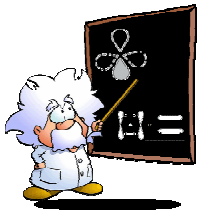
Name:_____ **Date:**_____ **Class Notes**
Chemistry

Valence Bond Theory



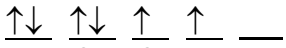
The valence bond theory describes how the molecular shapes and molecular orbitals are formed by the overlapping of **hybridized atomic orbitals**. The idea that hybrid orbitals are formed is used to help explain how atoms can have bonds of equal energy even though the electrons are in different orbitals. The carbon atom for example has two electrons in an s-orbital and two p-orbitals with one electron each, but we know that carbon forms four equal bonds. How is this possible? **Hybridization!**

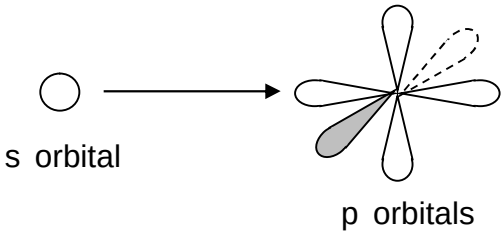
Remember: Molecules refer to covalent compounds only.

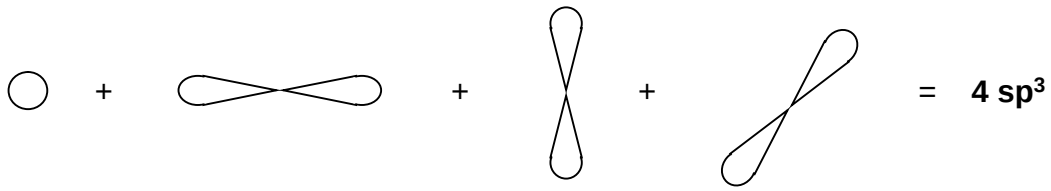
Hybrid Orbitals

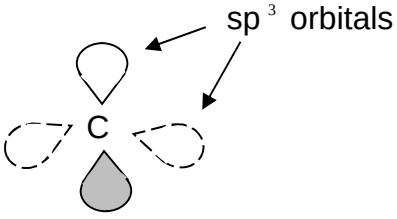
Hybridization is the mixing of a set of unequal orbitals on an atom to obtain a new set of equal orbitals with properties somewhere between the original unequal orbitals. Hybridization occurs on the central atom and does not always occur. The number of new hybridized orbitals always equals the number of orbitals used for hybridization. The name for the new hybridized orbitals reflects the number and kind of orbitals used. Both the energy and shape are changed by the hybridization.

Example:

Carbon 



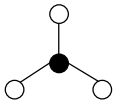
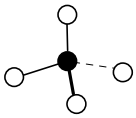
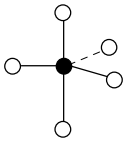
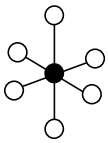




Note: Superscripts are used to indicate the number of "p" and "d" orbitals used in the hybridization.

Hybrid Orbitals and Shape

Orbital hybridization occurs on the central atom of a molecule. The energy of each new hybridized orbital is equal and moves as far away from each other as possible. This repulsion is believed to give the molecule its shape.

HYBRIDIZATION	SHAPE
"s" + "p" = 2 sp	linear 
"s" + 2 "p" = 3 sp^2	trigonal planar 
"s" + 3 "p" = 4 sp^3	tetrahedral 
"s" + 3 "p" + "d" = 5 sp^3d	trigonal bi-pyramidal 
"s" + 3 "p" + 2 "d" = 6 sp^3d^2	octahedral 

Molecular orbitals

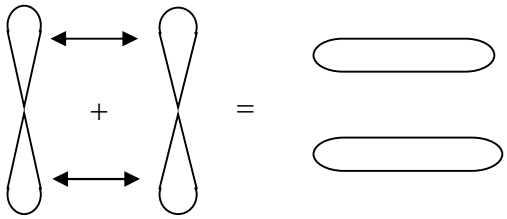
Molecular Orbitals are formed by the over-lapping of atomic orbitals from different atoms to create a molecule.

sigma bonds (σ) – a molecular orbital (MO) created by the overlapping of atomic orbitals parallel to the plane

pi bonds (π) – a molecular orbital (MO) created by the overlapping of atomic orbitals perpendicular to the plane

SIGMA BONDS

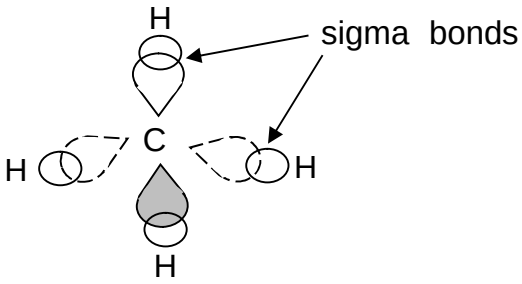
PI BONDS



Sigma Bond (MO)

Single chemical bonds – create one sigma bond

CH_4



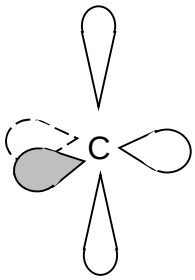
The above is the **overlap diagram** for the methane molecule

Pi Bond (MO)

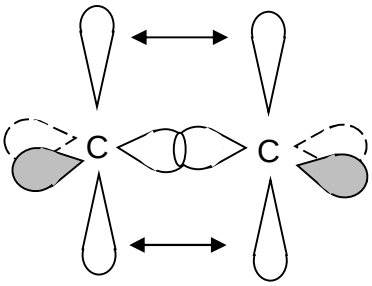
Double chemical bonds – consists of one sigma bond and one pi bond

Carbon with 4 bonds

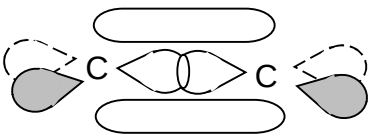
carbon with 3 sp^2 bonds and a p-orbital



Carbon forming a double bond

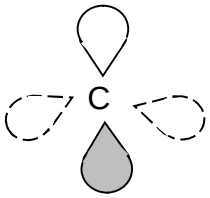


carbon with 3 sp^2 bonds and a pi-orbital

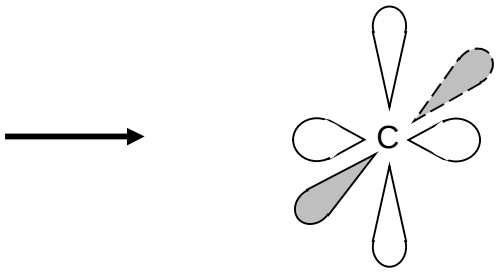


Triple chemical bonds – consists of one sigma bond and two pi bond

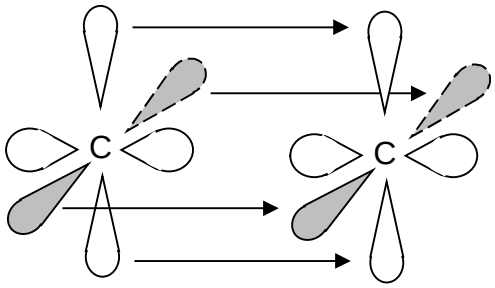
Carbon with 4 bonds



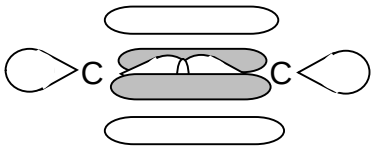
carbon with 2 sp bonds and 2 p-orbitals



Carbon forming a triple bond



carbon with 2 sp bonds and a 2 pi-orbital

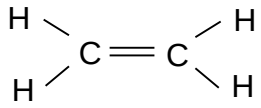


Overlap Diagramming steps

1. Determine the VSEPR shape for the molecule.
2. Determine the number of sigma and pi bonds on each central atom.
3. Determine hybridization.

Example:

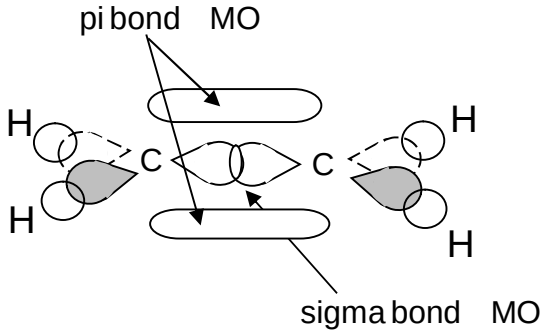
C_2H_4



Central atom: carbon

3 sigma bonds
1 pi bond

Hybridization: 3 sp^2



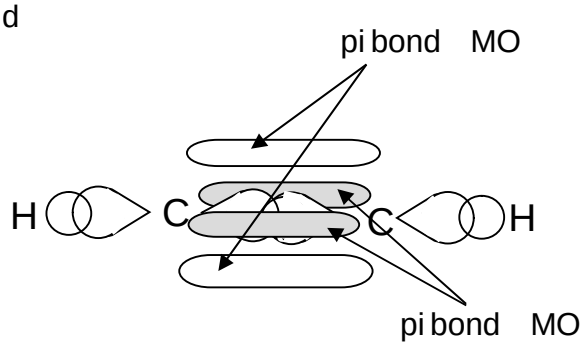
Example:

C_2H_2

H — C ≡ C — H

Central atom: carbon 2 sigma bonds
2 pi bond

Hybridization: 2 sp



Practice: Draw the overlap diagram for the following molecule

BF_3

"Imagination is more important than knowledge. For knowledge is limited to all we know and understand, while imagination embraces the entire world, and all there ever wil be to know and understand."

--Albert Einstein