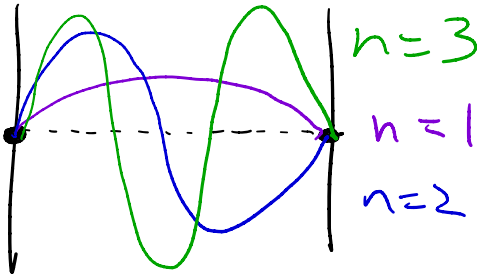
May the 4th, 2020

Standing wave – In standing waves, energy is quantized, meaning it can only have specific values.



The # of nodes total = n-1

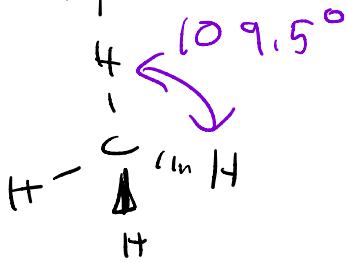
$l=0$ $l=1$ $l=2$

$l \rightarrow$ orbital angular momentum $\rightarrow$ how "fast" an electron is moving around the nucleus.

The # of spherical nodes = l

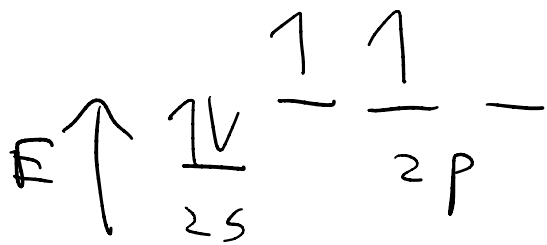
The unique shapes of atomic orbitals are due to the fact that there is exactly one nucleus.

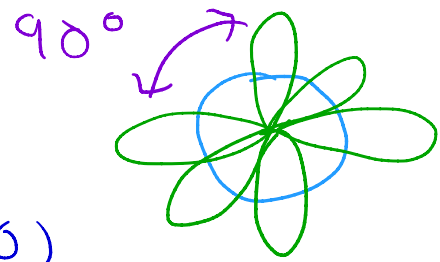
CH_4



tetrahedral

C





Atomic orbitals (AO) fail to describe the structure of molecules because molecules contain multiple nuclei.

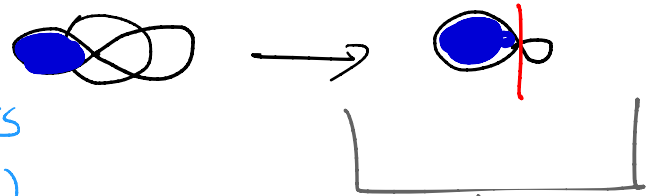
In methane, all bonds are equal in energy and the bonds form tetrahedral geometry (109.5° angles) even though the valence orbitals of carbon are unequal in energy and different in geometry.

Solution: Create a new set of hybrid orbitals by combining AOs.

How hybridization works → model

H – Be – H

180°



Shading in these diagrams represents the sign (+ or –) of Ψ (wavefunction)

overlap

Hybridization creates orbitals with the right geometry and correct energy.

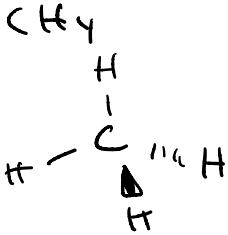
E ↑↓ 2s 2p ⇒ E ↑ ↑ sp 2p

before hydridization

Linear combination of atomic orbitals (LCAO)

– Atomic orbitals are added and subtracted to create a new set of hybrid orbitals.

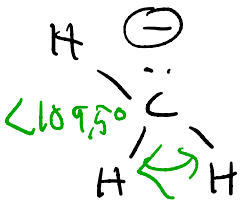
$$\Psi_C = a\Psi_A + b\Psi_B$$



methane

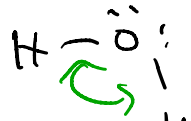
4 equivalent bonds →
4 equivalent hybrids →
4 AOs needed

before after



methyl anion

107°
ammonia

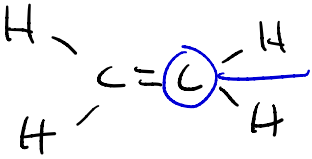


104.5°
water

All of these shapes are almost equal to tetrahedral geometry → electron pair geometry. Therefore, they are all best described by sp^3 hybrids.

# of hybrid orbitals = # of <u>bonds</u> and lone pairs

single, double, and triple bonds are all counted once.



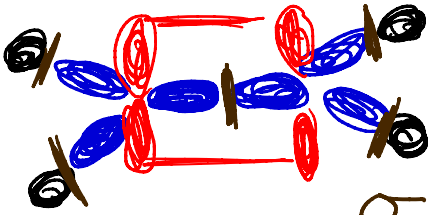
sp^2 (total of 3 individual bonds)

ethene
(ethylene)

simplification

sp

minor lobe left out



s

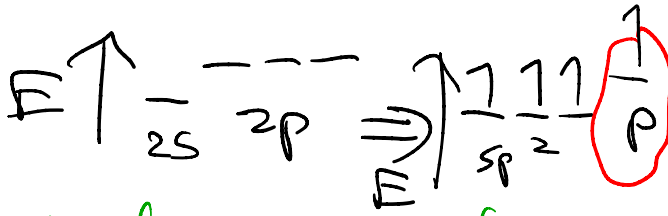
sp^2

p

σ (sigma) bond

π (pi) bond

one set of 3 sp^2 orbitals



before

after

Shading in this diagram represents orbital type, not mathematical sign.