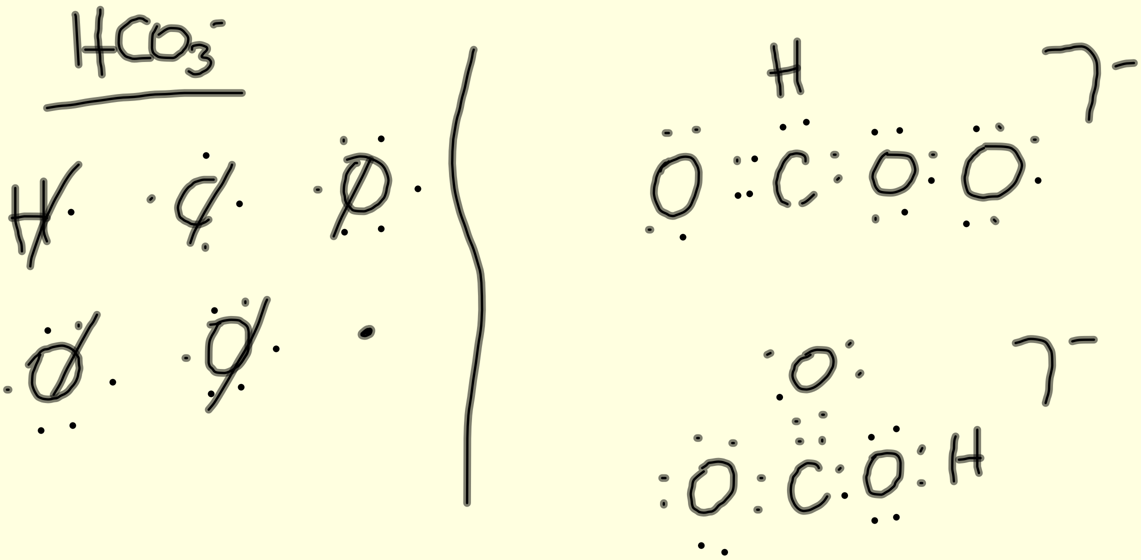
p. 225 #7-12

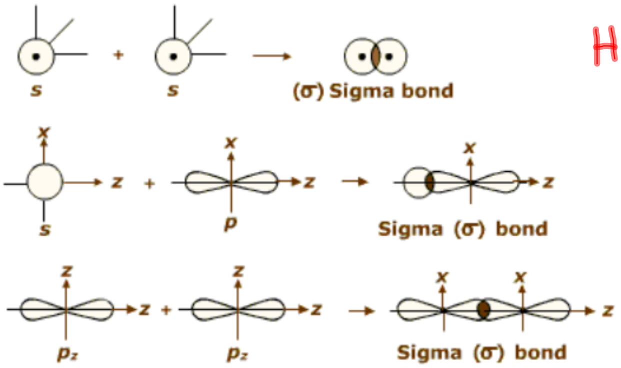


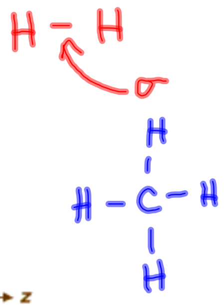
Molecular Orbitals

When two atoms share electrons to form a molecule, their atomic orbitals combine to produce molecular orbitals.
s, p

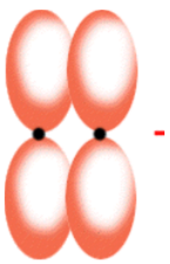
When the orbital is filled with two electrons, it is called a **bonding orbital**.

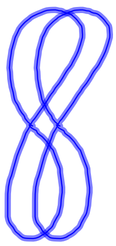
Sigma bond
Bond that forms when two atomic orbitals overlap head-on.
-strong bond



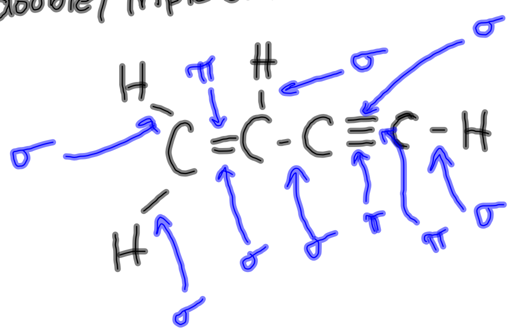


Pi bond
"p"
Bond that forms when two atomic orbitals overlap side-by-side.
-orbitals overlap less than in sigma bonds, thus the bonds are weaker than sigma bonds.

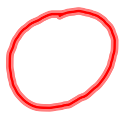




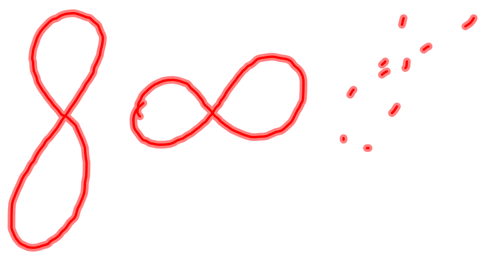
- double/triple bonds



s



p



$\underline{H_2}$

H·

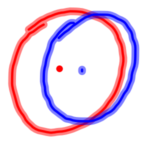
H·

H:H

1s 1s ↑ ↑

H H

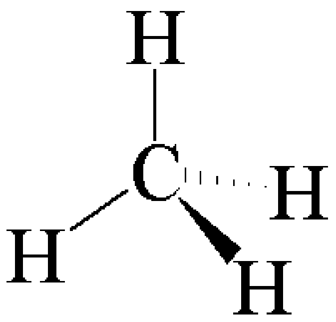
H_2



VSEPR Theory

Valence-Shell Electron-Pair Repulsion Theory
Repulsion between electron pairs causes molecular shapes to adjust so that the valence-electron pairs are as far apart as possible.

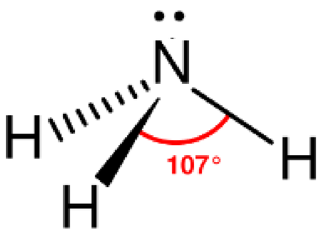
Ex. CH_4



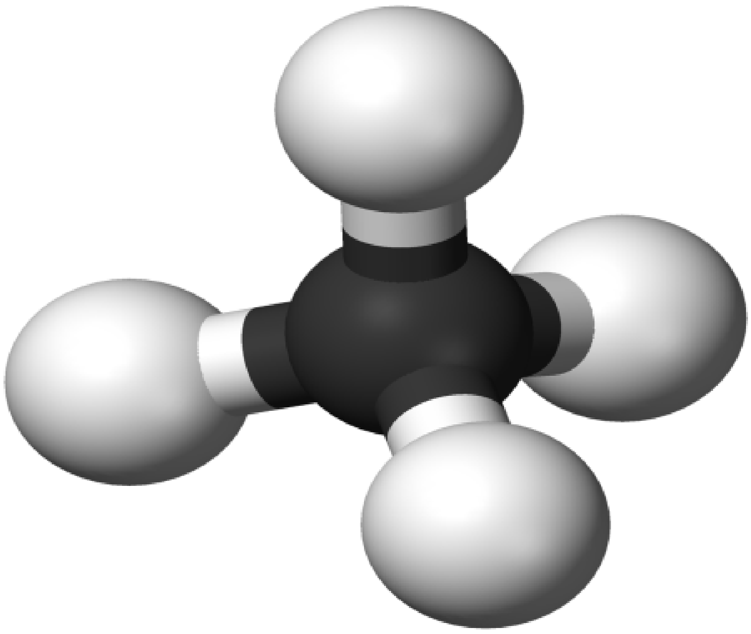
tetrahedral angle (109.5°)

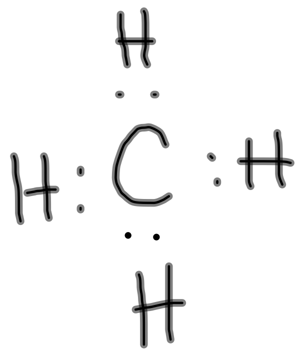
Ex. NH_3

Lone pairs (unshared pairs) also affect the shapes of molecules.



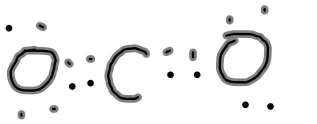
tetrahedral (pyramidal)

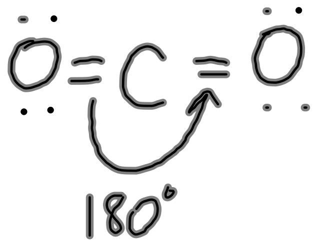




Ex. CO_2

When predicting molecular shapes, double and triple bonds are treated as single bonds.

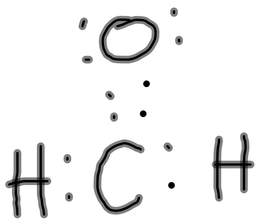


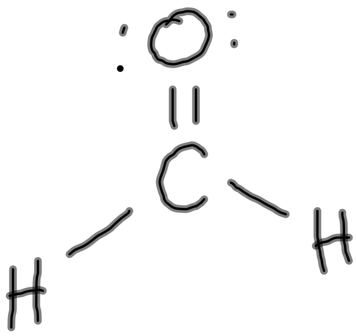


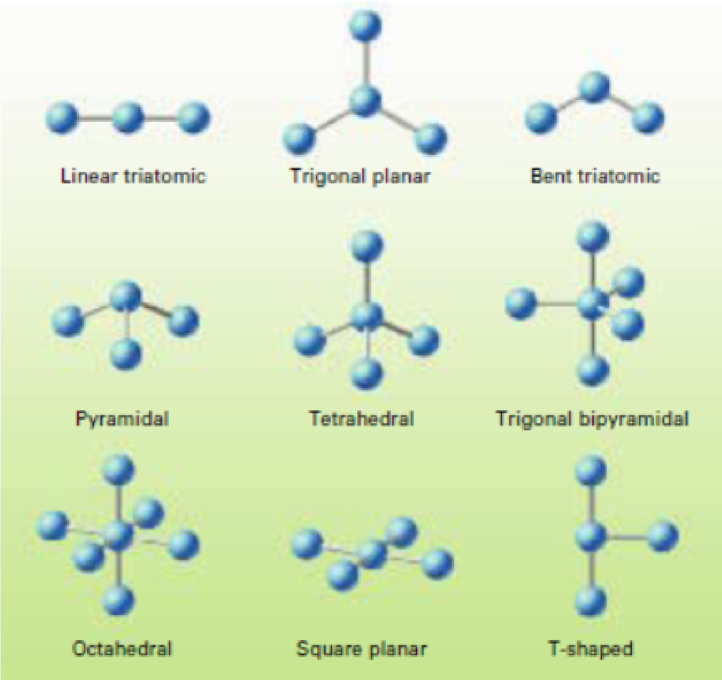
linear

Ex. CH_2O

trigonal planar (120°)





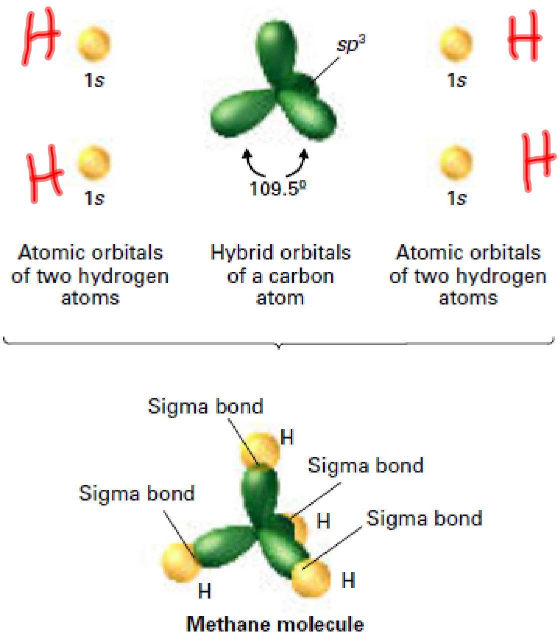

Linear triatomic
Trigonal planar
Bent triatomic
Pyramidal
Tetrahedral
Trigonal bipyramidal
Octahedral
Square planar
T-shaped

Hybridization Involving Single Bonds

In **hybridization**, atomic (s, p) orbitals mix to form the same total number of equivalent hybrid orbitals.

Ex. CH_4

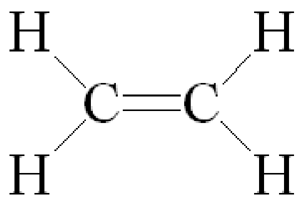
The one *2s* orbital and three *2p* orbitals of a carbon atom mix to form four sp^3 hybrid orbitals.



$$s + p_x + p_y + p_z \rightarrow \underbrace{sp^3 + sp^3 + sp^3 + sp^3}_{4\sigma}$$

Hybridization Involving Double Bonds

Ex. C_2H_4

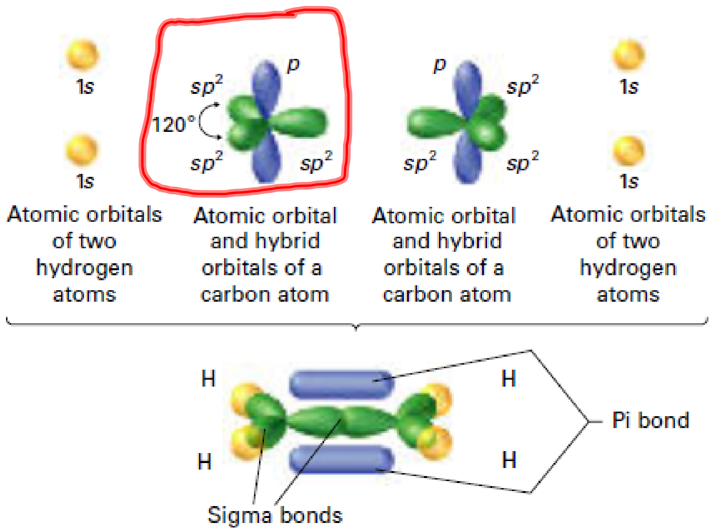


The one *2s* orbital and two *2p* orbitals of each carbon atom mix to form three sp^2 hybrid orbitals.

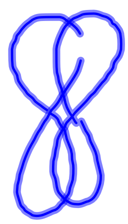
Two of the sp^2 orbitals overlap with the *1s* hydrogen orbital to form carbon-hydrogen sigma bonds.

The third sp^2 orbital overlaps with an sp^2 orbital from the other carbon to form a carbon-carbon sigma bond.

The non-bonding *2p* orbitals overlap side-by-side to form a carbon-carbon pi bond.



Ethene molecule



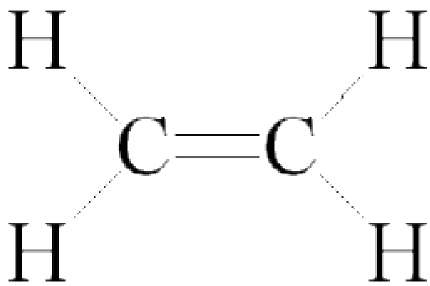
$H-C \equiv C-H$

2σ

$s + p_x \longrightarrow sp + sp$

$p_y \longleftarrow \pi$

$p_z \longleftarrow \pi$



$$s + p_x + p_y \longrightarrow sp^2 + sp^2 + sp^2$$

$$3\sigma$$

$$p_z$$

$$\downarrow$$

$$\pi$$

Hybridization Involving Triple Bonds

Ex. C_2H_2

The one *2s* orbital and one *2p* orbitals of each carbon atom mix to form two *sp* hybrid orbitals for each carbon.

One of the *sp* orbitals overlap with the *1s* hydrogen orbital to form carbon-hydrogen sigma bonds.

The second *sp* orbital overlaps with the *sp* orbital from the other carbon to form a carbon-carbon sigma bond.

The non-bonding *2p* orbitals overlap side-by-side to form two carbon-carbon pi bonds.