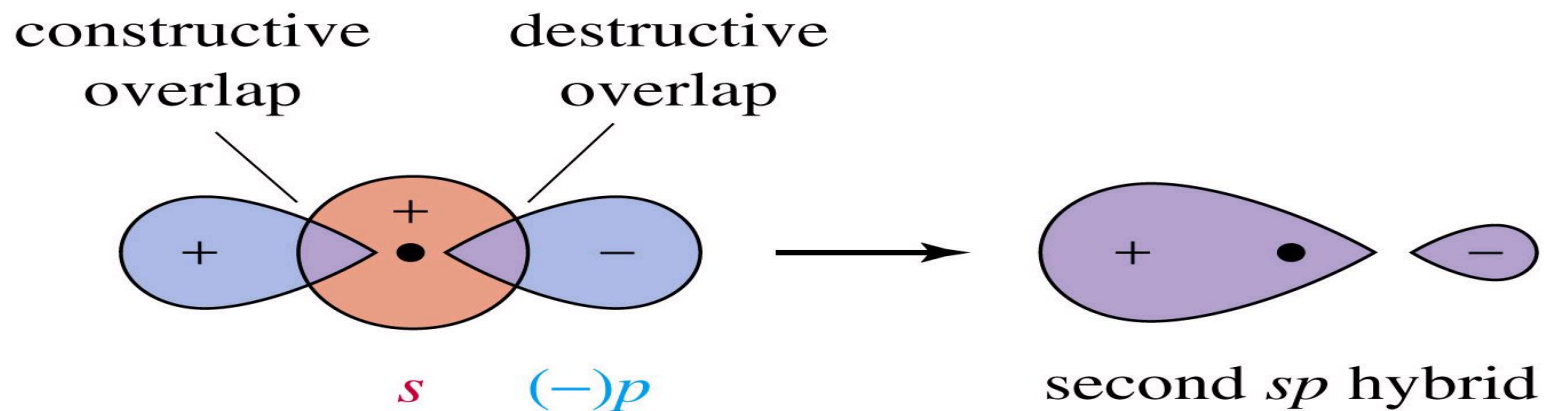
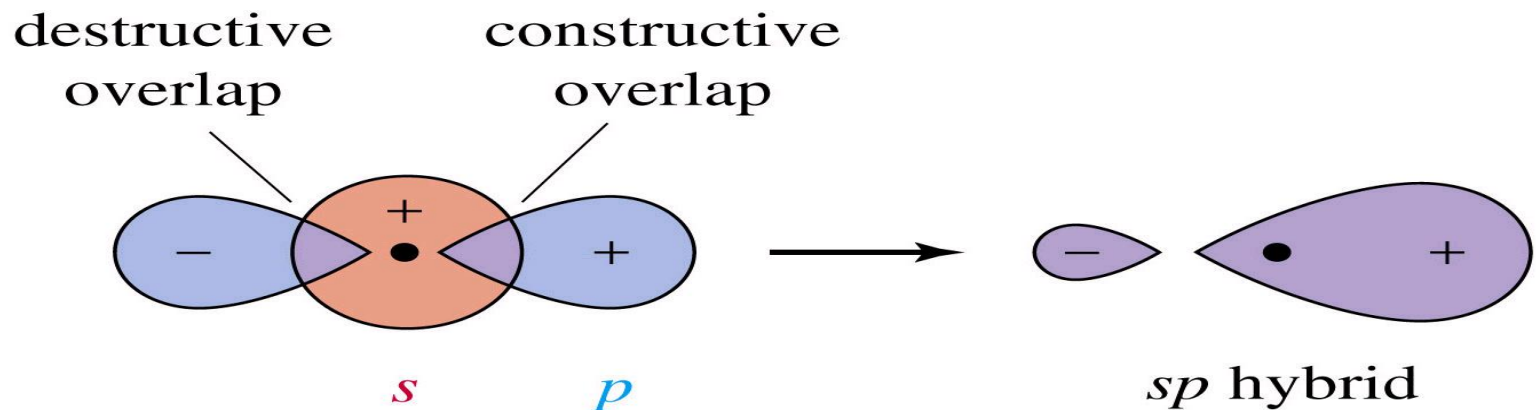
Mix together (hybridize) the $2s$ orbital and one of the three $2p$ orbitals



sp Orbital Hybridization



The sp Orbital

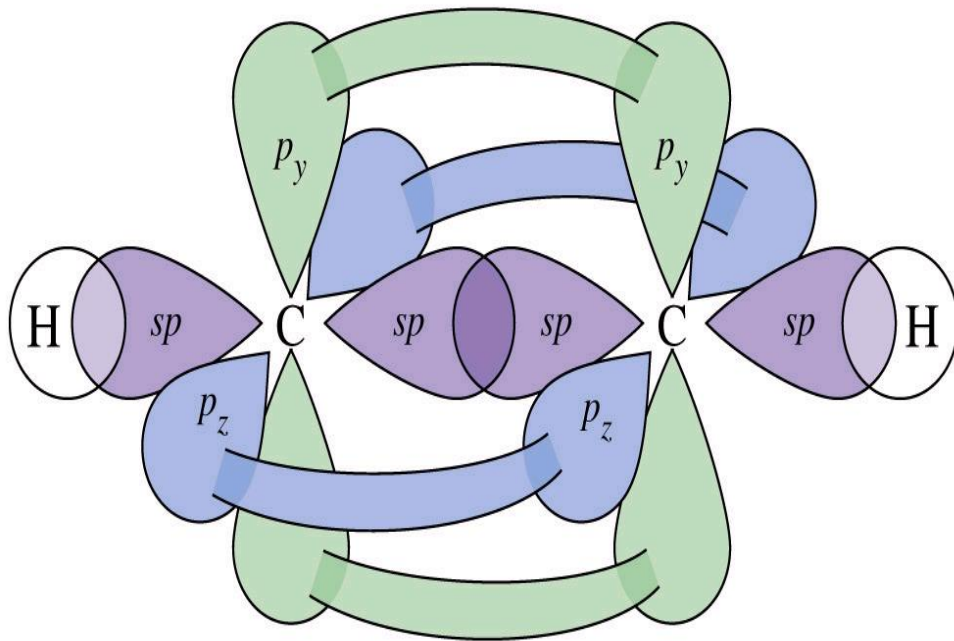


- The sp hybrid orbitals has **one-half** s-character and **one-half** p-character.
- This type of orbitals are formed when carbon atoms form only **triple bonds** with other atoms.

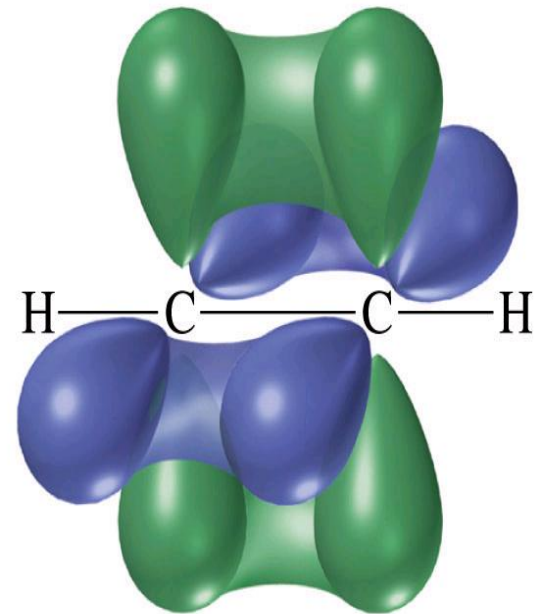
Acetylene, C_2H_2 ,

1 σ bond

2 perpendicular π bonds



acetylene



acetylene