

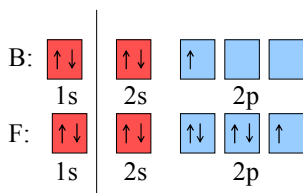
Chemical Bonding 4.8

Valence Bond Theory
Hybrid Orbital Theory
Multiple Bonds

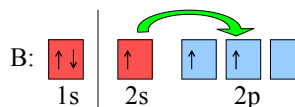
Valence Bond Theory

- Combines Lewis' theory of filling octets by sharing pairs of electrons with the electron configuration of atomic orbitals.
- Valence Bond Theory states that bonding occurs when atomic orbital overlap.

Building BF_3 with Valence Bond Theory

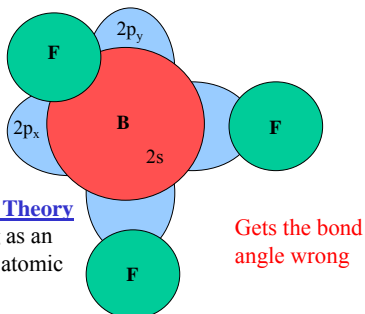


Building BF_3 with Valence Bond Theory



Boron enters an excited state where an electron from the 2s orbital is promoted to the 2p_y orbital.

Valence Bond Theory has problems with the shape



Valence Bond Theory
Views bonding as an overlapping of atomic orbitals.

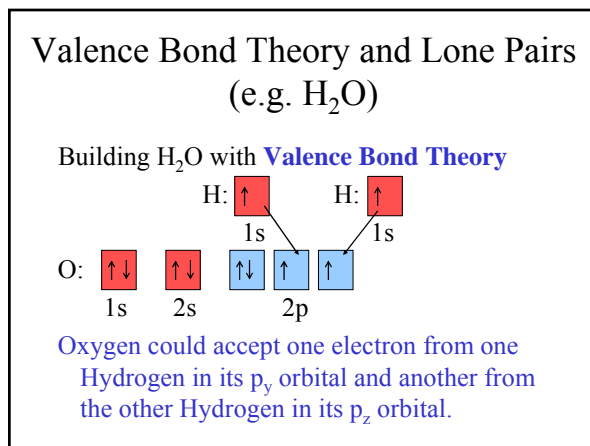
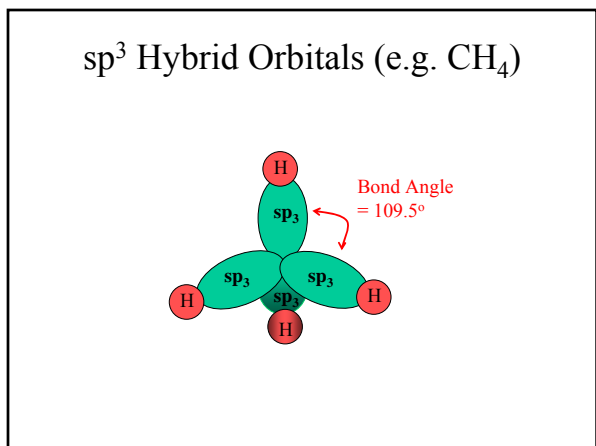
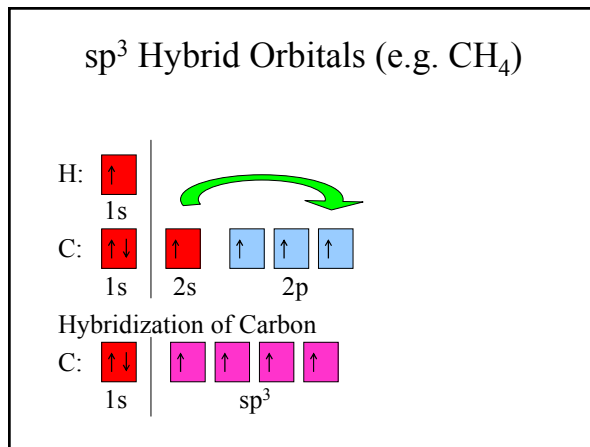
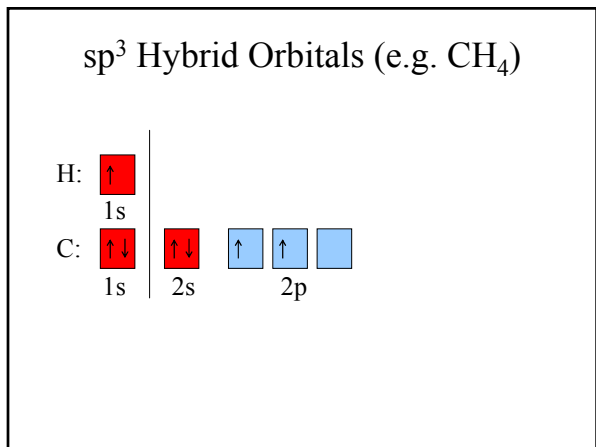
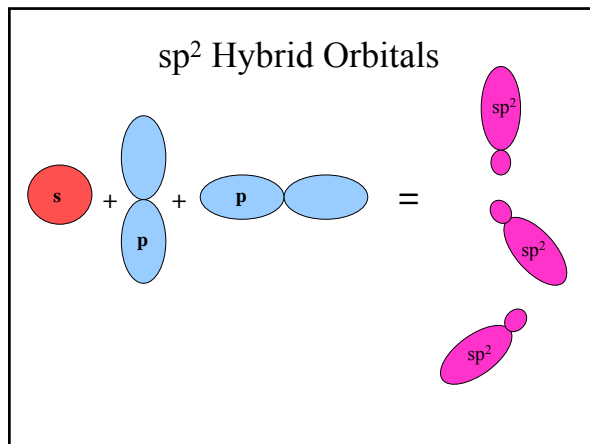
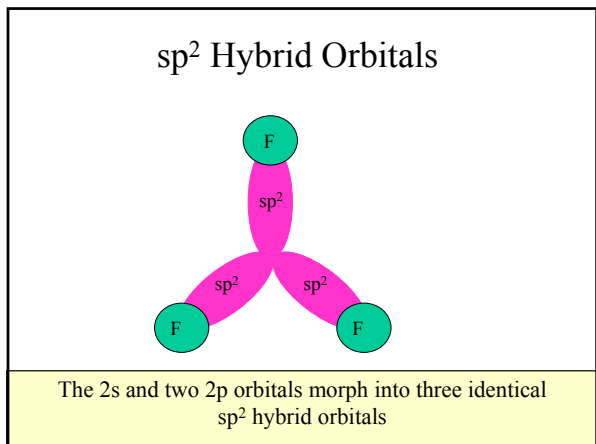
Problems with Valence Bond Theory and BF_3

Problem (the bond angle is wrong)

- Valence Bond Theory says 90° and a random angle for the fluorine bonded to the s-orbital.
- VSEPR theory says 120°

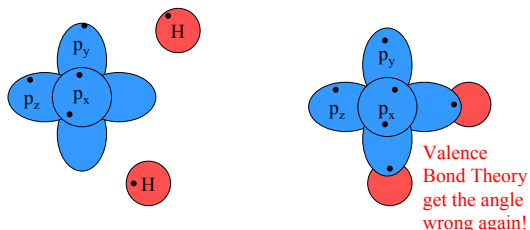
Solution (Hybrid Orbitals)

- When the electron is promoted, the 2s, 2p_x, and 2p_y orbitals of boron morph into three separate **sp² hybrid orbitals** that are identical in shape and size.



Valence Bond Theory and Lone Pairs (e.g. H₂O)

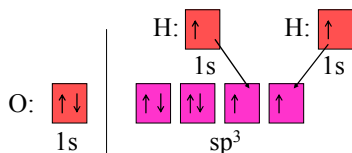
- Valence Bond Theory views bonding as an overlapping of atomic orbitals.



Problems with Valence Bond Theory in the H₂O Example

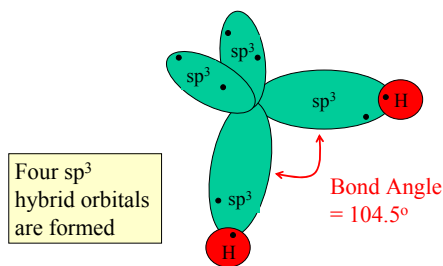
- The bond angle is wrong.
 - Valence Bond Theory predicts 90°
 - VSEPR Theory predicts 104.5°
- The orbital shape must be wrong.
 - Shared electrons are not spending enough time with the Hydrogen.

Hybrid Orbital Theory and Lone Pairs (e.g. H₂O)

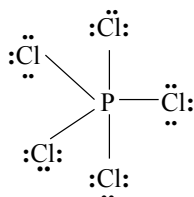


Electrons are not promoted here, but every orbital in the $n = 2$ energy level becomes hybridized.

sp³ Hybrid Orbitals (H₂O)

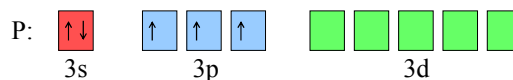


Hybrid Orbital Theory and 5 Charge Clouds! (e.g. PCl₅)

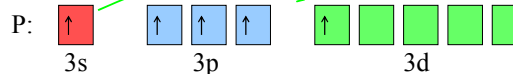


sp³d Hybrid Orbitals

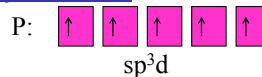
Atomic Orbitals



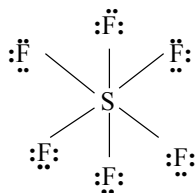
Promotion



Hybridization

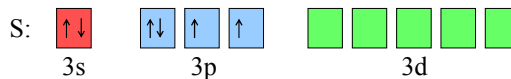


Hybrid Orbital Theory and 6 Charge Clouds! (e.g. SF₆)

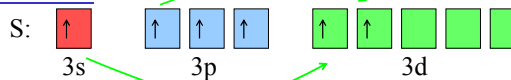


sp³d² Hybrid Orbitals

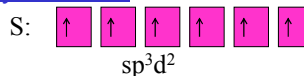
Atomic Orbitals



Promotion



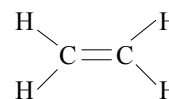
Hybridization



Summary

Charge Clouds	Hybridization
2	sp
3	sp ²
4	sp ³
5	sp ³ d
6	sp ³ d ²

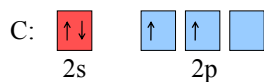
Double Bonds (e.g. C₂H₄)



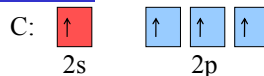
Each carbon has 3 charge clouds.
sp² hybrid orbitals

Double Bonds (e.g. C₂H₄)

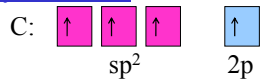
Atomic Orbitals



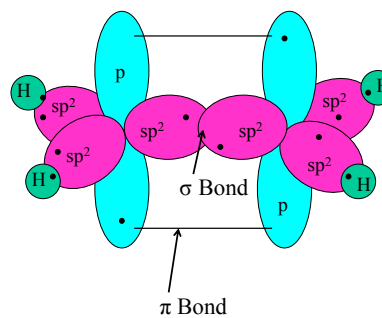
Promotion



Hybridization



Double Bond (C₂H₄)



Triple Bonds (e.g. C₂H₂)

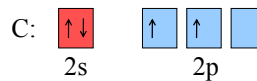


Each carbon has two charge clouds.

sp hybrid orbitals

Triple Bonds (e.g. C₂H₂)

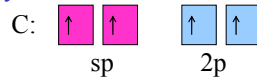
Atomic Orbitals



Promotion



Hybridization



Triple Bond (C₂H₂)

