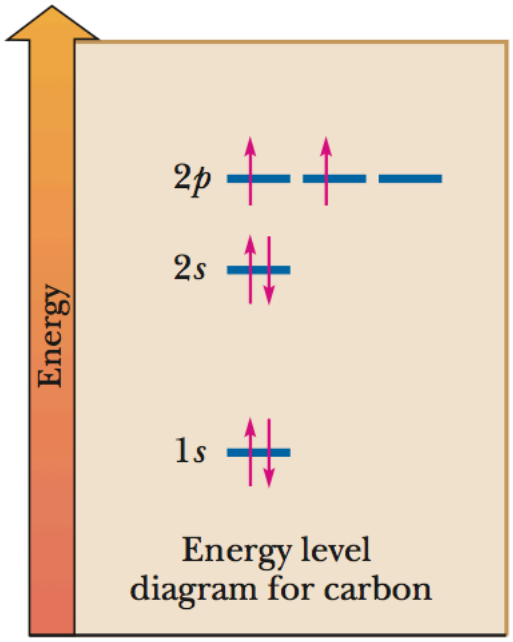
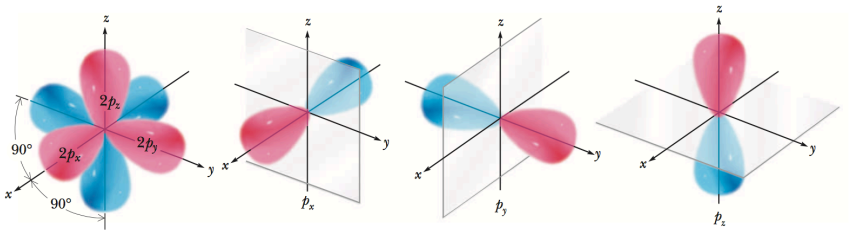
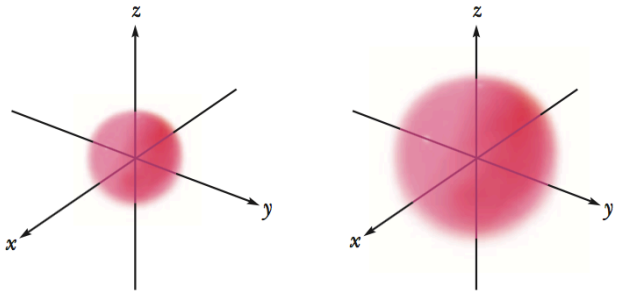
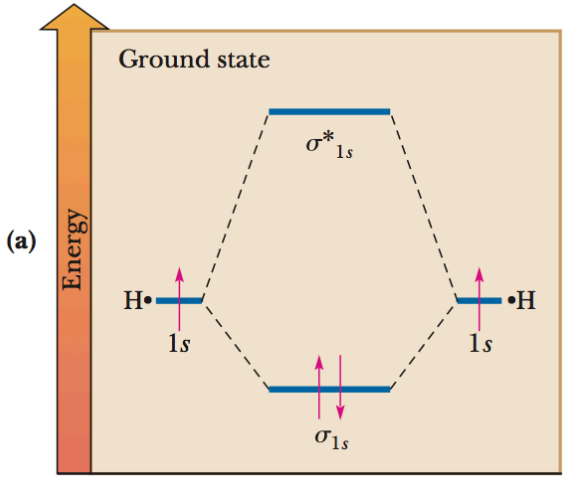




(b) Cartoon representations of 2*p* orbitals



(b) Cartoon representations of 1*s* and 2*s* orbitals



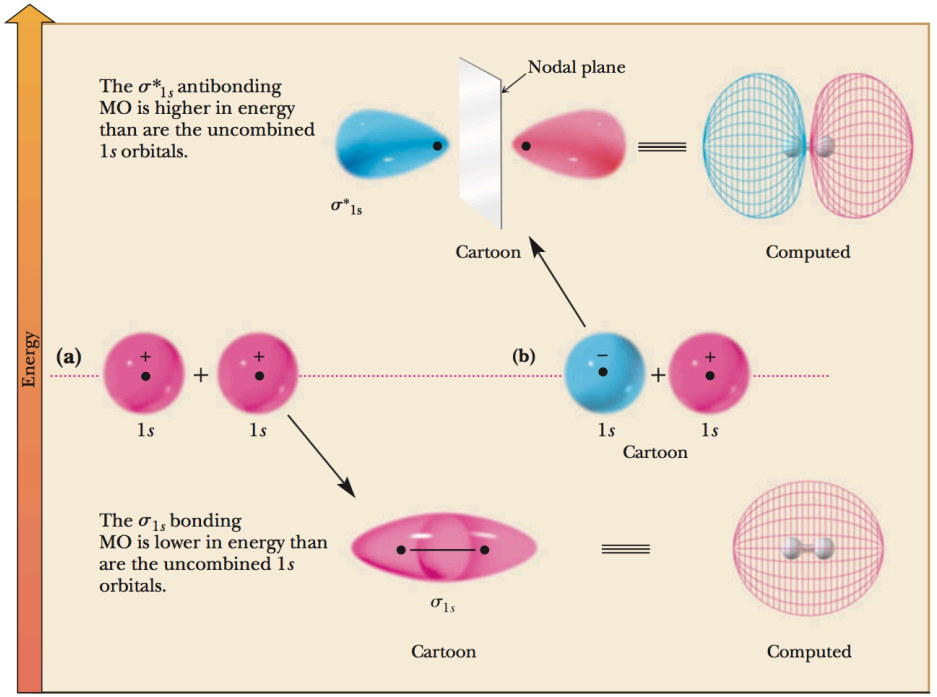


Figure 1.10
Molecular orbitals (plots of ψ) derived from combination of two 1*s* atomic orbitals: (a) combination by addition and (b) combination by subtraction. Electrons in the bonding MO spend most of their time in the region between the two nuclei and bond the atoms together. Electrons in the antibonding MO lead to repulsion between nuclei and decrease bonding.

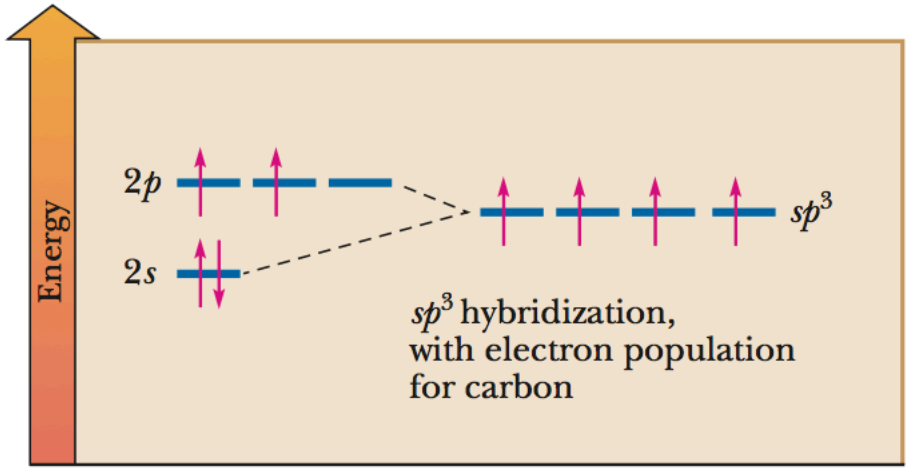
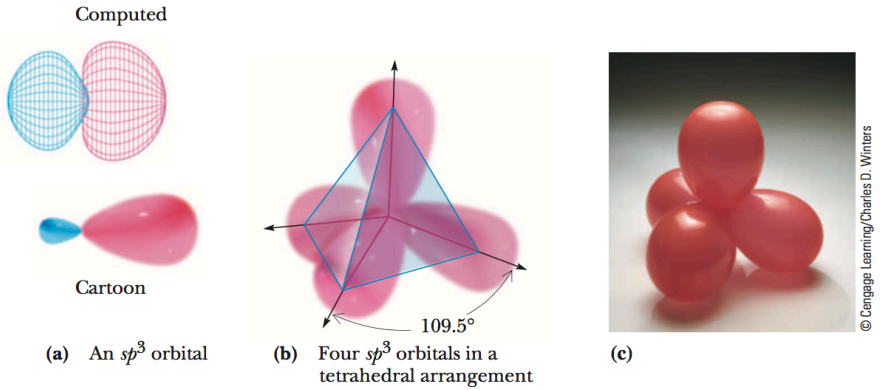
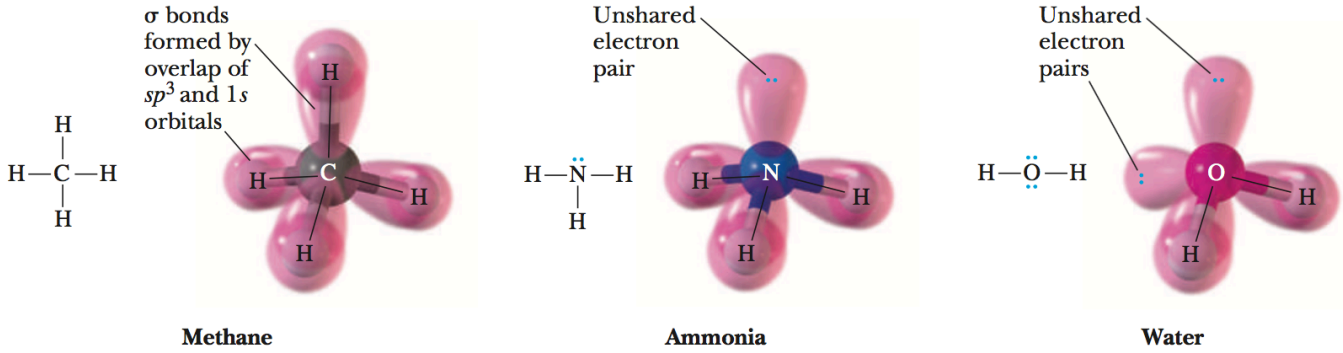


Figure 1.12
sp^3 Hybrid orbitals.
(a) A single sp^3 hybrid orbital in computed and cartoon form. (b) Three-dimensional cartoon representation of four sp^3 hybrid orbitals centered on the same atom and directed toward the corners of a regular tetrahedron. (c) If four balloons of similar size and shape are tied together, they will naturally assume a tetrahedral geometry.

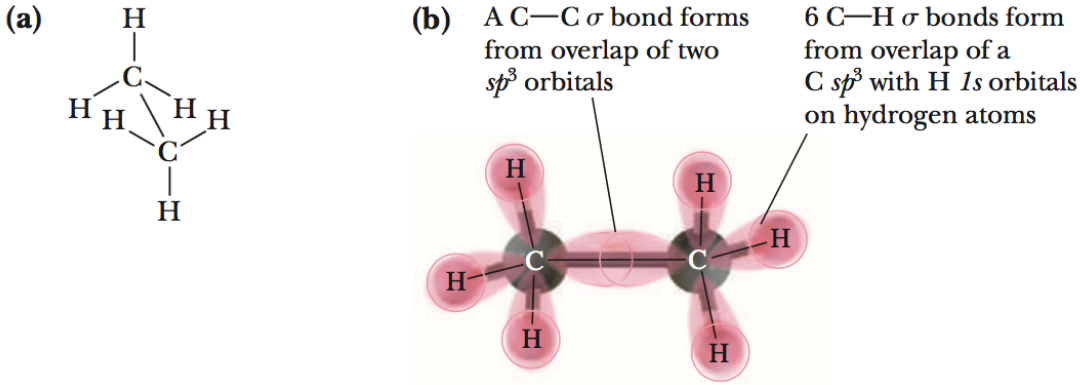


(a) An sp^3 orbital (b) Four sp^3 orbitals in a tetrahedral arrangement (c)



Methane **Ammonia** **Water**

Figure 1.13
Orbital overlap pictures of methane, ammonia, and water.



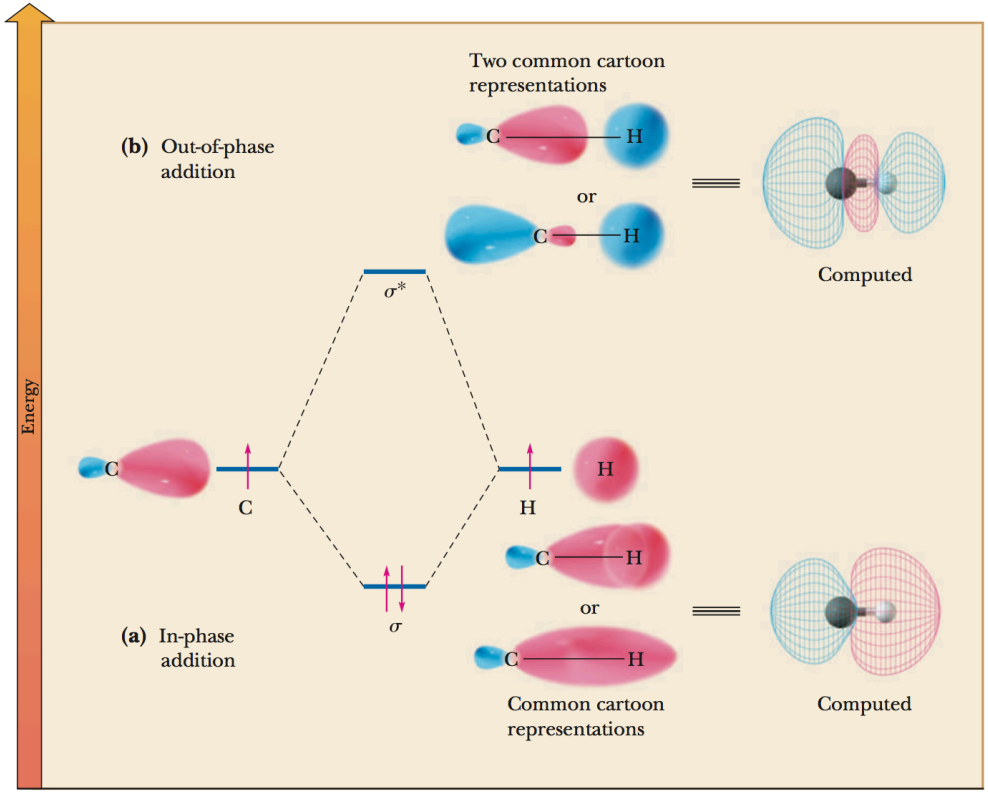


Figure 1.17
Molecular orbital mixing diagram for the creation of any C—H σ bond. (a) In-phase addition of a C hybrid orbital (either sp^3, sp^2, or sp) with a H 1s orbital forms a σ orbital that is lower in energy than the two starting orbitals. When the resulting orbital is populated with two electrons, a σ bond results. (b) Addition of the orbitals in an out-of-phase manner (meaning reversing the phasing of one of the starting orbitals) leads to an antibonding σ^* orbital.

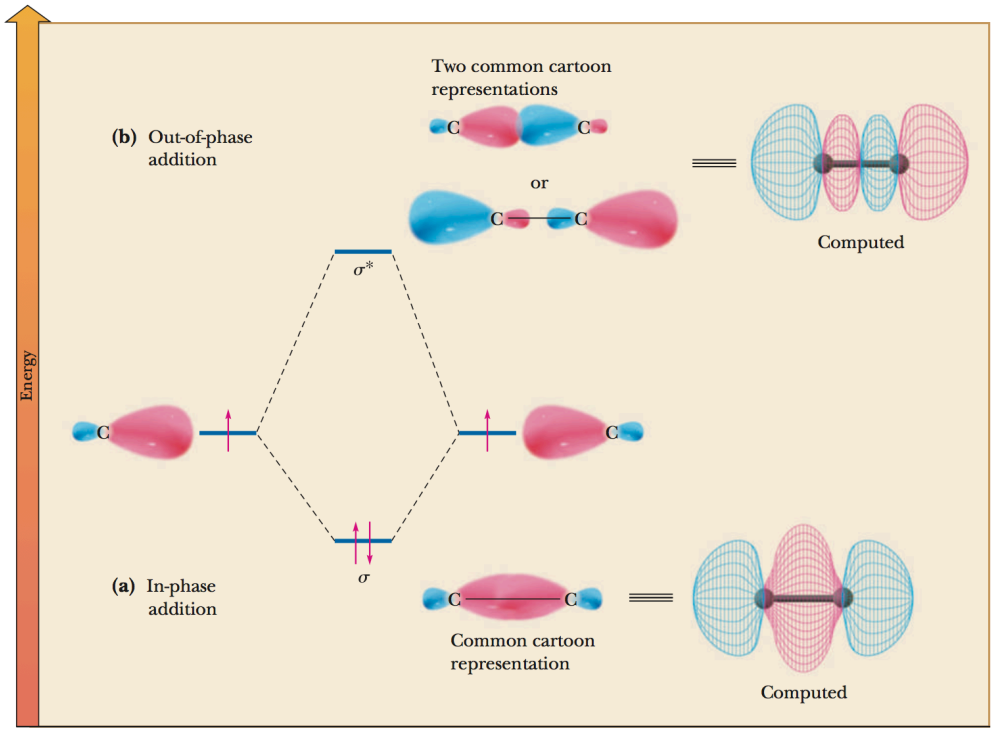
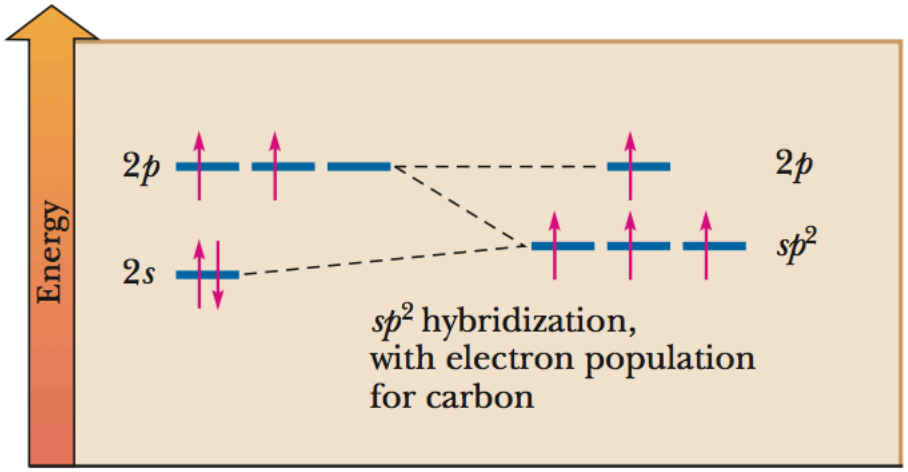


Figure 1.18
Molecular orbital mixing diagram for the creation of any C—C σ bond. (a) In-phase addition of two C hybrid orbitals (either sp^3, sp^2, or sp orbital) forms a σ orbital that is lower in energy than the two starting orbitals. When the resulting orbital is populated with two electrons, a σ bond results. (b) Addition of the orbitals in an out-of-phase manner (meaning reversing the phasing of one of the starting orbitals) leads to an antibonding σ^* orbital.



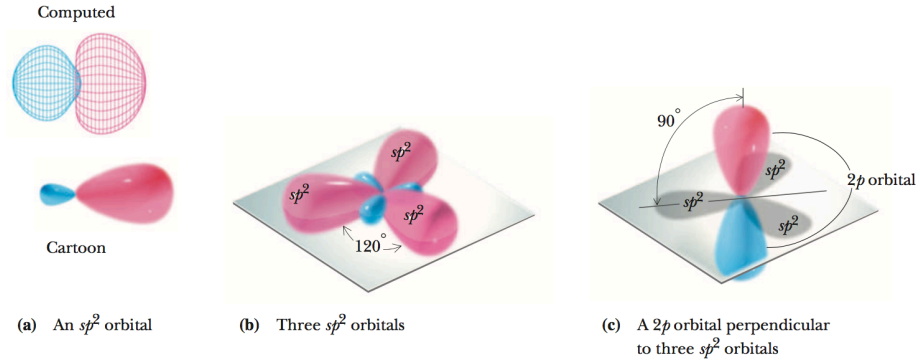


Figure 1.14
sp^2 Hybrid orbitals and a single p orbital on an sp^2 hybridized atom. (a) A single sp^2 hybrid orbital in computed and cartoon form. (b) Three sp^2 hybrized orbitals in a trigonal planar arrangement. (c) The lone p orbital.

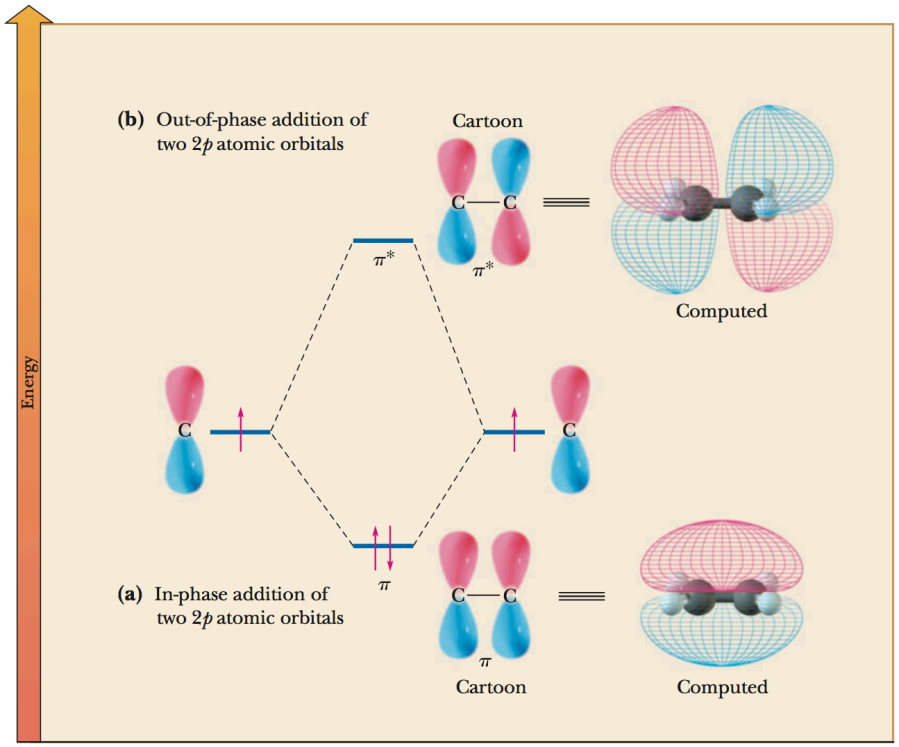


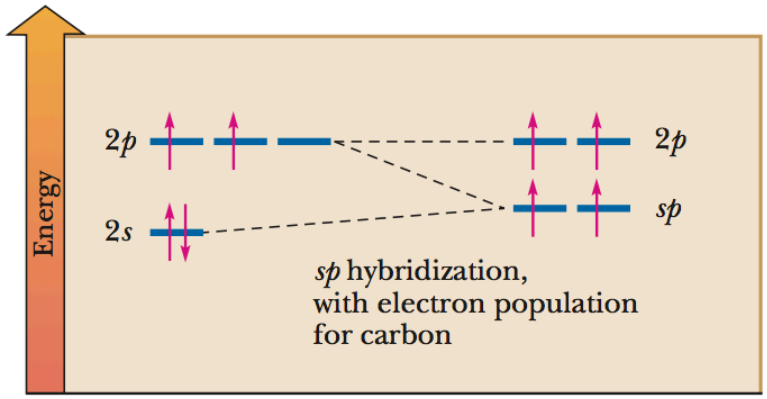
Figure 1.21
Molecular orbital mixing diagram for the creation of any C—C π bond. (a) Addition of two p atomic orbitals in phase leads to a π orbital that is lower in energy than the two separate starting orbitals. When populated with two electrons, the π orbital gives a π bond. (b) Addition of the p orbitals in an out-of-phase manner (meaning a reversal of phasing in one of the starting orbitals) leads to a π^* orbital. Population of this orbital with one or two electrons leads to weakening or cleavage of the π bond respectively.

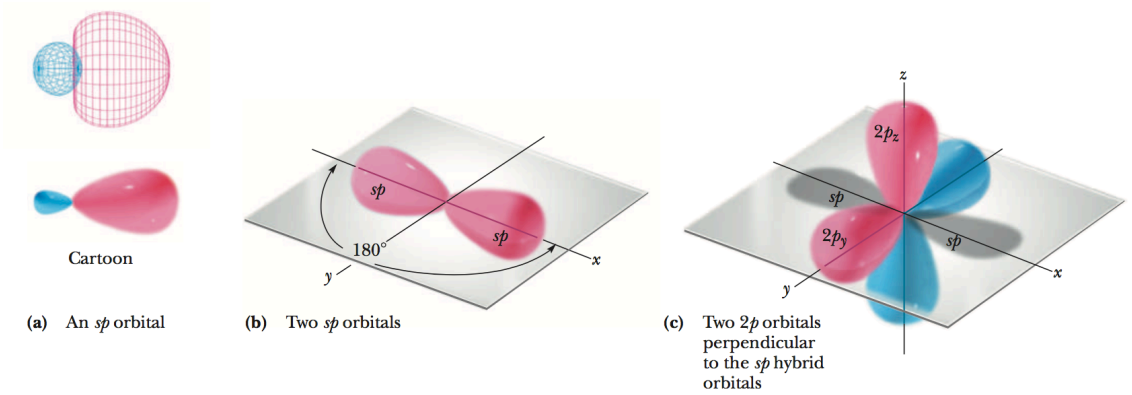
How to remember π-bonds: Hot Dog + Diet Coke

Hot Dog 'Meat' = Sigma Bond
(formed from overlap of hybridized orbitals)

Hot Dog Bun = Pi Bond
(above and below the sigma bond)

Diet Coke = [drink too much you'll have] '2p'
(π-bond formed from overlap of adjacent 2p orbitals)





(a) An *sp* orbital (b) Two *sp* orbitals (c) Two 2*p* orbitals perpendicular to the *sp* hybrid orbitals

Figure 1.16
sp Hybrid orbitals and two 2*p* orbitals on an *sp* hybridized atom. (a) A single *sp* hybrid orbital in computed and cartoon form. (b) Two *sp* hybrid orbitals in a linear arrangement. (c) The two 2*p* orbitals in perpendicular orientations to the *sp* hybrid orbitals.

Figure 1.22
Covalent bond formation in acetylene. (a) Lewis structure. (b) Overlap of *sp* hybrid orbitals on adjacent carbons forms a C—C σ bond (see Figure 1.18), and overlap of carbon *sp* hybrid orbitals with hydrogen 1*s* orbitals gives C—H σ bonds (see Figure 1.17). Further, overlap of parallel 2*p* orbitals on the adjacent carbons gives a C—C π bond (see Figure 1.21). Two such π bonds exist in acetylene.

(a) H—C≡C—H

(b) Two C—H σ bonds form from overlap of a *C sp* and a H 1*s* orbital. See one here.

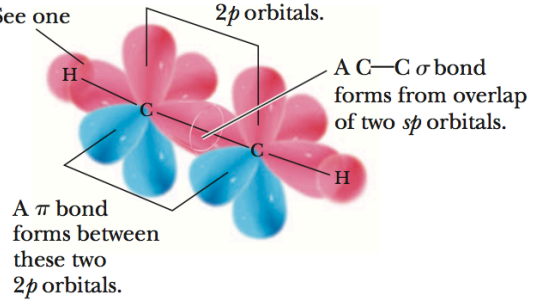


Figure 1.26
An example of molecular orbitals for delocalized systems: the three π orbitals of acetate anion. Only the lowest two are populated with electrons.