

Localized Electron Model

Models for Chemical Bonding

Localized electron model

(Valence bond model)

Molecular orbital model

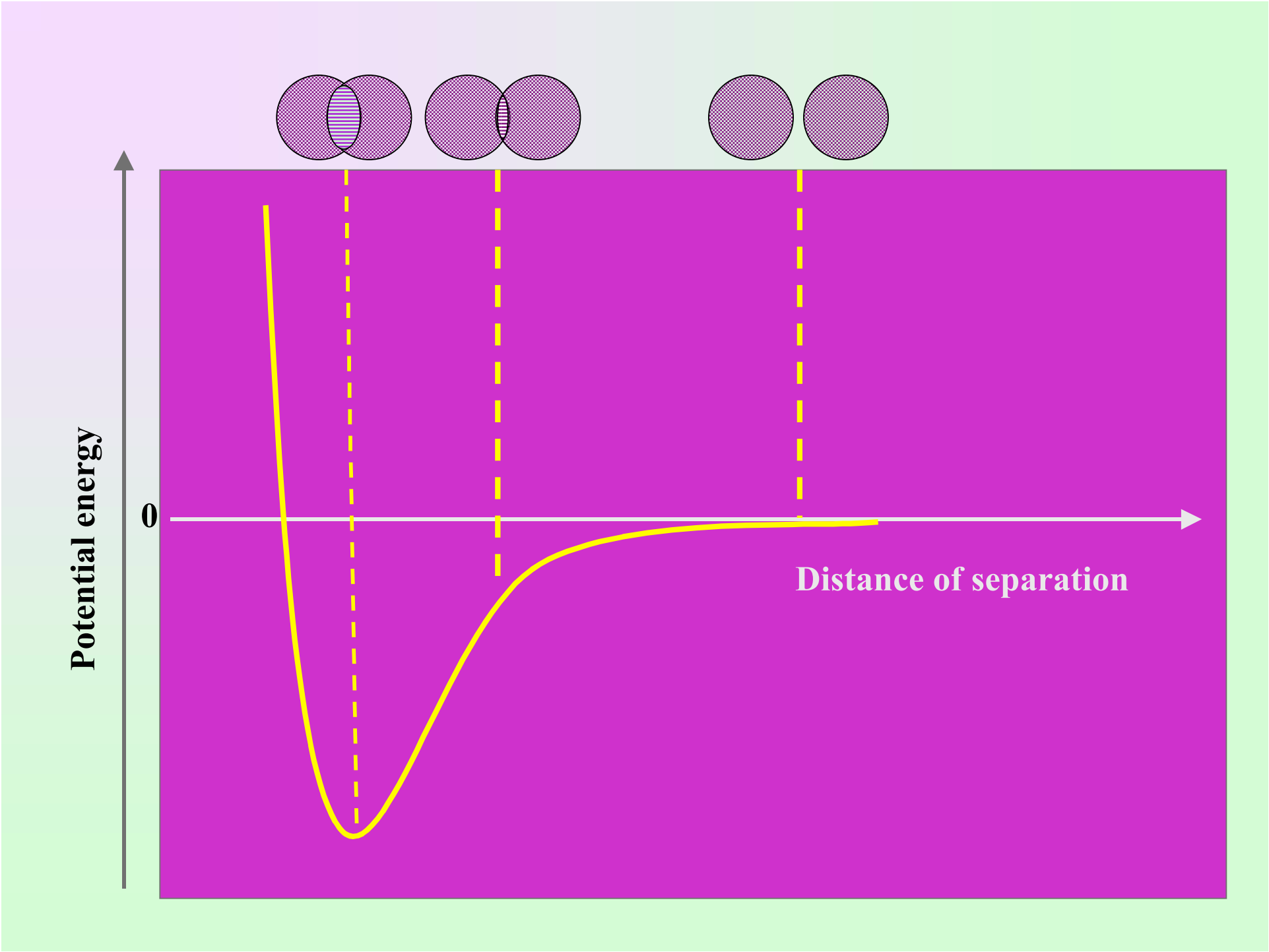
Localized Electron Model

Useful for explaining the structure of molecules especially nonmetals bonded to nonmetals

Localized electron model

Electron pair can be shared when half-filled orbital of one atom overlaps with half-filled orbital of another.

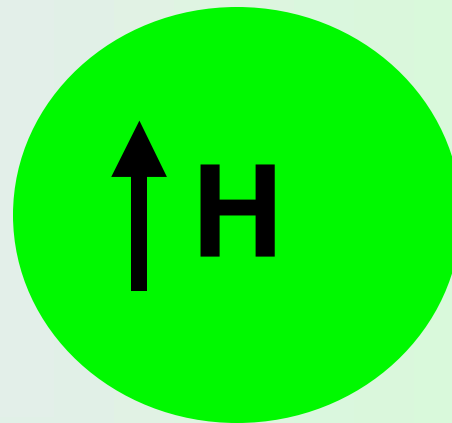
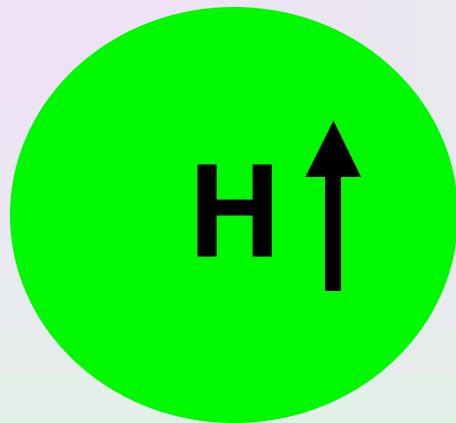
- **Bond**: orbitals overlap along the internuclear axis
- **Bond**: side by side overlap of orbitals parallel to the internuclear axis



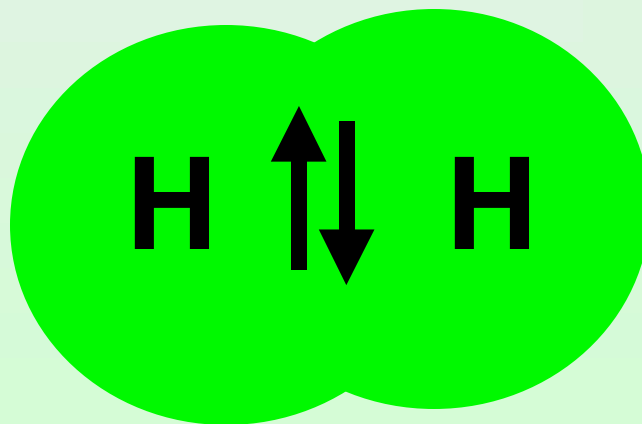
As the atoms approach each other, each electron is attracted by the nucleus of the other atom; at the same time, the electrons repel each other, as do the nuclei

□ Bond in H₂

s

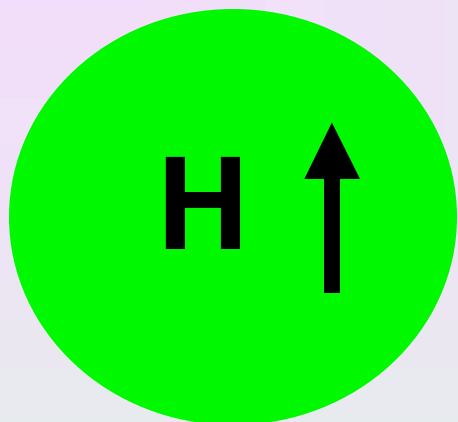


s

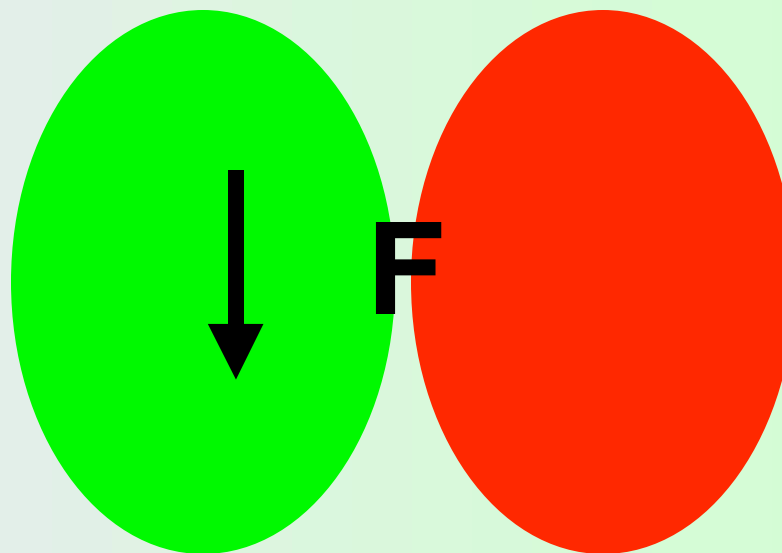


□

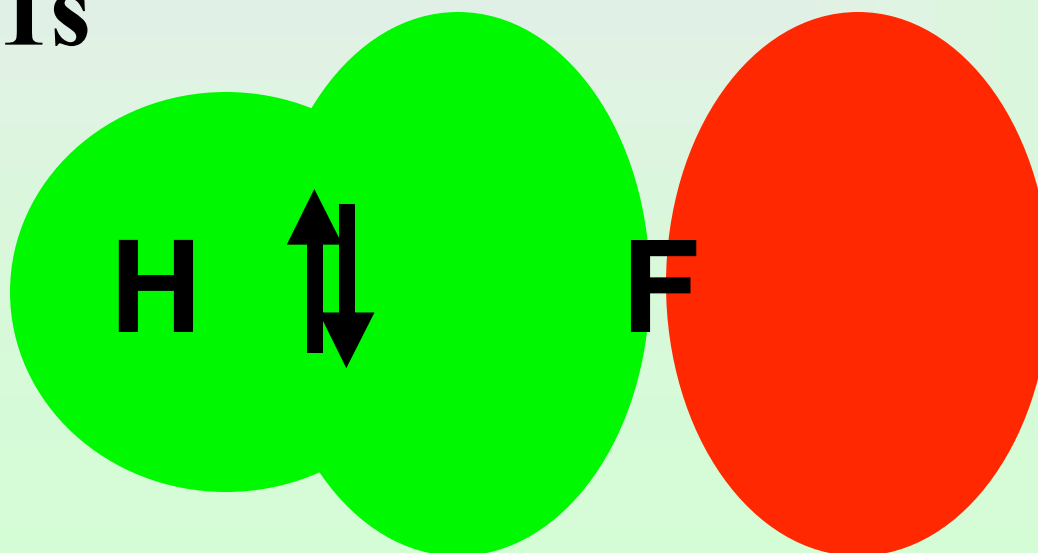
□ Bond in HF



1s

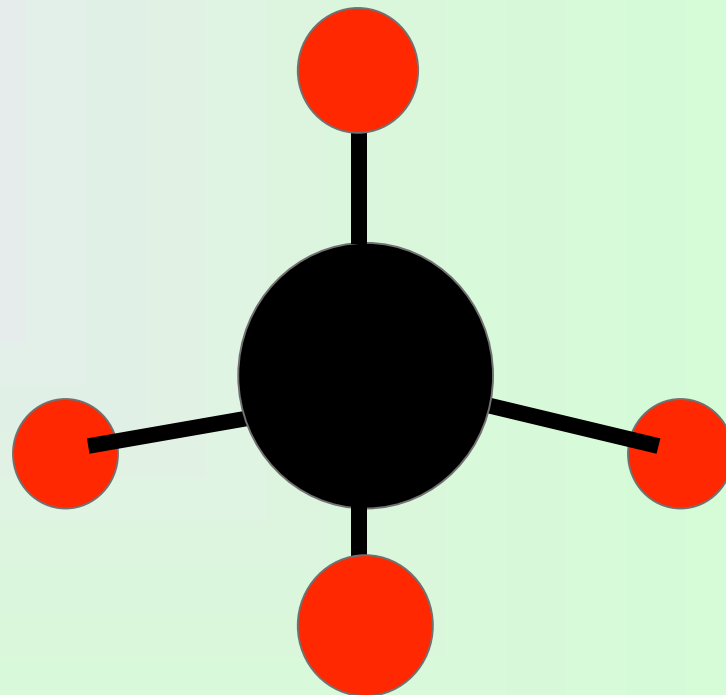


2p



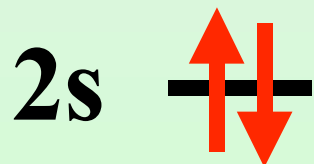
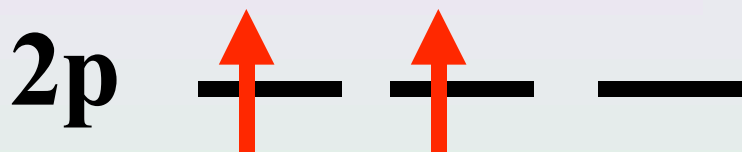
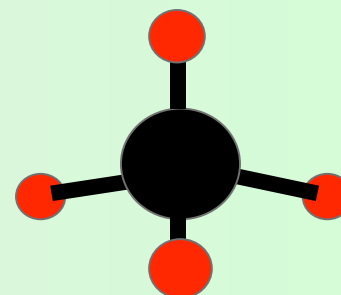
Structure of Methane (CH₄)

structure of
methane seems
inconsistent with
electron
configuration of
carbon



carbon

only two unpaired electrons



Carbon Should
form $\square\square$ bonds with
only two Hydrogen
atoms ?

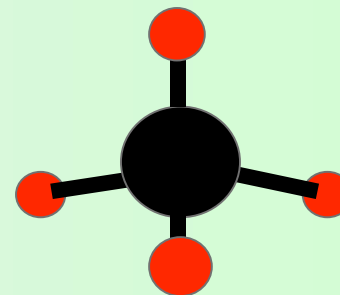
Hybridization of Atomic Orbitals

Hybrid orbitals

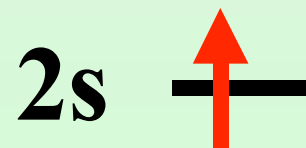
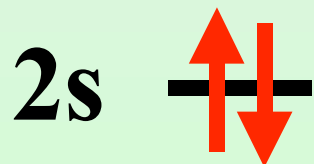
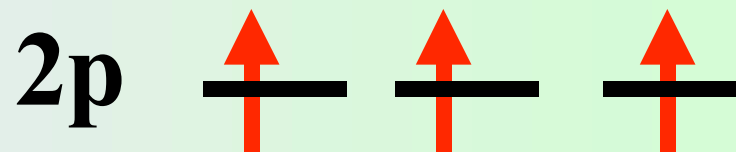
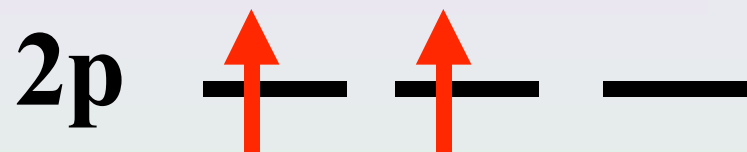
atomic orbitals obtained when two or nonequivalent orbitals of the same atom combine in preparation for covalent bond formation

sp^3 Hybridization

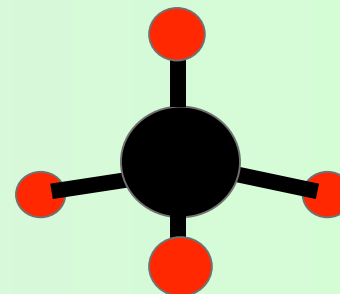
sp^3 Hybridization



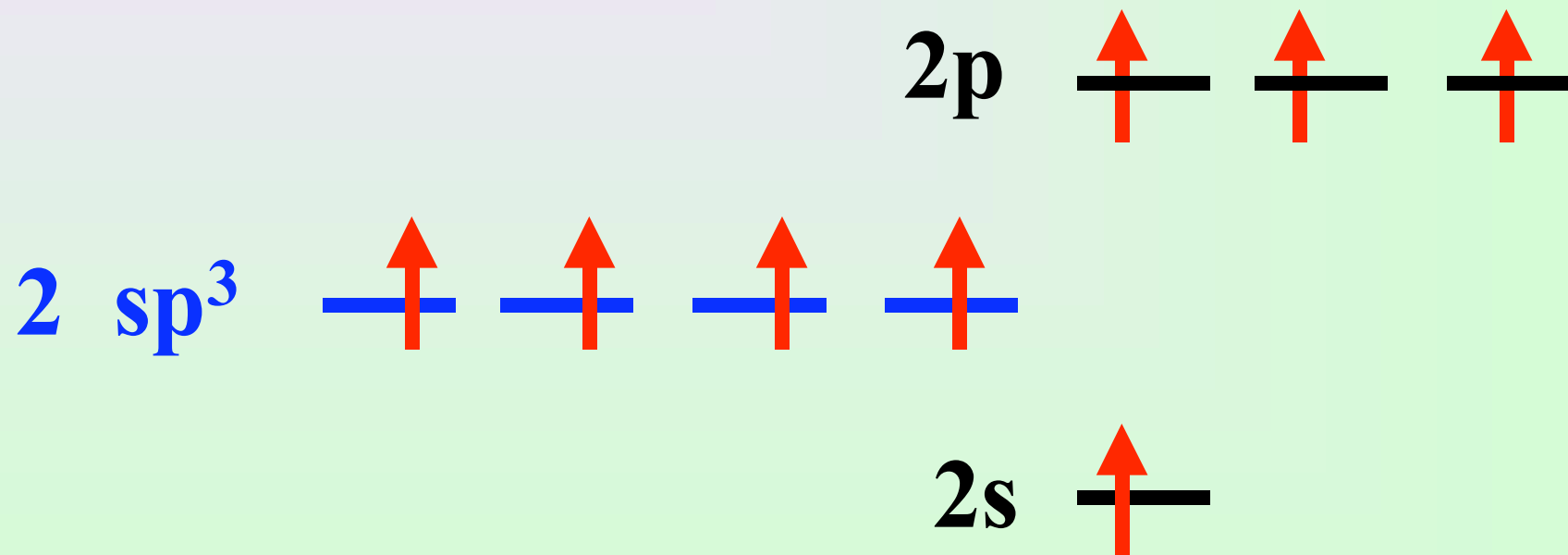
Promote an electron from the 2s to the 2p orbital



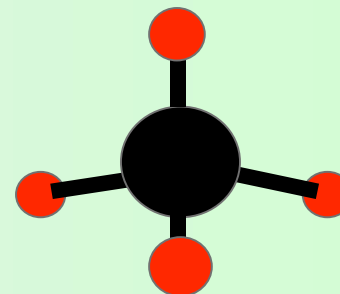
sp^3 Hybridization



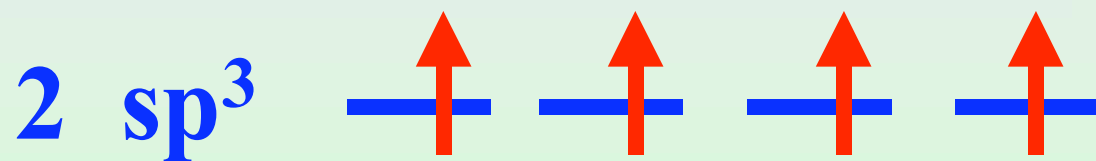
Mix together (hybridize) the 2s orbital and the three 2p orbitals



sp^3 Hybridization



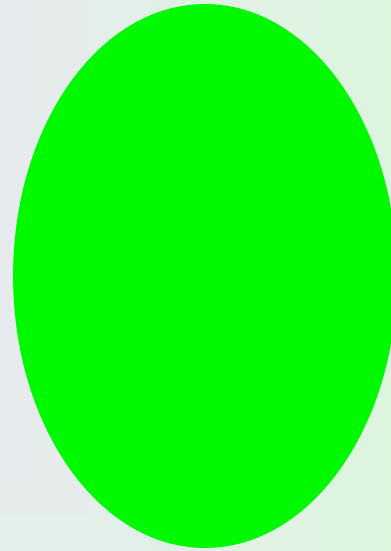
Mix together (hybridize) the 2s orbital and the three 2p orbitals



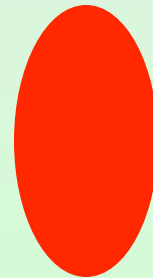
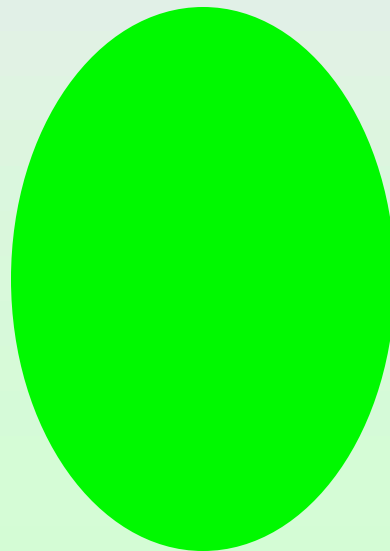
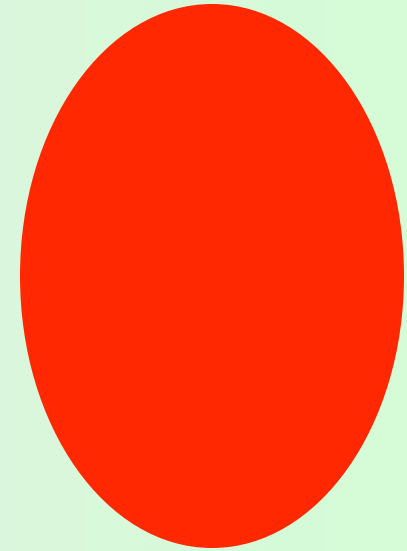
Shapes of orbitals



s

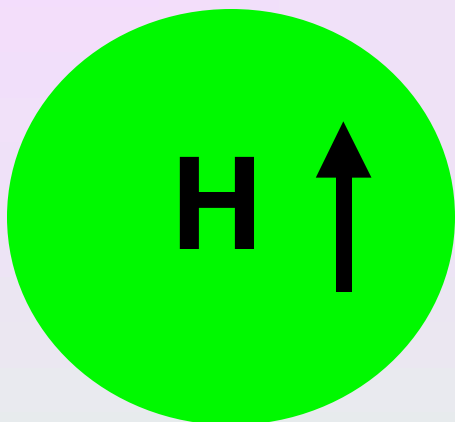


p

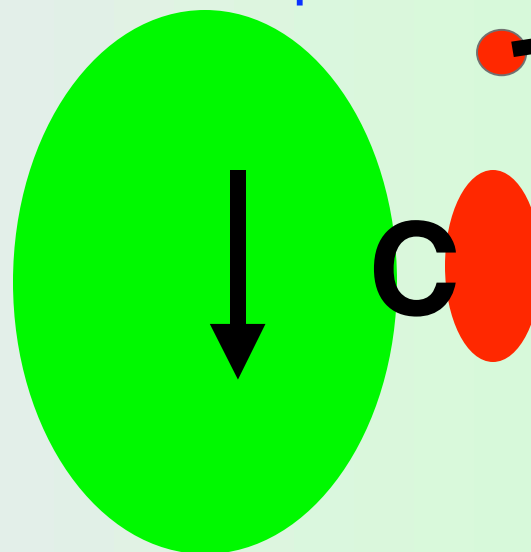


sp³

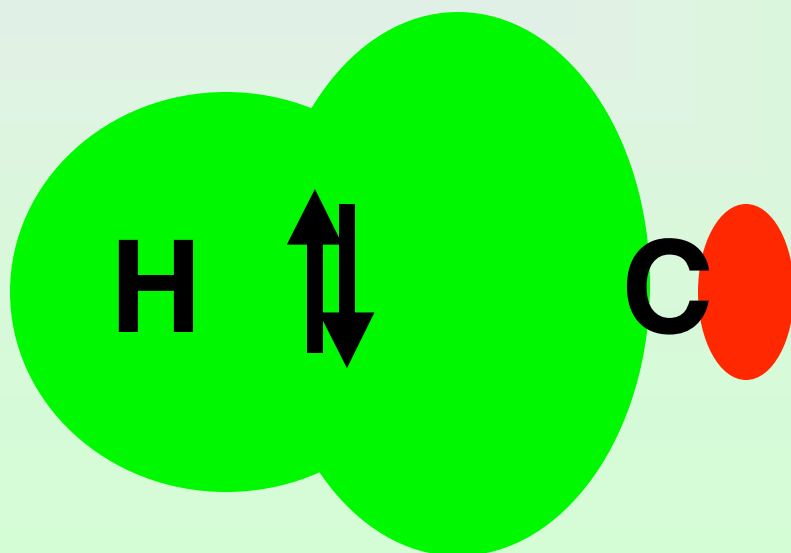
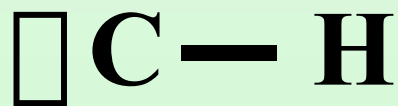
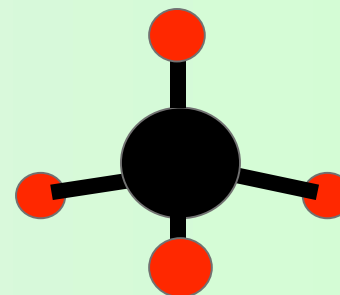
□ Bond in CH₄



s



*sp*³



Justification for Orbital Hybridization

The model is consistent with structure of methane

Allows for the formation of more bonds (4 rather than 2)

Bonds involving sp^3 orbitals are stronger than s-s overlap or p-p overlap

Remember

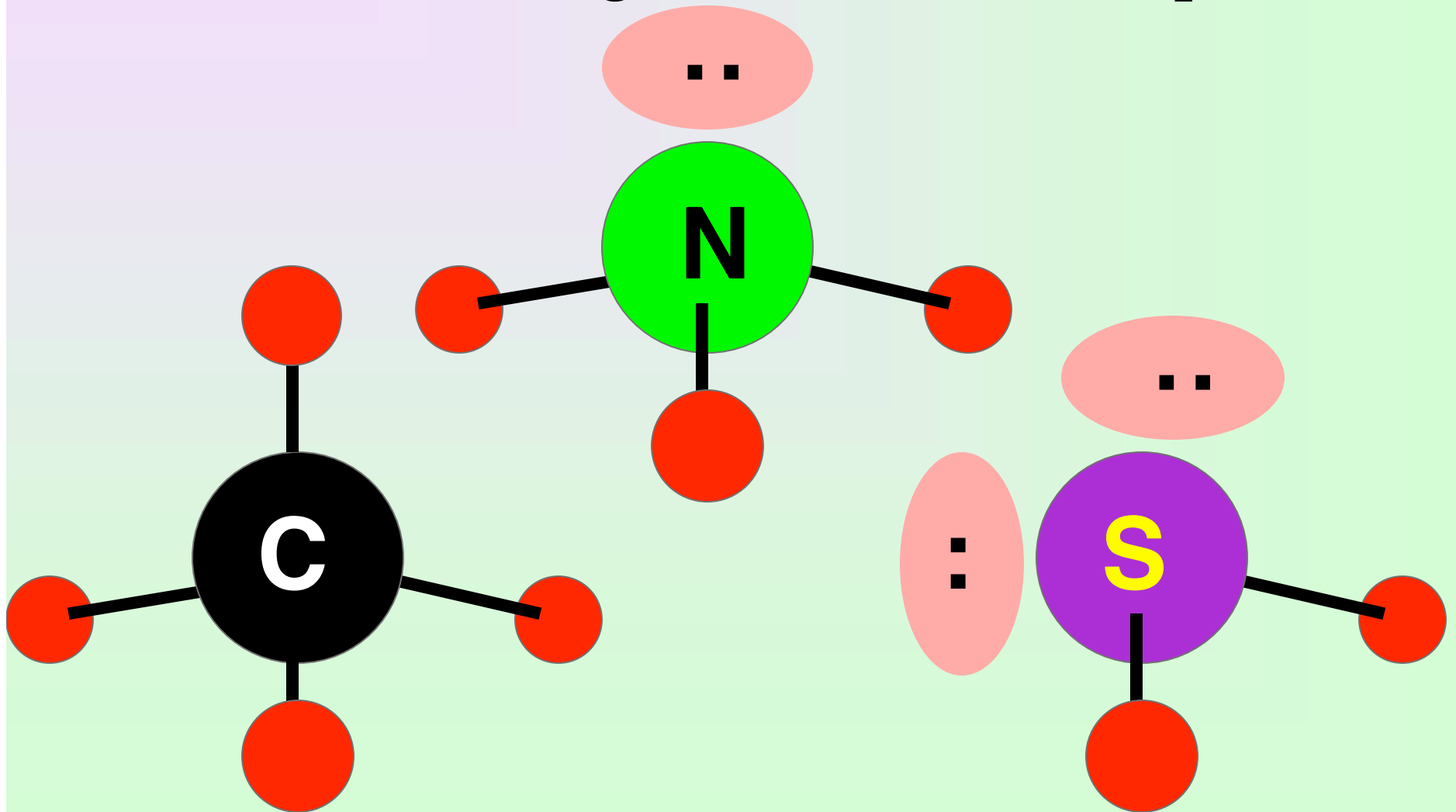
Four electron pairs

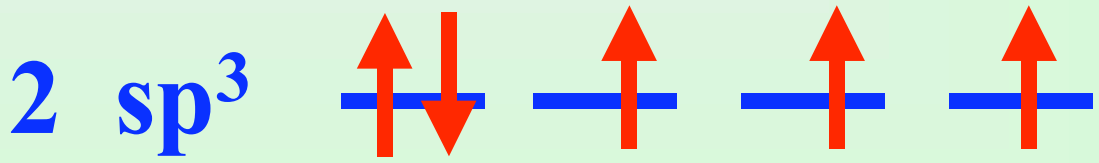
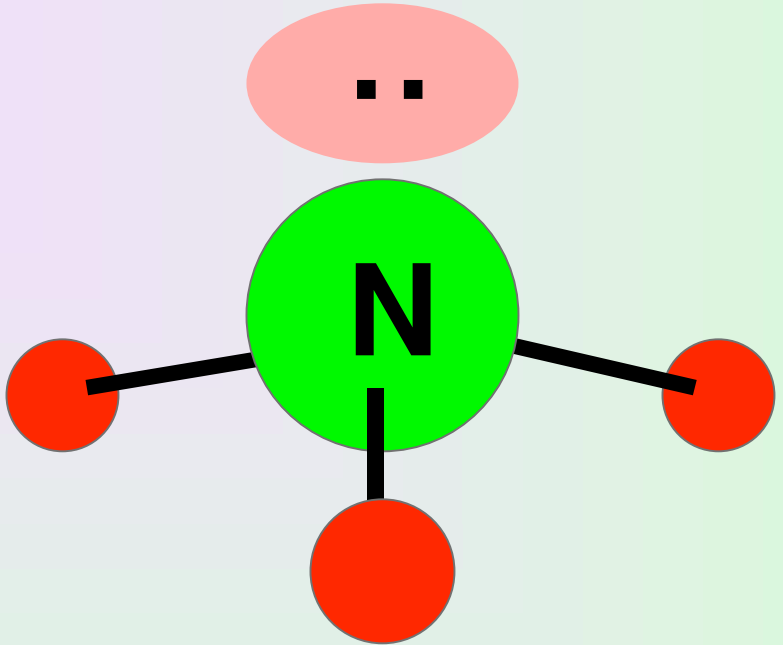
**= tetrahedral arrangement of those
electron pairs**

= sp^3 hybridization

Four electron pairs

tetrahedral arrangement of electron pairs

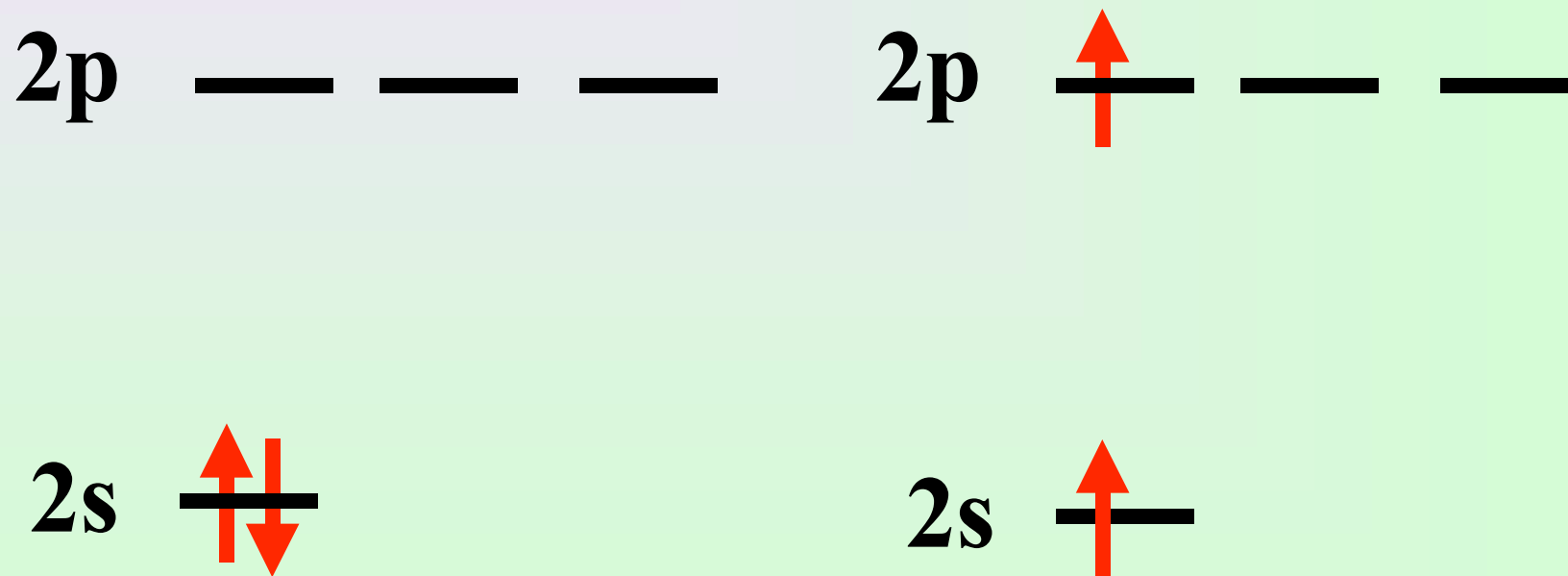




sp Hybridization

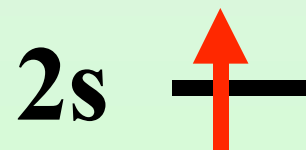
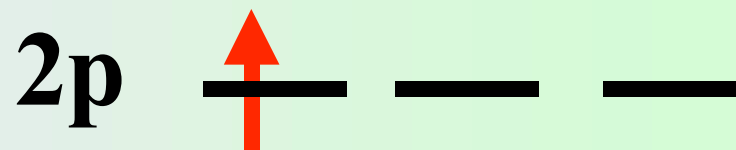
Beryllium chloride (BeCl_2)

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



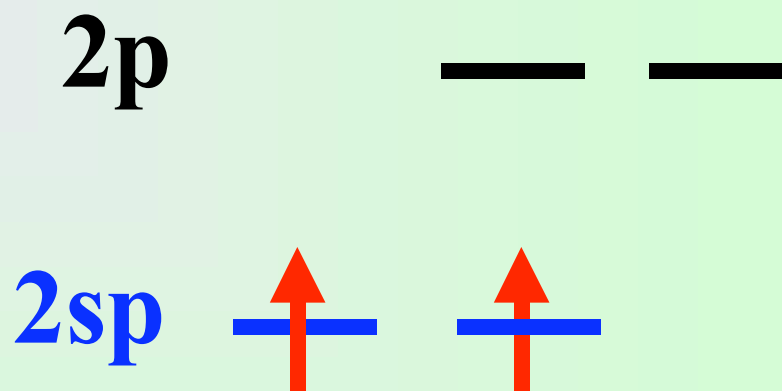
Beryllium chloride (BeCl_2)

**Mix together
(hybridize) the
2s orbital and
one 2p orbitals**

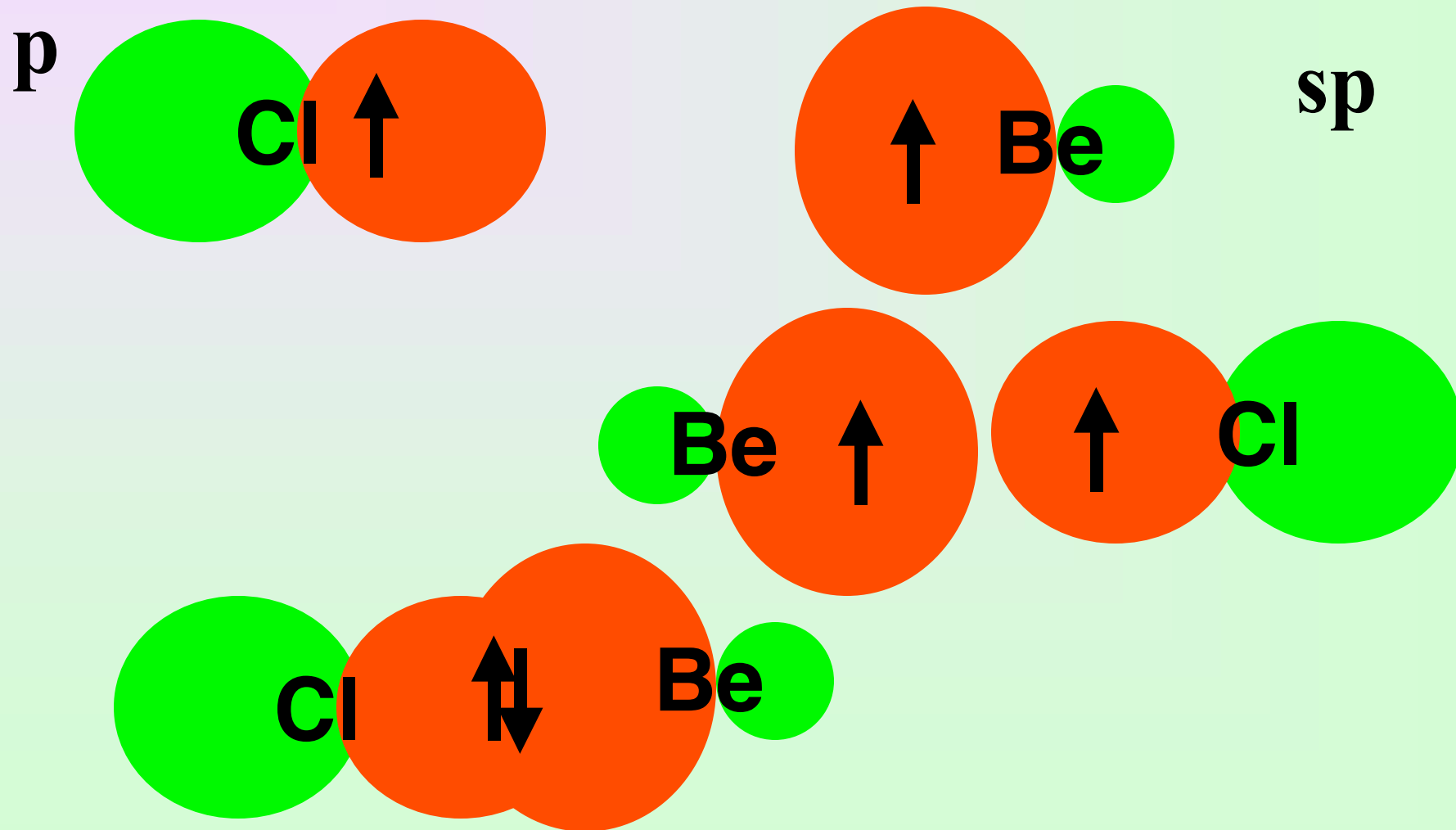


Beryllium chloride (BeCl_2)

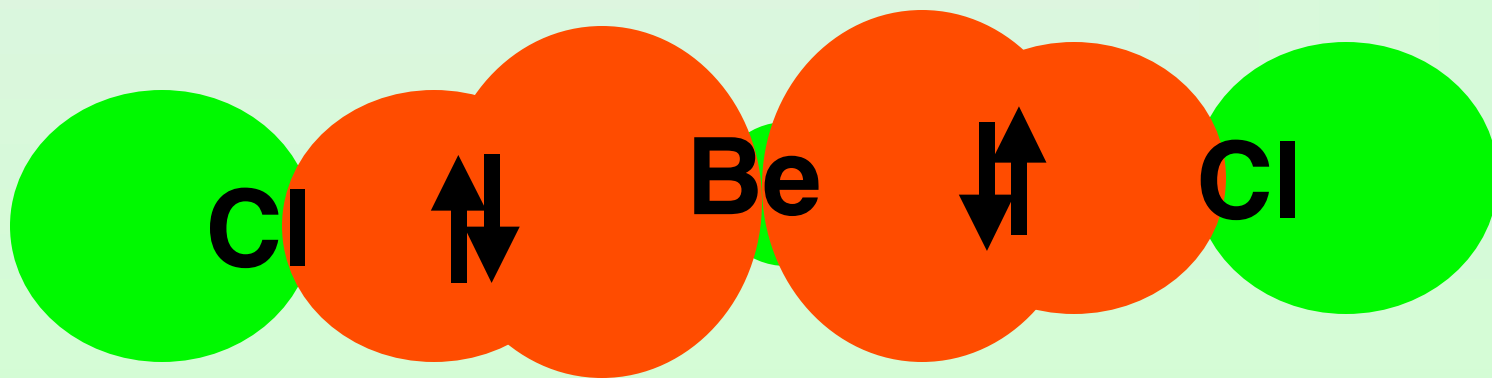
**Mix together
(hybridize) the
2s orbital and
one 2p orbitals**



The Be — Cl σ Bond in BeCl



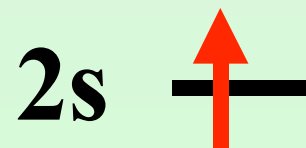
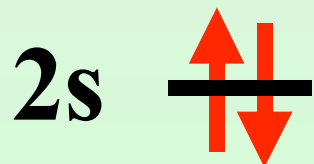
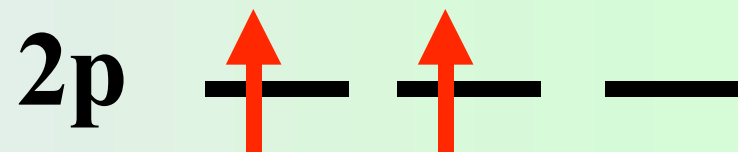
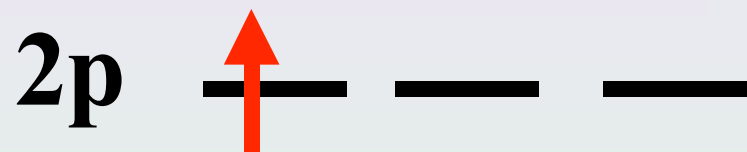
The Be — Cl σ Bond in BeCl



*sp*² Hybridization

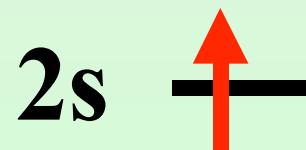
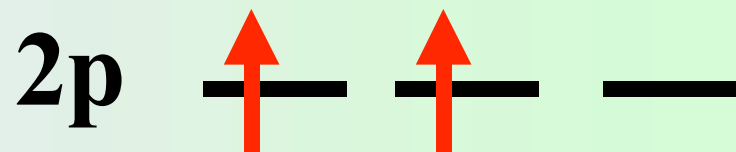
Boron trifluoride

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



Boron trifluoride

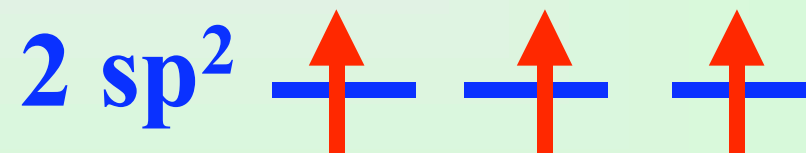
Mix together
(hybridize) the
2s orbital and
two 2p orbitals

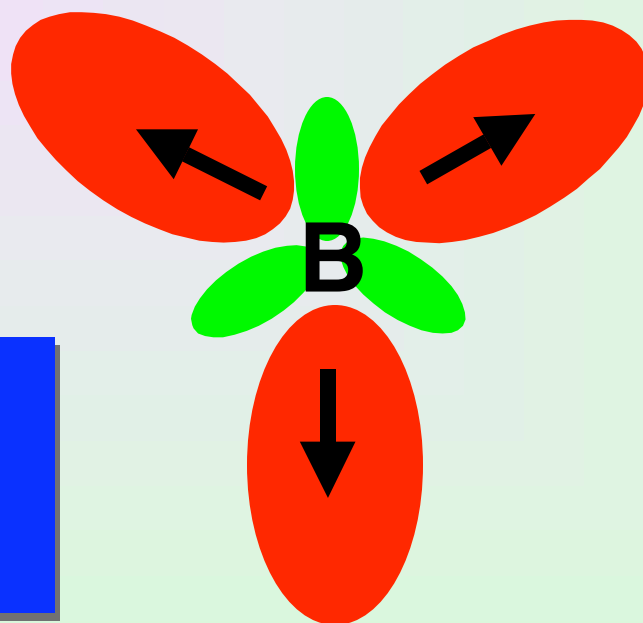
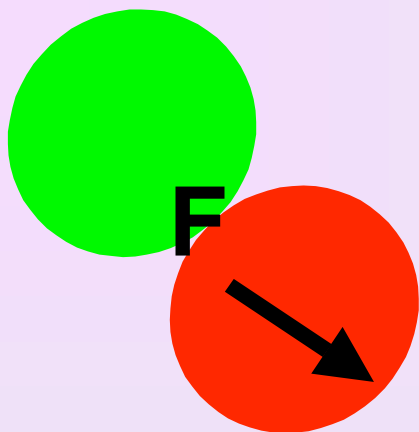


Boron trifluoride

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

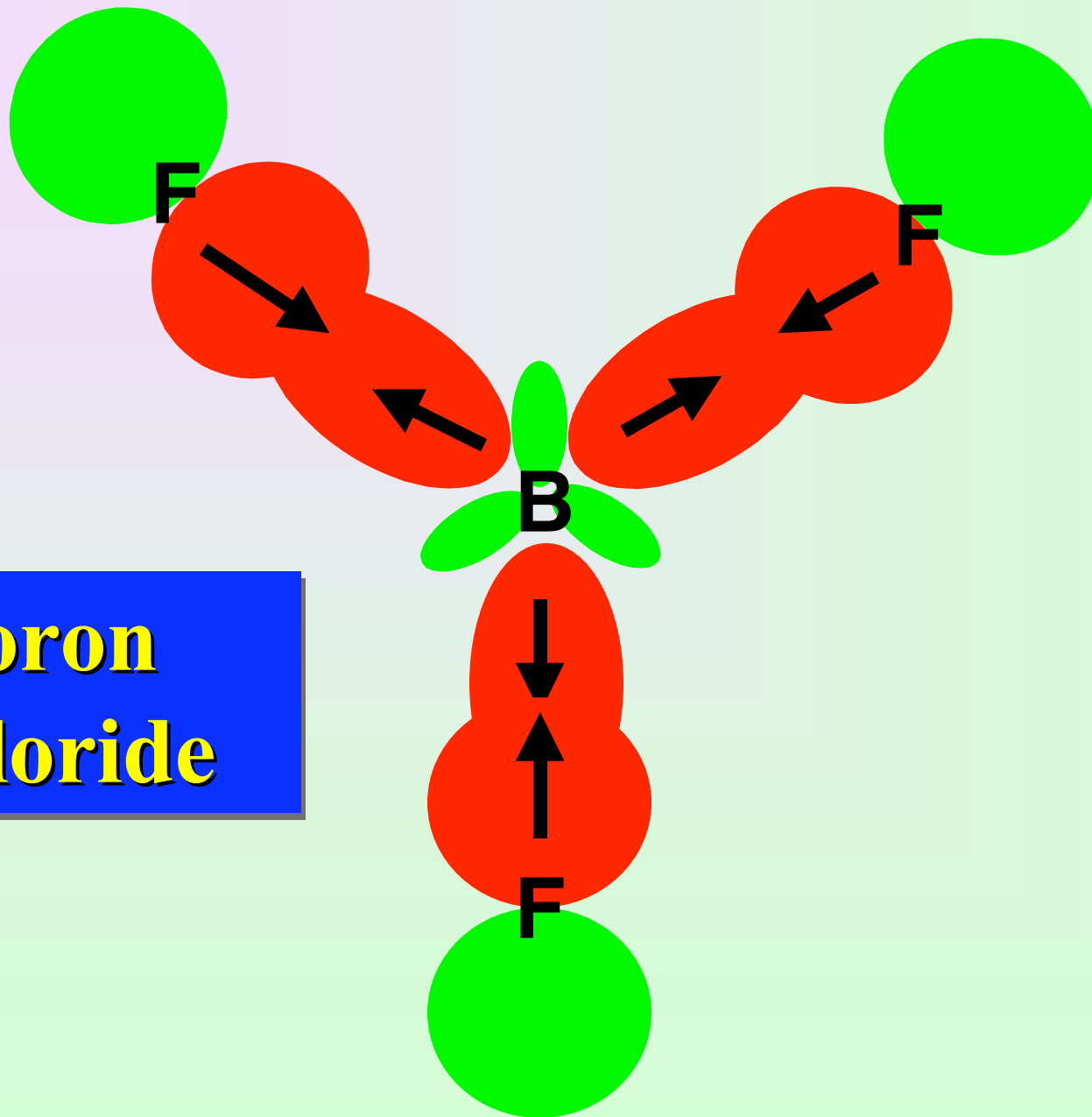
2p —





**Boron
trifluoride**

**Boron
trifluoride**



Hybridizing Atomic Orbitals

hybrid orbitals are used only for atoms in a molecule, not for isolated atoms

hybrid orbitals are different in shape from the atomic orbitals from which we derive them

number of hybrid orbitals equals number of atomic orbitals from which they were generated

hybridization permits more bonds and stronger bonds

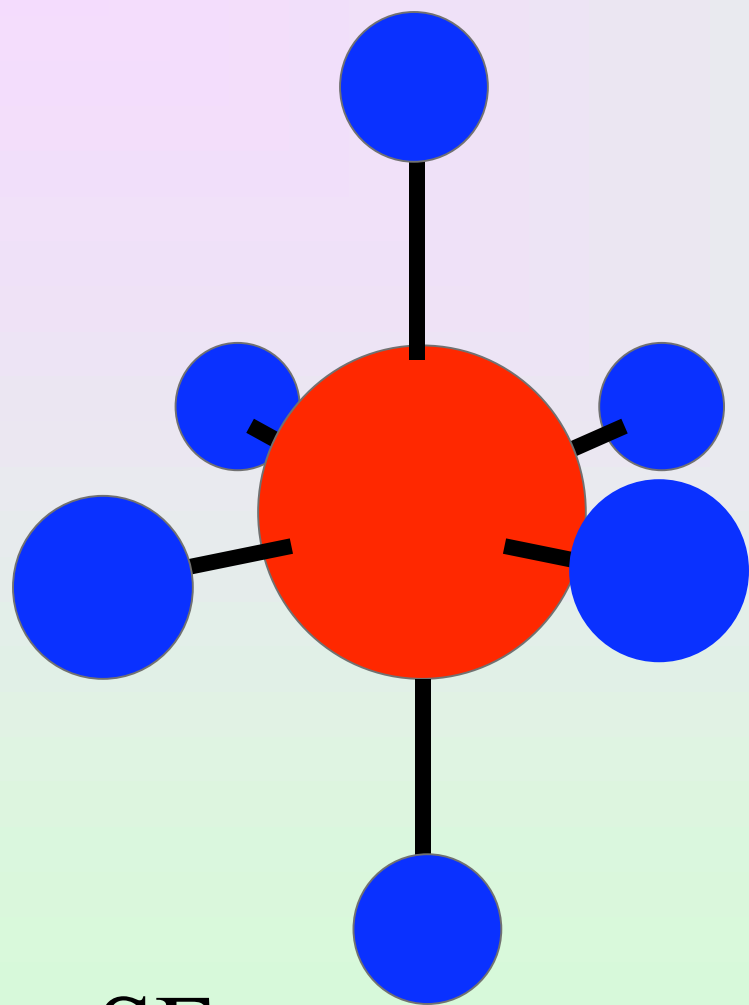
covalent bond results from overlap of half-filled orbitals

Procedure For Hybridizing Atomic Orbitals

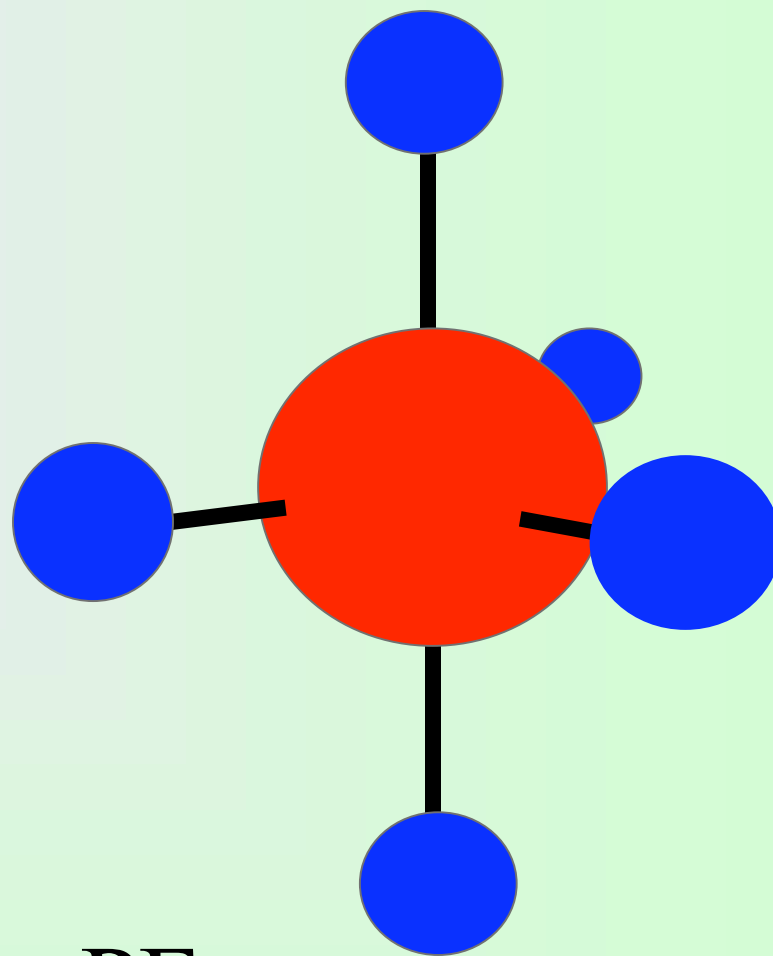
draw the Lewis structure of the molecule

predict the overall arrangement of the electron pairs using the VSEPR model

deduce the hybridization of the central atom



SF_6



PF_5

Hybridization of s, p, and d Orbitals

Beginning with the third period of the periodic table

1 3s orbital + **3** 3p orbital + **1** 3d orbital

gives sp^3d

Permits five electron pairs (trigonal bipyramidal)

1 3s orbital + **3** 3p orbital + **2** 3d orbital

gives sp^3d^2

Permits six electron pairs (octahedral)

□ -Bonds

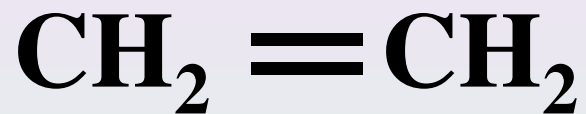
Review : Valence bond model

Electron pair can be shared when the half-filled orbital of one atom overlaps with half-filled orbital of another.

□ **Bond**: orbitals overlap along the internuclear axis

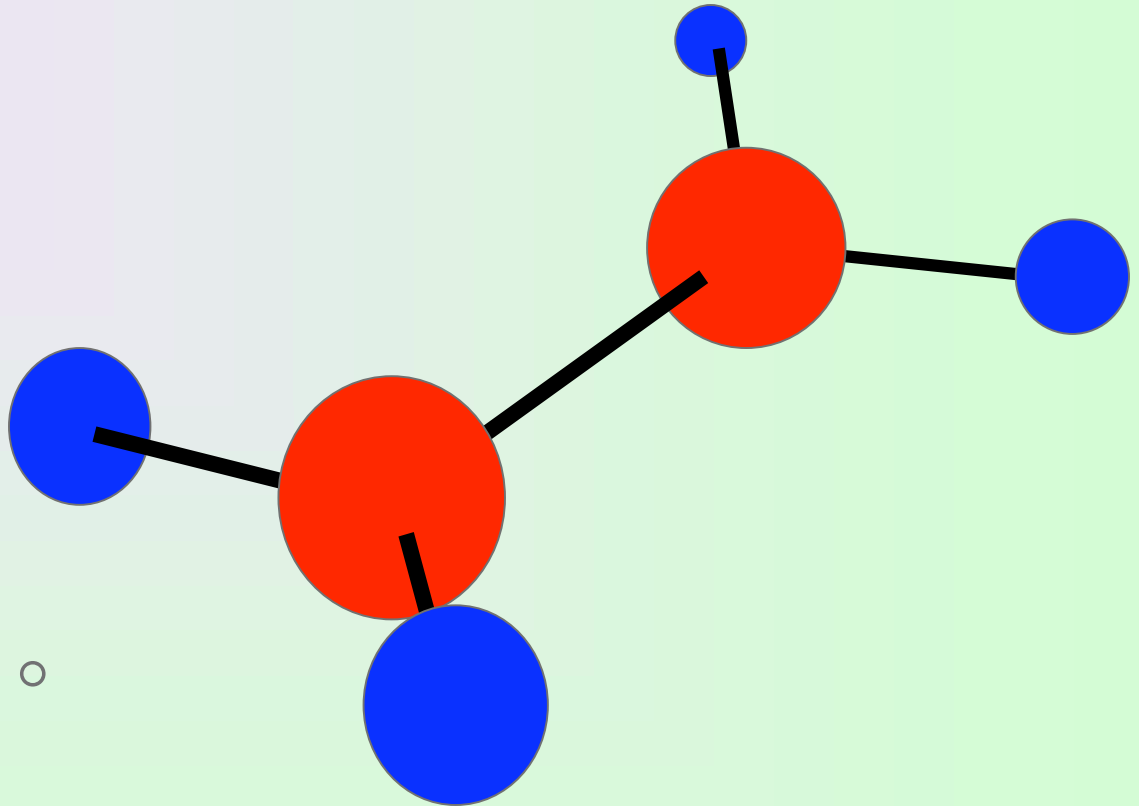
□ **Bond**: side by side overlap of orbitals

Structure of Ethylene



planar

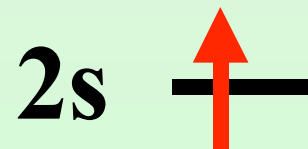
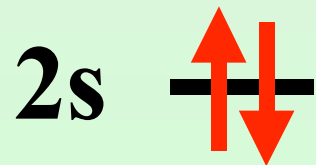
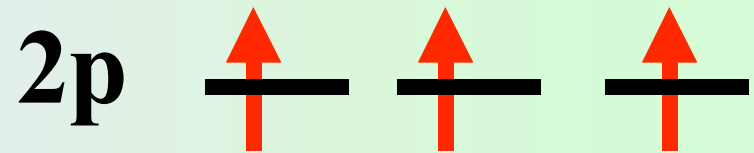
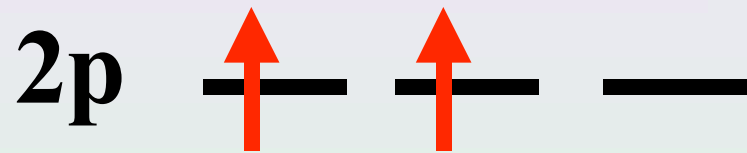
Bond angle 120°



Requires hybridization different from sp^3

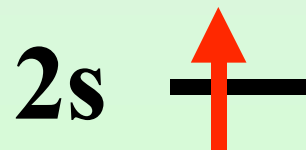
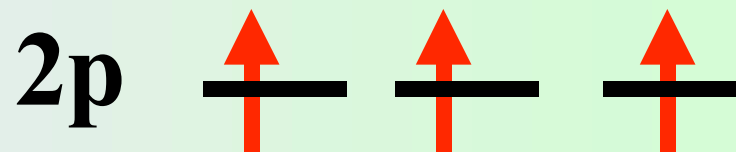
Orbital Hybridization

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



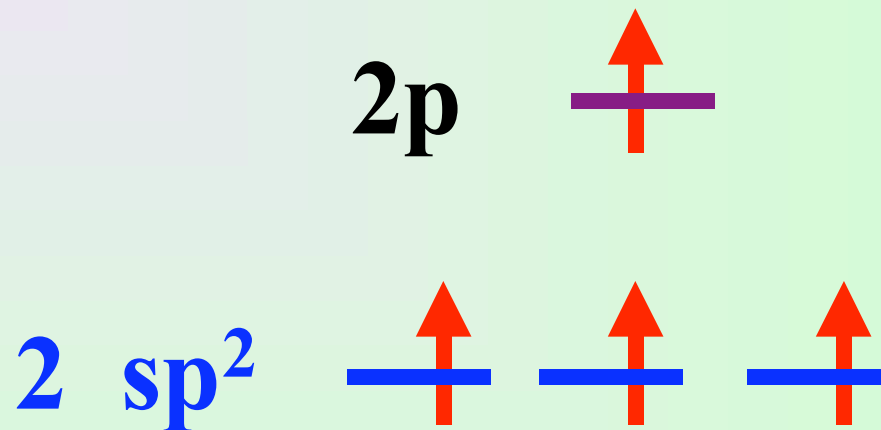
Orbital Hybridization

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

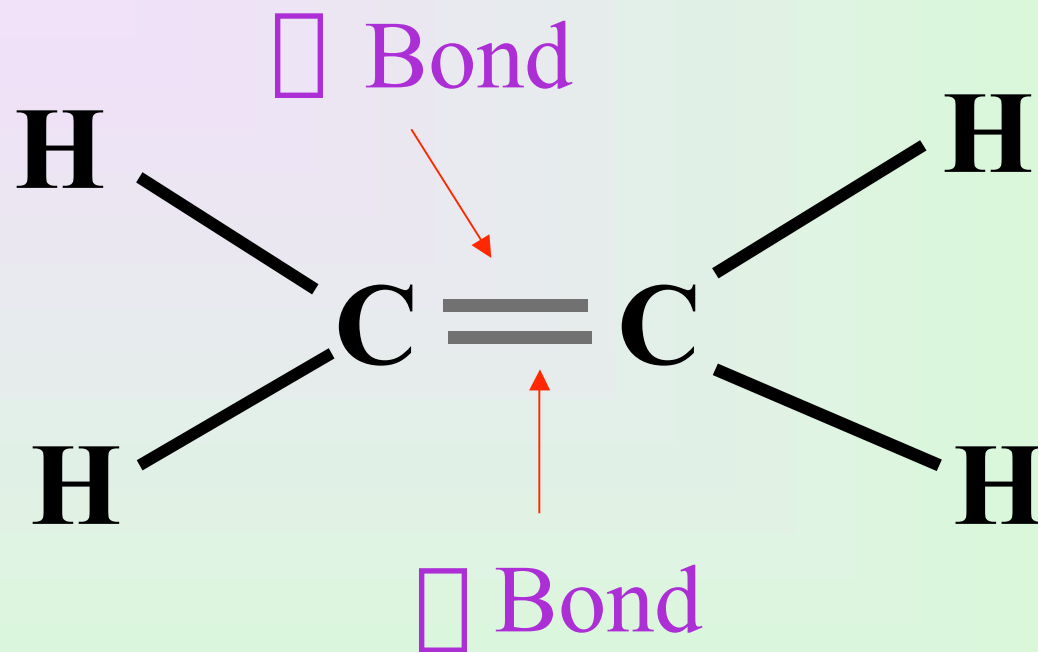


Orbital Hybridization

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

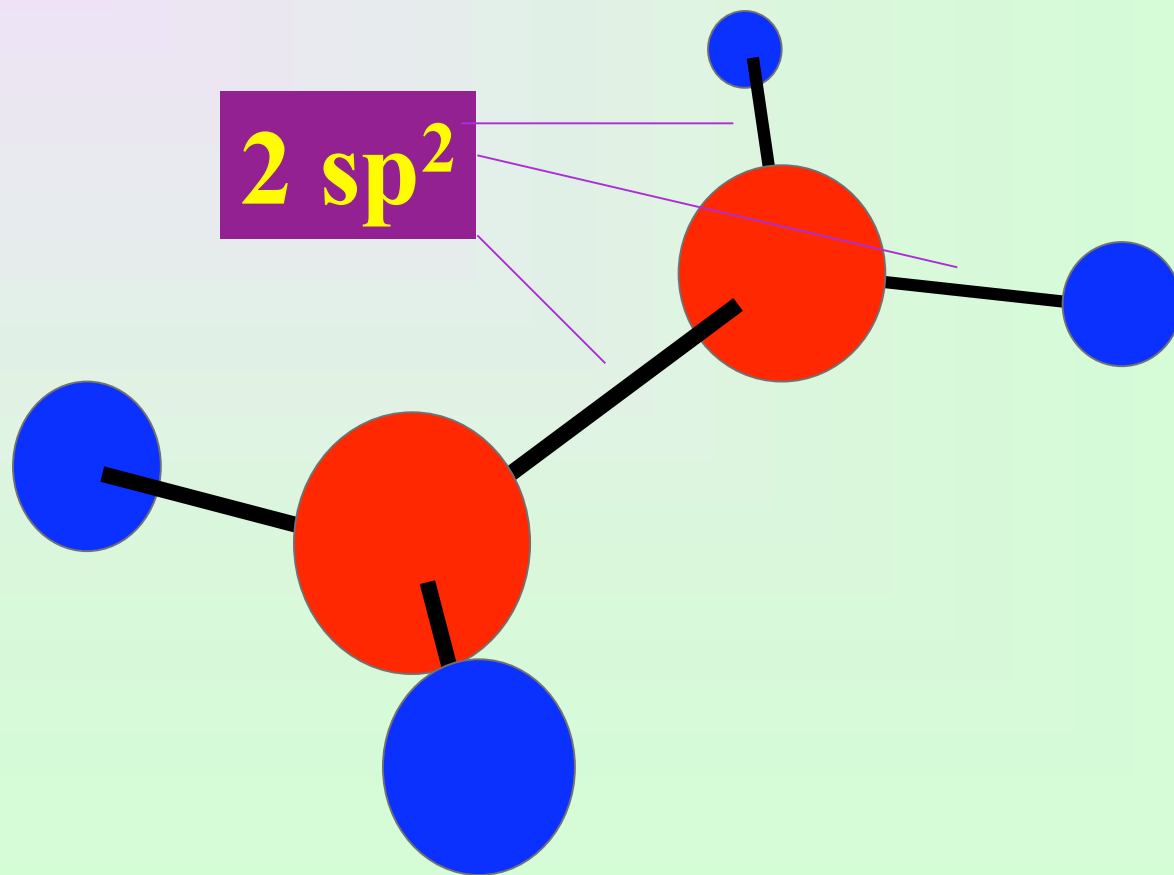


Lewis model : Ethylene

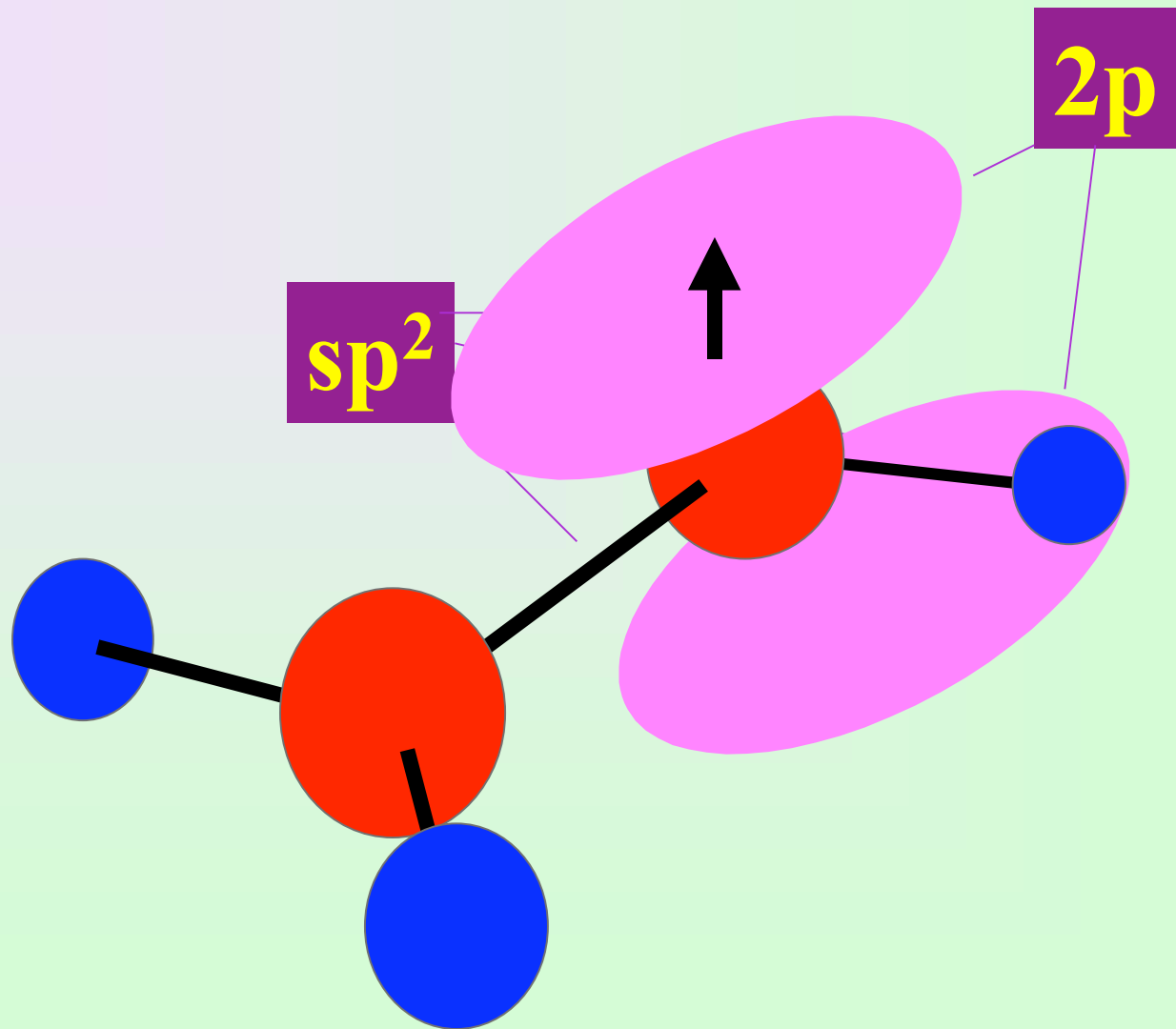


The carbon-carbon double bond of ethylene is a combination of an □ Bond and □ Bond

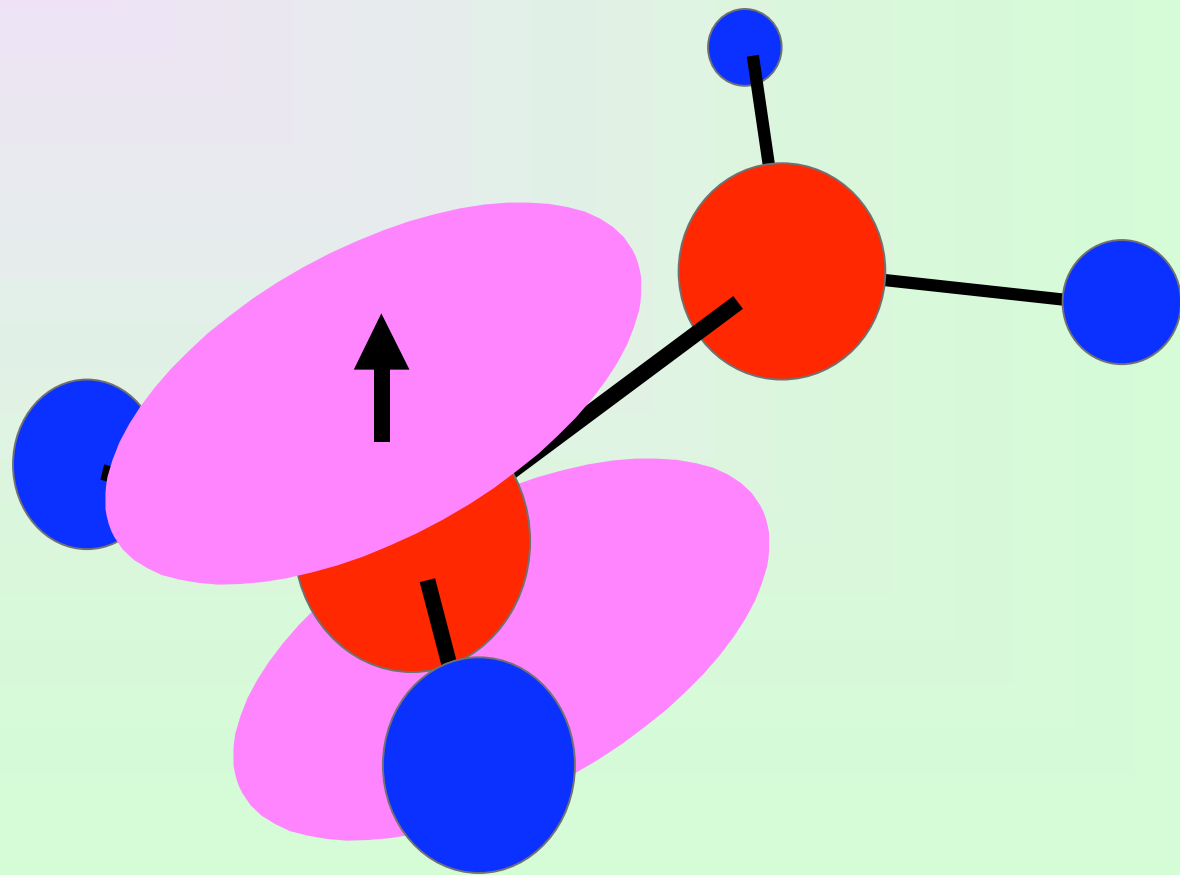
Bonding in Ethylene



□ □ Bonding in Ethylene



□ □ Bonding in Ethylene



□ □ Bonding in Ethylene

