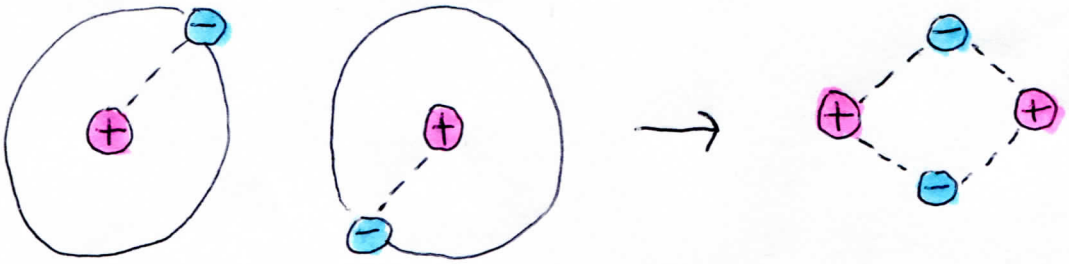
Chemistry Lecture #37: Covalent Bonding

Ionic bonds occur between metal and nonmetal atoms. In ionic bonding, electrons are transferred from one atom (metal) to another atom (nonmetal). The atoms stick together because they have opposite charge.

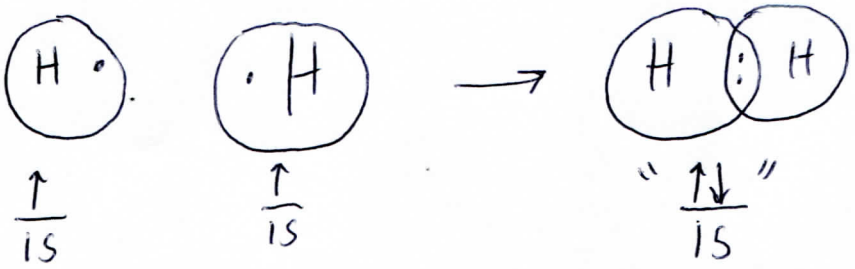
Covalent bonding occurs between two nonmetal atoms. In covalent bonding, electrons are shared between two atoms. The atoms stick together because the electrons that are between the atoms act like glue holding the positive nuclei together.

For example, suppose two hydrogen atoms come close to each other. The electron attached to one hydrogen atom will be attracted to the nucleus of the other hydrogen atom. Thus, each electron will be attracted to the nuclei of both atoms.



The electrons are like peanut butter and the nuclei are like two slices of bread. The peanut butter holds the bread together, and the electrons hold the nuclei together.

Atoms will overlap orbitals to achieve a covalent bond. For example, when hydrogen atoms bond, they overlap their s orbitals.



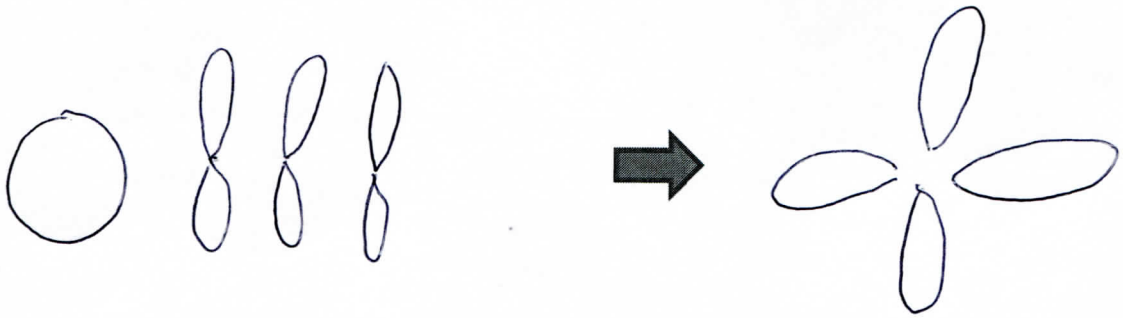
When the two s orbitals overlap, it is as though there are two electrons in both s orbitals, and this stabilizes the hydrogen atoms. Remember that a full s orbital makes an atom more stable.

Also, orbitals are capable of holding two electrons. When an orbital with one electron overlaps with another orbital that has a single electron, both orbitals will then have two electrons. This makes both atoms more stable.

Thus, when covalent bonding occurs, single electrons on one atom will be paired up with single electrons on other atoms.

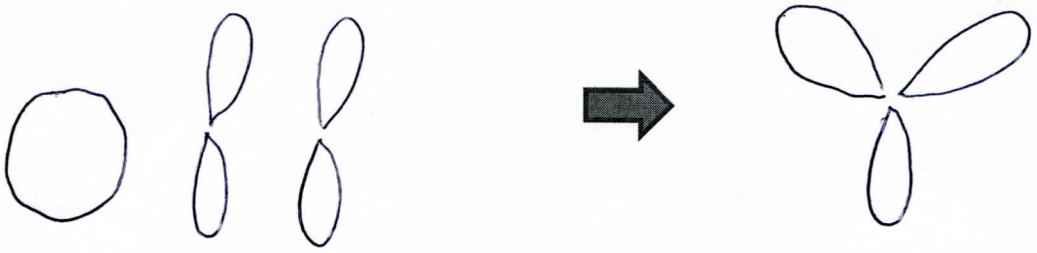
In addition, s and p orbitals on an atom will combine to form a hybrid orbital. An s orbital can combine with 1, 2, or 3 p orbitals.

When an s orbital combines with three p orbitals, it looks like this:



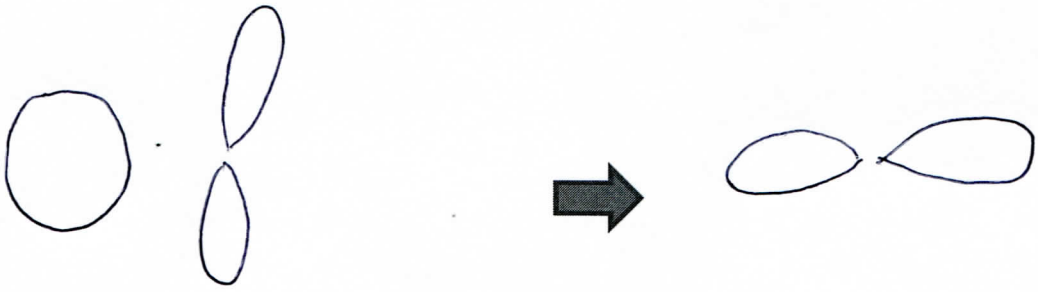
sp^3 hybrid

When an s orbital combines with two p orbitals, it looks like this:



sp^2 hybrid

When an s orbital combines with one p orbital, it looks like this:

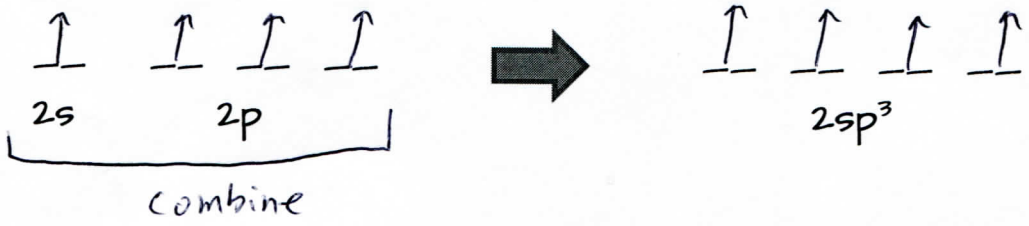


sp hybrid

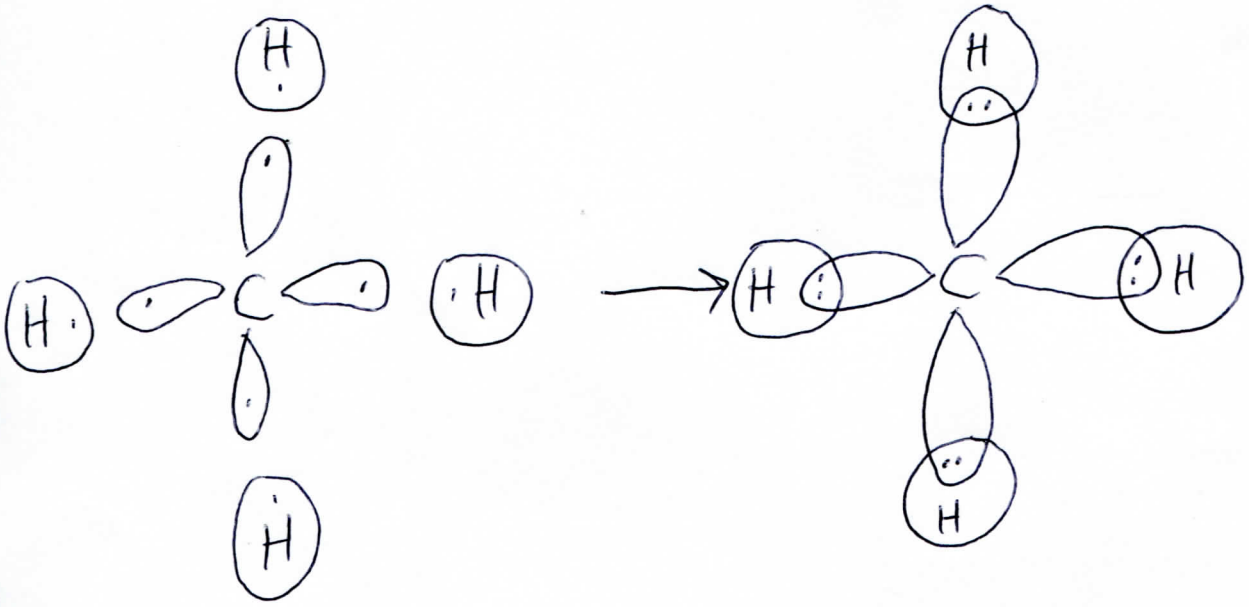
In covalent bonding, hybrid orbitals will overlap with other types of orbitals to pair up unpaired electrons.

In addition, electrons that are paired up and shared give the nonmetals an octet, which is a higher form of stability.

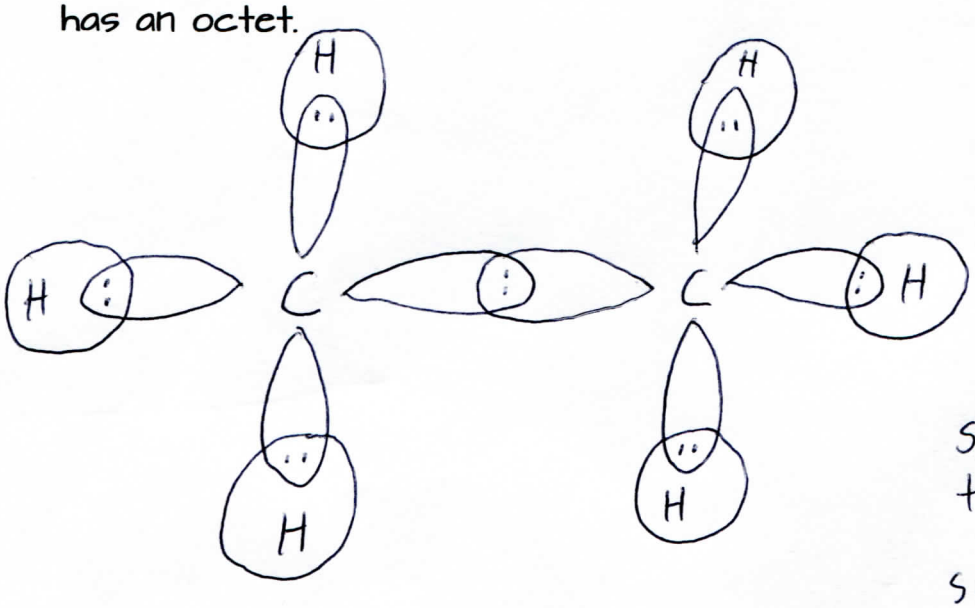
Carbon will hybridize its orbitals in the 2nd energy levels to form sp^3 hybrid orbitals.



Below is a diagram showing how the s orbitals of four hydrogens overlap the sp^3 orbitals of carbon to form covalent bonds. Notice that carbon has an octet.



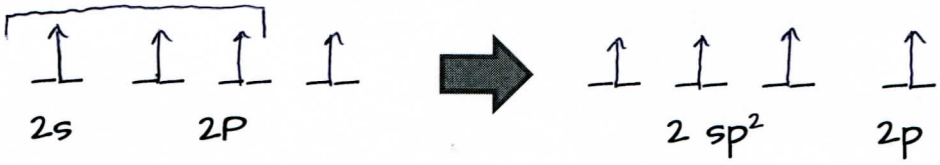
Below is a diagram showing how two carbons and six hydrogens will overlap their orbitals to form C_2H_6. Notice again that carbon has an octet.



single bond between the carbons.

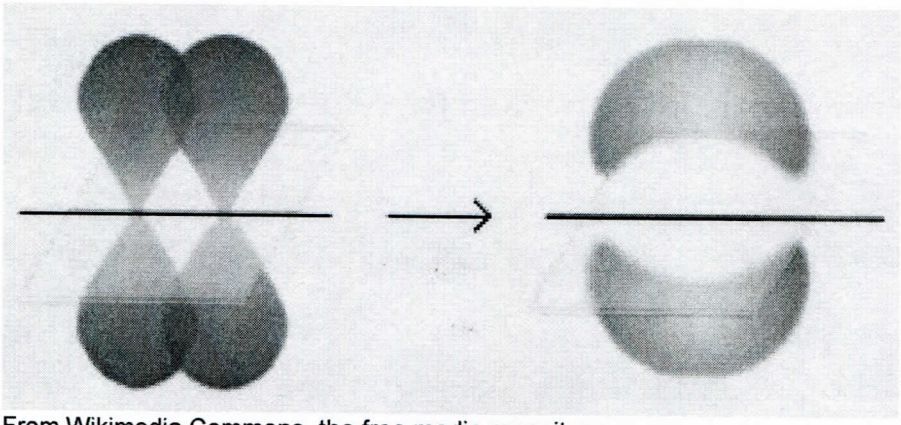
single bond between hydrogen and carbon.

Two carbons and four hydrogens can form covalent bonds. For this to occur, each carbon will hybridize their s and p orbitals to an sp^2 configuration.



Each carbon now has three sp^2 hybrid orbitals and a single p orbital.

The p orbitals in both carbons are oriented side by side. This allows the top of one p orbital to overlap the top of the other p orbital. The bottom half of each p orbital also overlap each other. The overlap of the p orbitals in this fashion produces a crescent shape above and below.



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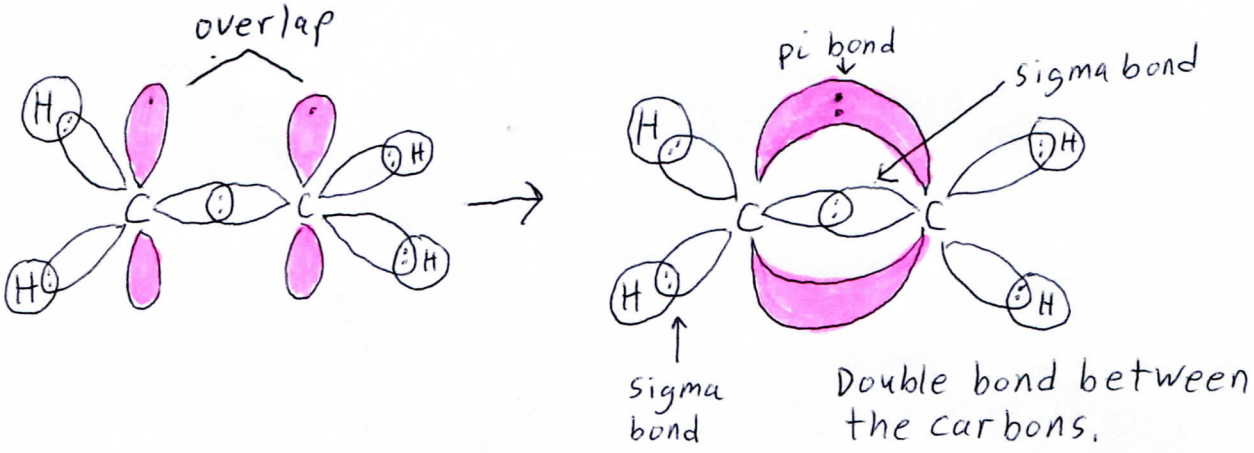
Pi-bond.jpg (307 × 139 pixels, file size: 26 KB, MIME type: image/jpeg)

Below is a diagram showing how the p orbitals and hybrid orbitals of carbon overlap to form C_2H_4. The p orbitals are colored pink.

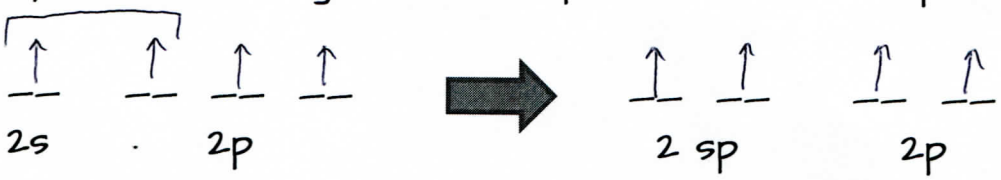


The diagram shows two types of bonds: sigma bonds and pi bonds. In a sigma bond the shared electrons are directly between the atoms. The diagram shows a sigma bond between the two carbons. There are also sigma bonds between the carbons and hydrogens. Sigma bonds are the result of a direct overlap between orbitals. A single bond between atoms is a sigma bond.

A pi bond is a covalent bond where the shared electrons are not directly between the atoms. The sideways overlap between p orbitals creates a pi bond.

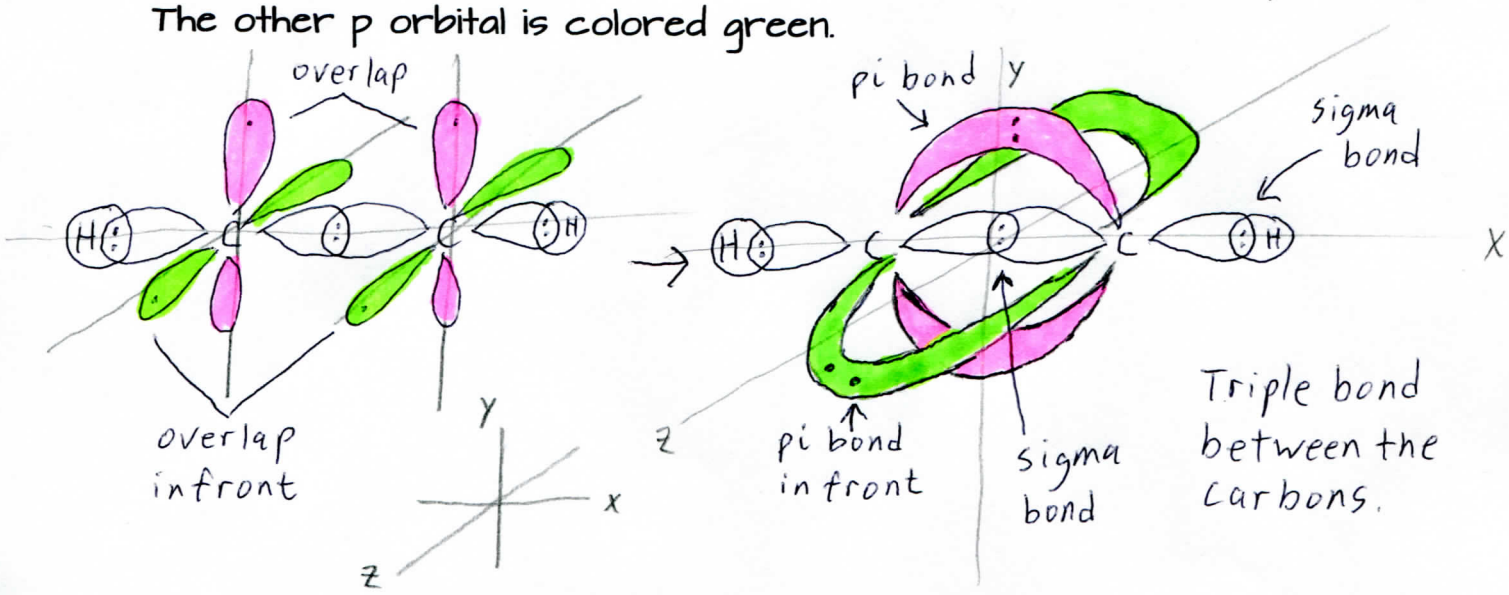
There are two covalent bonds between the carbons. When this occurs, we have a double bond. A double bond is made of one sigma and one pi bond.

Two carbons and two hydrogens can bond to form C_2H_2. For this to occur, each carbon will hybridize its orbitals to form an sp hybrid. This will give us two sp orbitals and two p orbitals.



Each carbon now has two sp orbitals and two p orbitals.

Below is a diagram showing how the p orbitals and hybrid orbitals of carbon overlap to form C_2H_2. One p orbital is colored pink. The other p orbital is colored green.



There are three covalent bonds between the two carbons. This is called a triple bond. A triple bond is made of one sigma bond and two pi bonds. The pi bonds are made by the sideways overlap of p orbitals:

The p orbitals overlap on top and bottom [pink crescents], and in front and behind [green crescents].