Organic Chemistry (1)

What is Organic Chemistry?

Organic chemistry is the chemistry of compounds that contain the element carbon.

Carbon compounds are central to life on this planet.

Importance of Organic Compounds

- The chemical substances that make up our bodies; are organic.
    1. DNA: the giant molecules that contain all the genetic information for a given species.
    2. proteins: blood, muscle, and skin.
    3. Enzymes: catalyze the reactions that occur in our bodies.
- Petroleum: furnish the energy that sustains life.
- Polymers: Cloths, cars, plastic, kitchen appliances.
- Medicine.

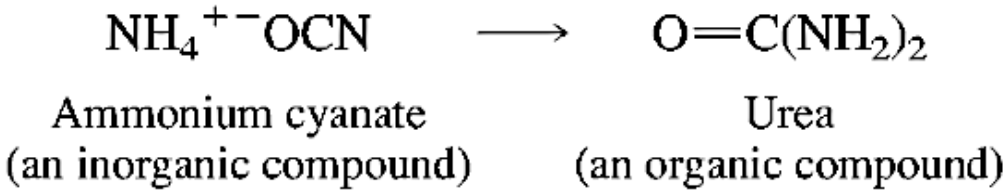
Development of the Science of Organic Chemistry

Theory Vitalism

According to Vitalism, organic compounds were only those that came from living organisms through intervention of a vital force.

Inorganic compounds are the compounds that came from nonliving sources.

In 1823, Friedrich Wohler discovered the synthesis of organic compound called urea (a constituent of urine) from inorganic compound.

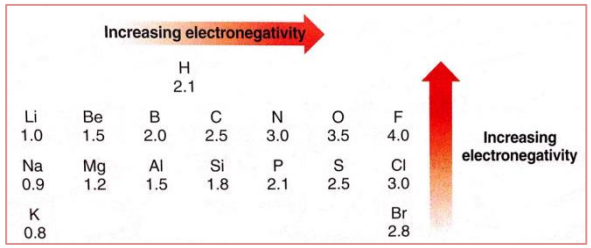


Chemical Bonds: The Octet Rule

A **chemical bond** is an attraction between atoms.

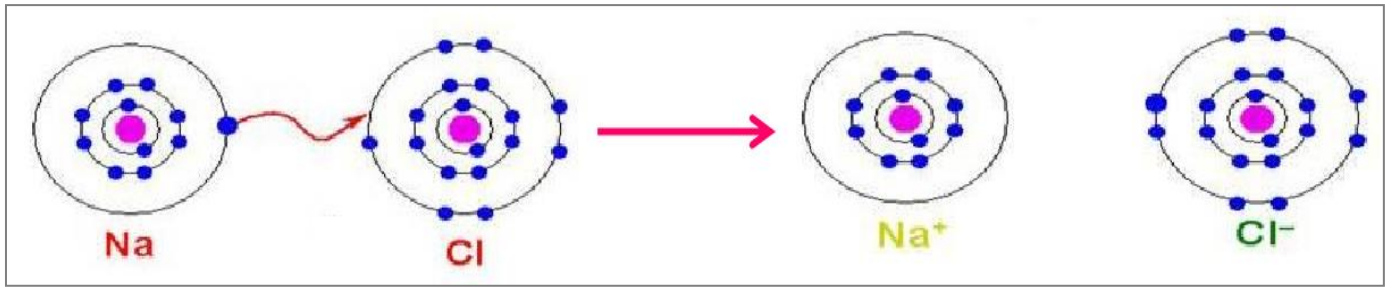
✓ When two atoms with large different electronegativity values:

1) Ionic Bonding



- **Ionic bonds form** from the electrostatic attraction between oppositely charged ions.
- Atoms **become ionic** by **losing** or **gaining** electrons from the atom it is bonding with.

Example: NaCl

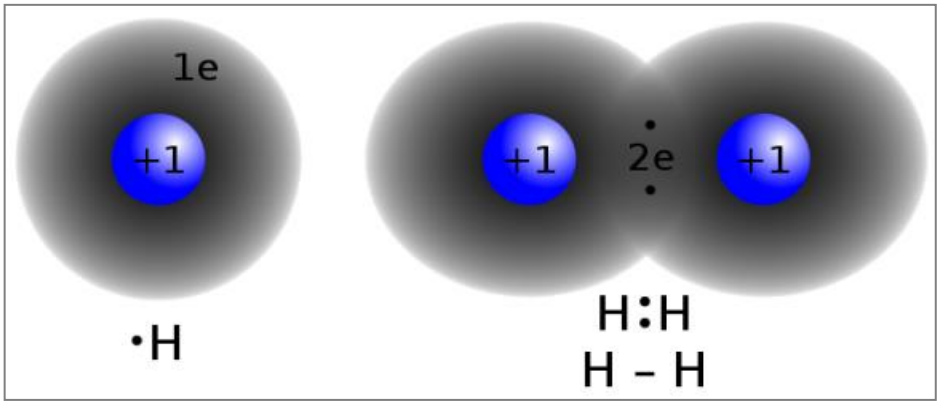


✓ When two atoms with similar electronegativity values:

1) Covalent Bonding

A **covalent bond** is a form of chemical bonding that is characterized by the sharing of pairs of electrons between atoms

Example: H_2

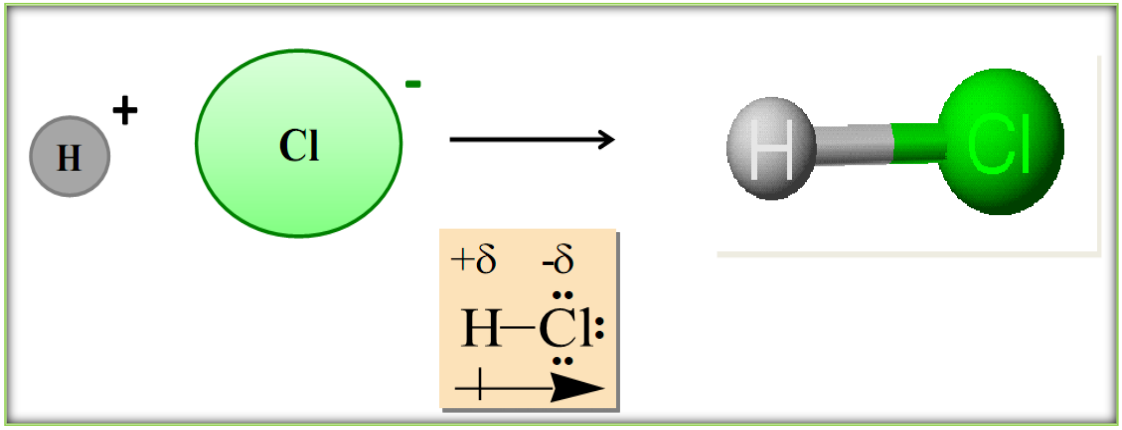


✓ When two atoms with different electronegativity values:

1) Polar Covalent Bonding

- A polar covalent bond is one in which one atom has a **greater attraction** for the electrons than the other atom.
- The electron cloud in a σ-bond between two unlike atoms is not uniform and is slightly **displaced towards** the more electronegative of the two atoms.

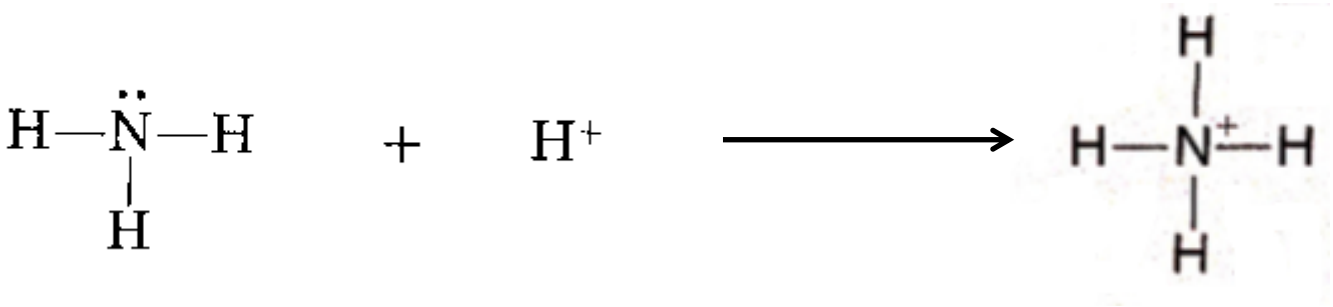
Example: HCl



2) Coordinate Covalent Bonding

There are molecules in which one atom supplies **both** electrons to another atom in the formation of covalent bond.

Example: Ammonium ion NH_4^+



How Many Bonds to an Atoms?

Covalent Number: is the number of covalent bonds that an atom can form with other atoms.

Covalence Numbers of Typical Elements in Organic Compounds

Element	Number of Valence electrons	Number of electrons in filled valence shell	Covalent number
H	1	2	1
C	4	8	4
N	5	8	3
O	6	8	2
F, Cl, Br, I (halogens)	7	8	1

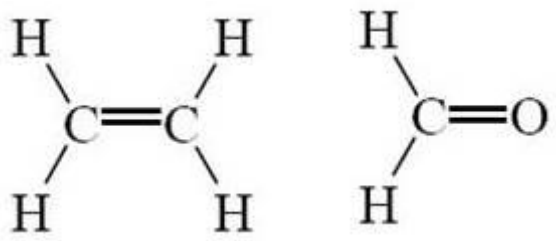
The Uniqueness of Carbon:

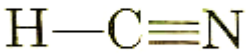
$$C_{6}^{12}$$

- It has 6 electrons in its outer shell arranges $1s^2 2s^2 sp^2$
- Carbon is unique among the elements for its ability to bond with itself to form compounds of various sizes and shapes as well as to bond with many other elements
- Carbon atom can form multiple bonds, long chains, side chains and cyclic chains.

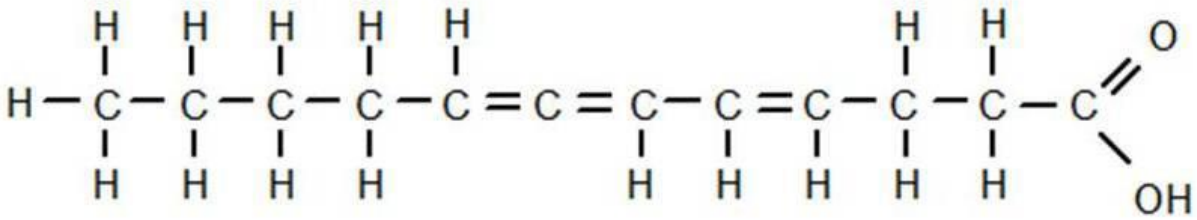
Examples:

1- Multiple bonds: double or triple

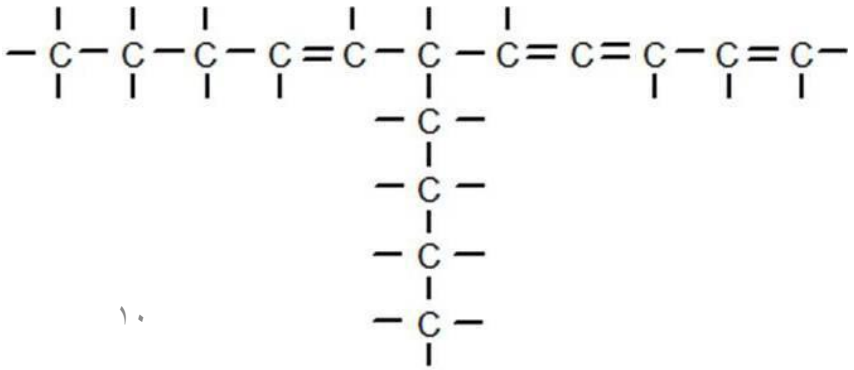




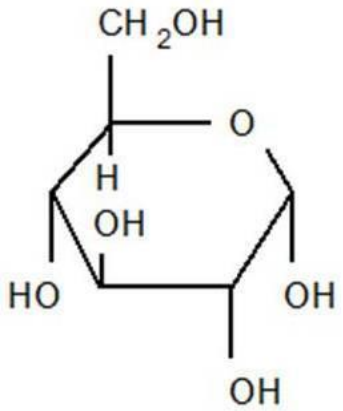
2-Long chains



3-Side chains



4-Cyclic chains



Formula and Diagrams:

1- Molecular Formula

Examples:

The molecular formula of alkyne

$$C_nH_{2n-2}$$

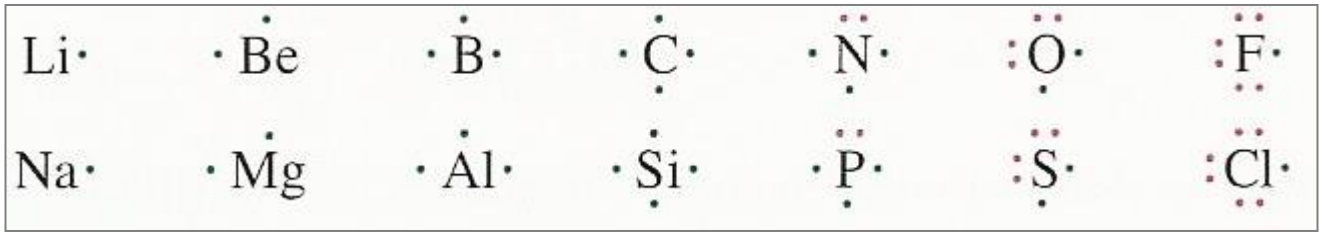
The molecular formula of carboxylic acids

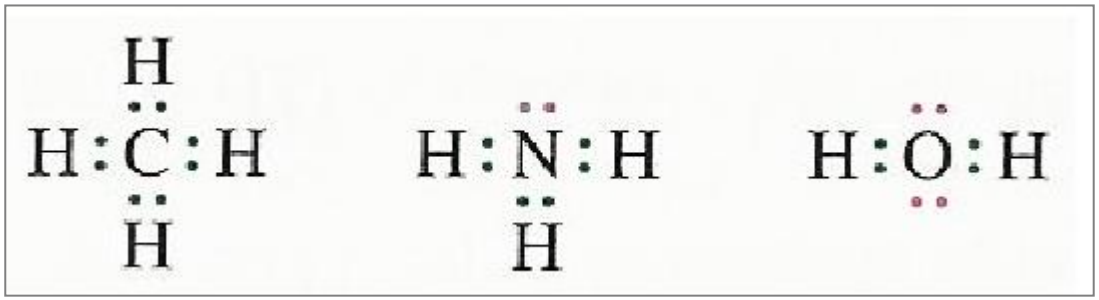
$$C_nH_{2n}O_2$$

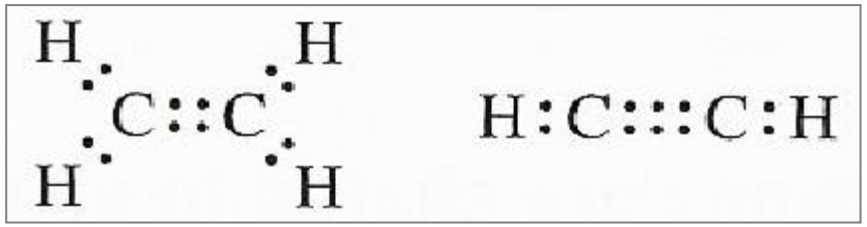
2- Electron Dot Diagrams (Lewis structure)

Electron valance as electron dots

Examples:





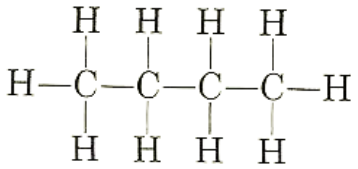


3- Structural Formula

The structure formula can be expressed by several ways

Structural Formula

Expanded structural formula



condensed formula

Partially

$CH_3—CH_2—CH_2—CH_3$

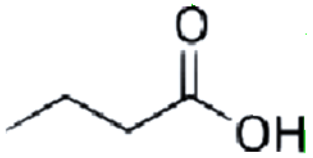
Fully

$CH_3CH_2CH_2CH_3$

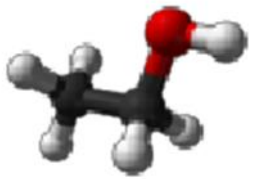
or

$CH_3(CH_2)_2CH_3$

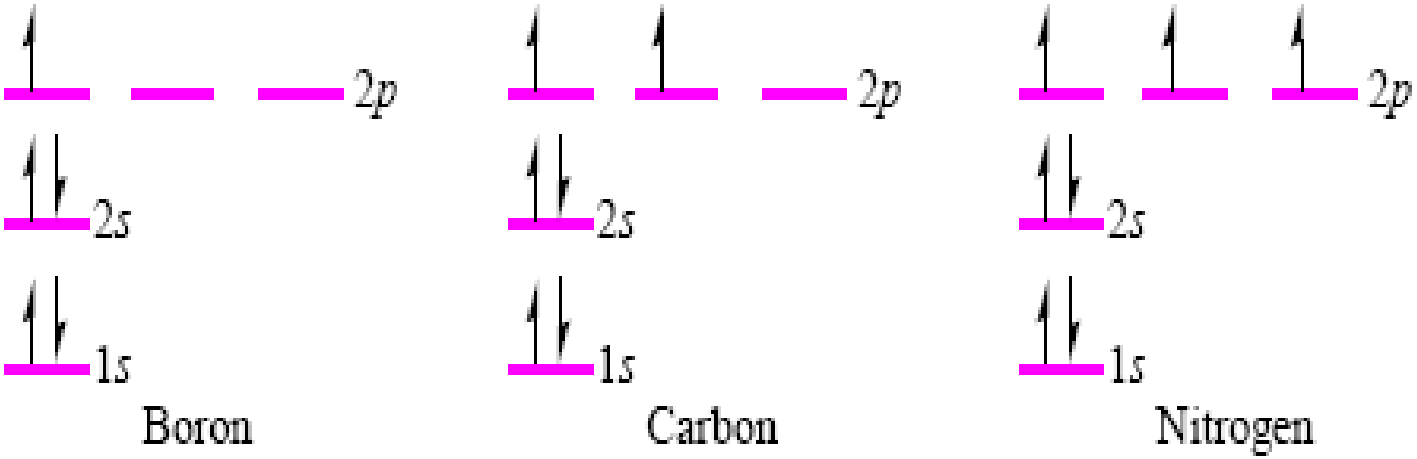
Bond line formula
(skeltel formula)



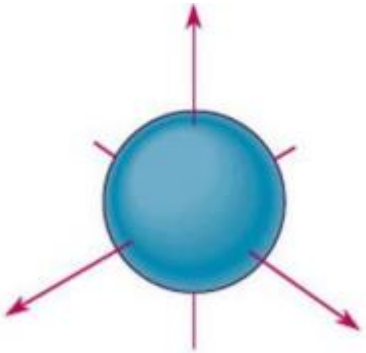
Ball-stick model



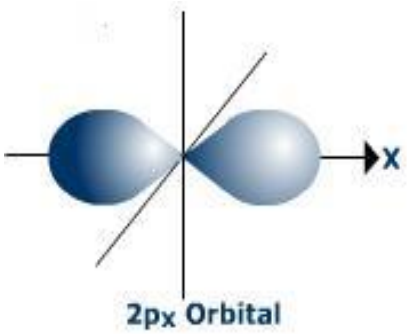
Atomic Orbitals and their Shapes

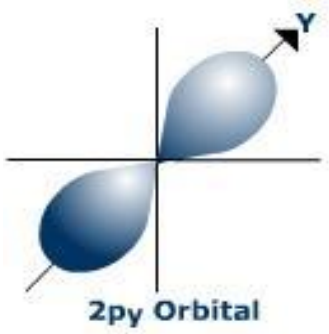


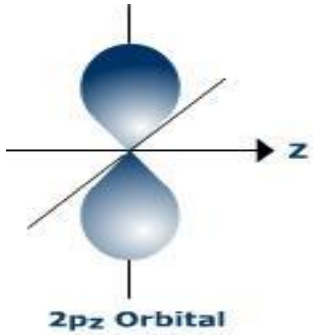
S-Orbital



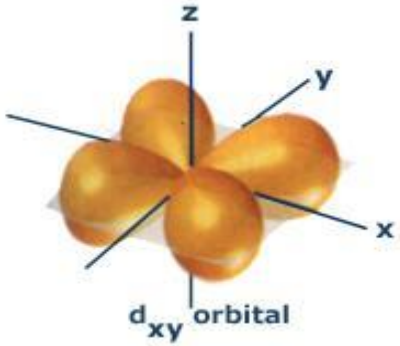
P-Orbital

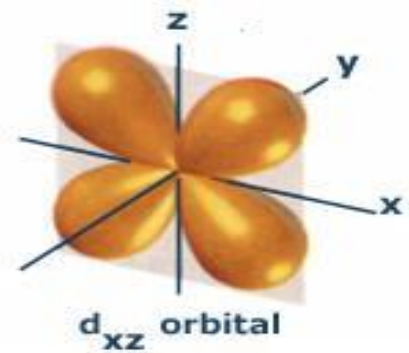


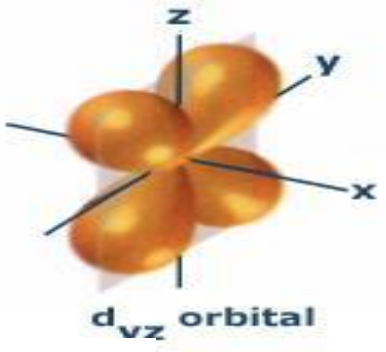


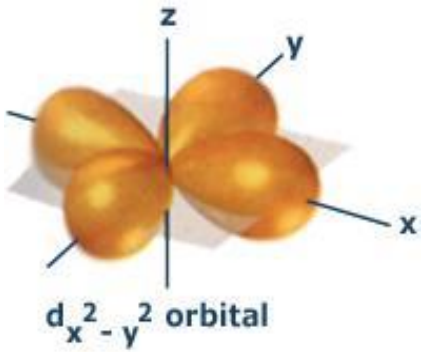


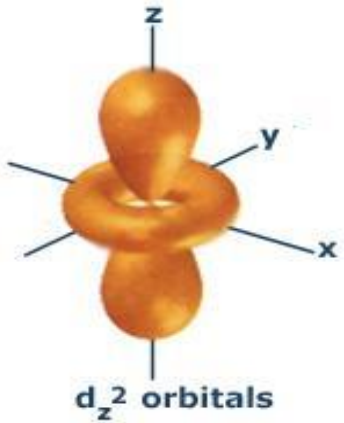
d-Orbital







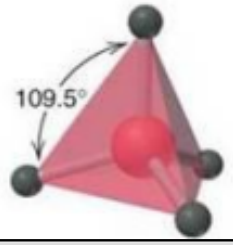
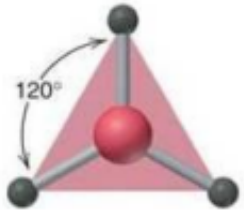
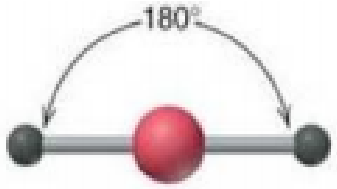




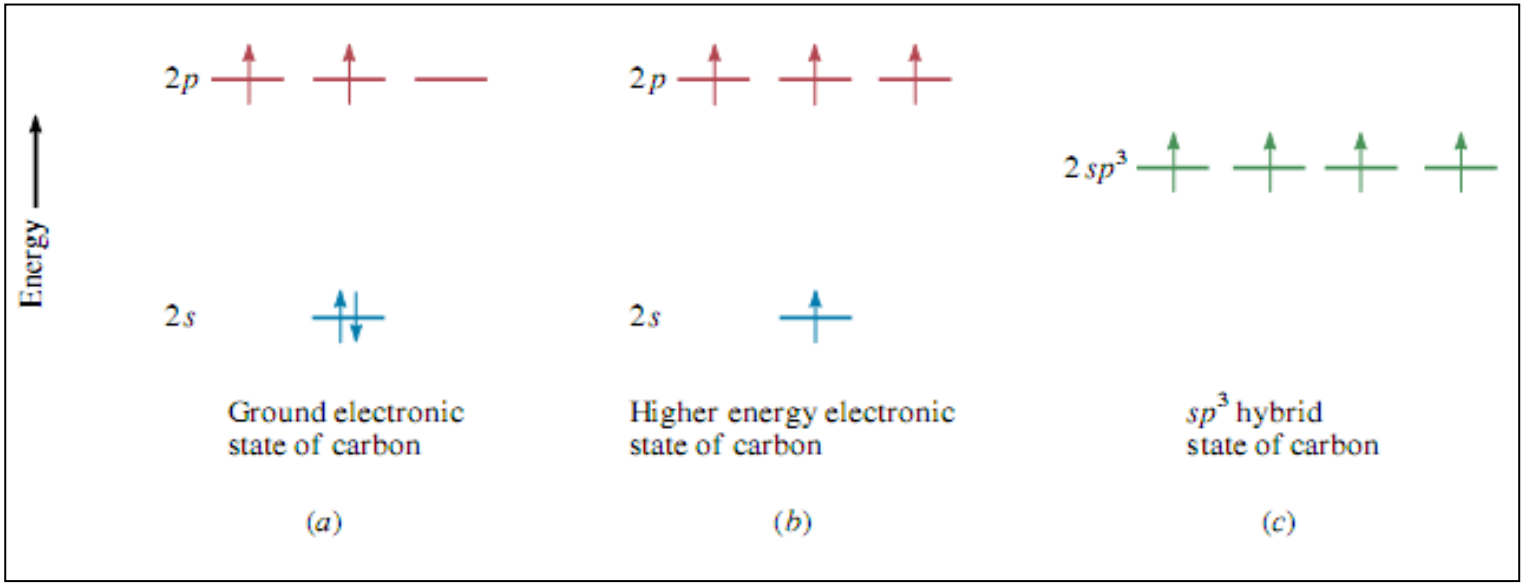
Molecular Orbital

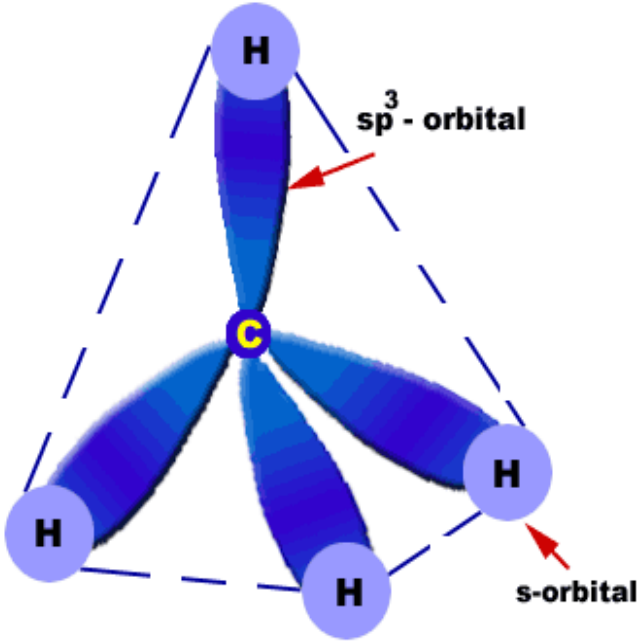
A molecular orbital is formed when two atomic orbitals overlap to generate a bond.

Types of Hybridization

sp^3	Tetrahedral	
sp^2	Trigonal Planar	
sp	Linear	

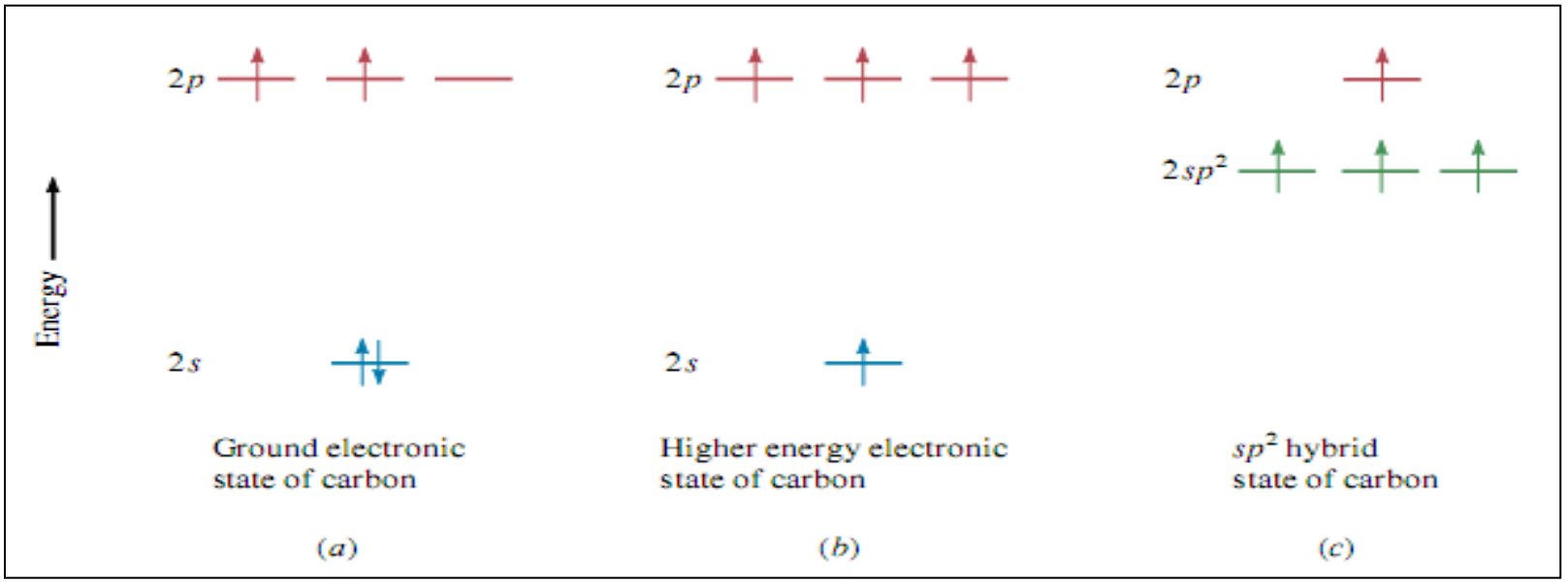
sp^3 hybridization in Methane

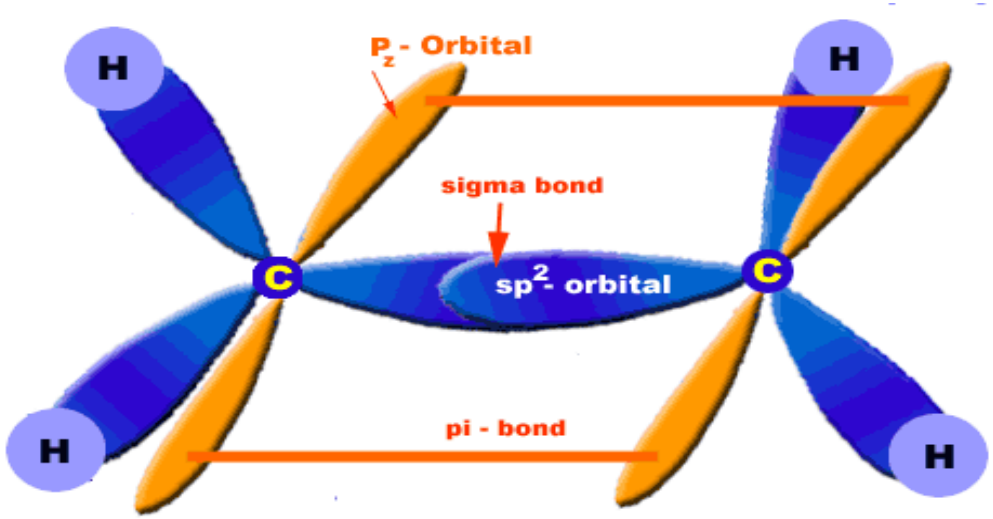




Orbital structure of methane

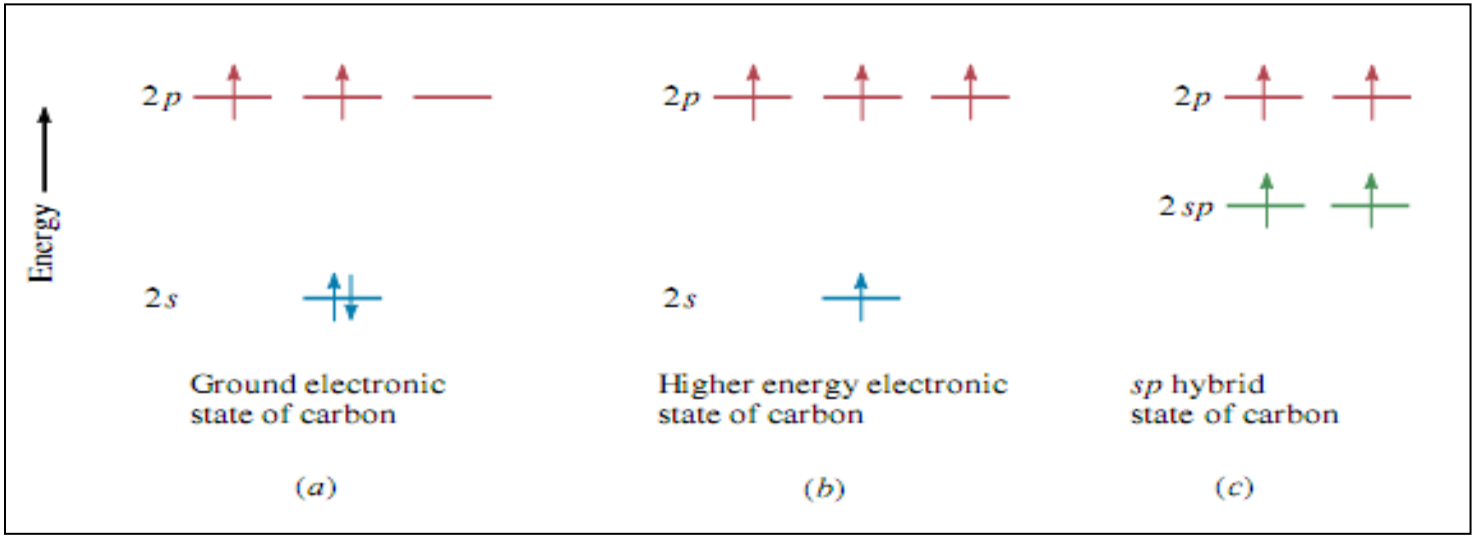
sp^2 hybridization in Ethene

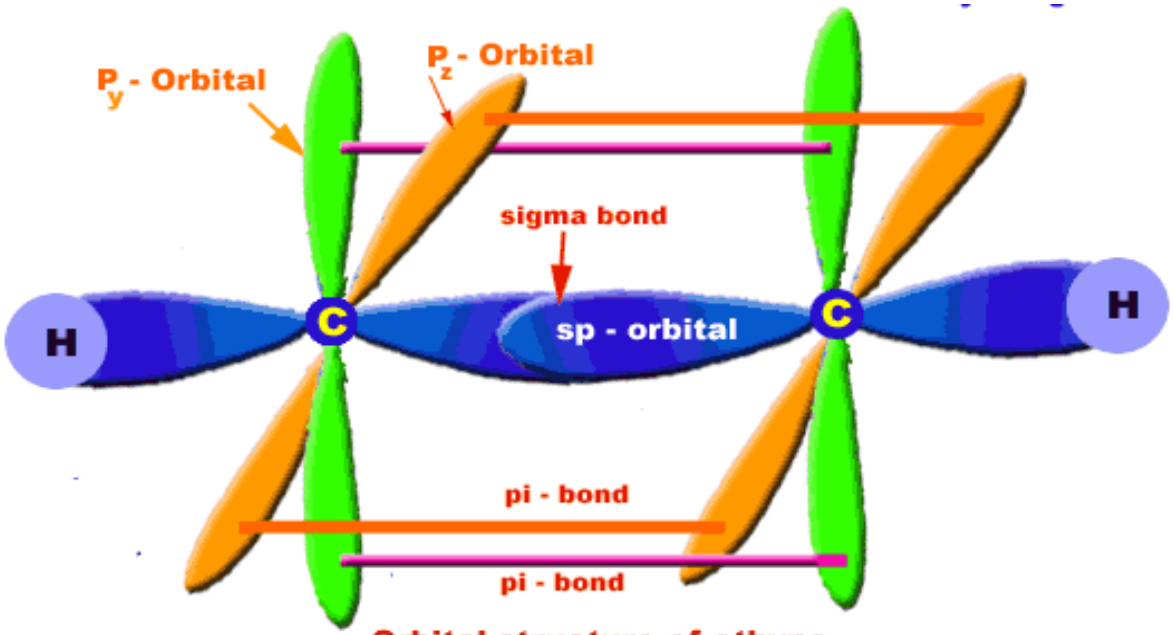




Orbital structure of ethene

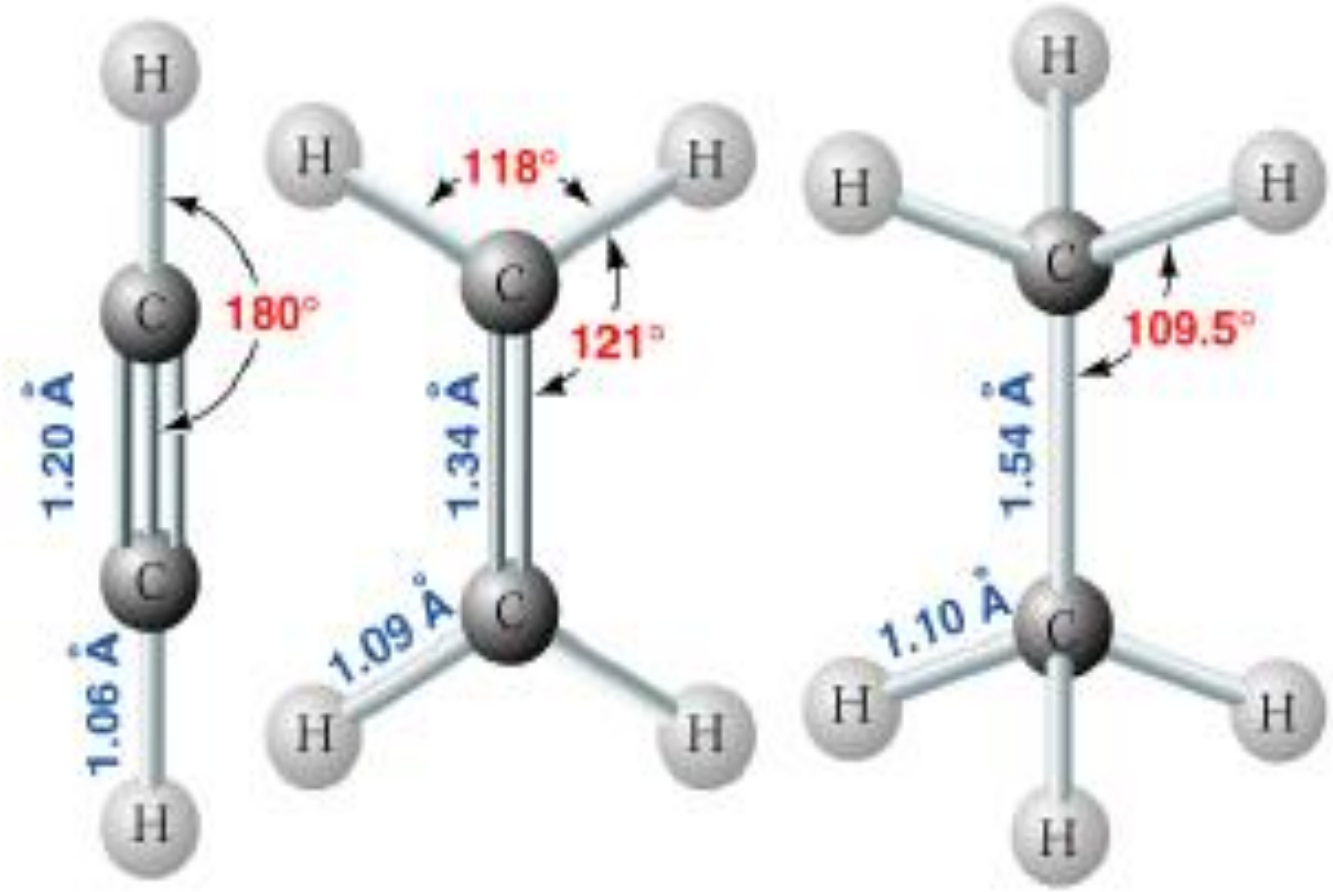
sp hybridization in Ethyne





Orbital structure of ethyne

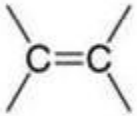
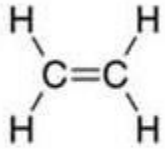
Bond lengths of Ethyne, Ethene, and Ethane



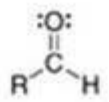
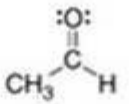
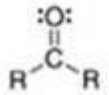
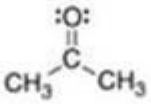
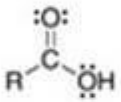
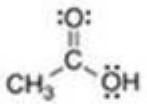
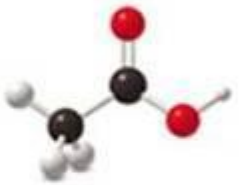
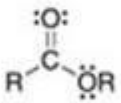
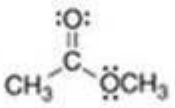
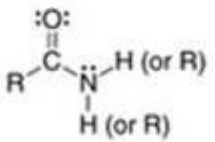
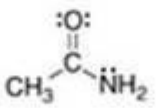
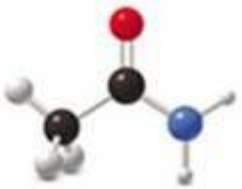
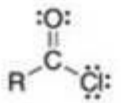
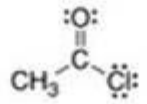
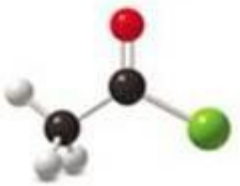
Functional Groups

Functional groups: special groups of reactive atoms that carry out chemical reactions in many organic compounds.

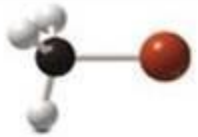
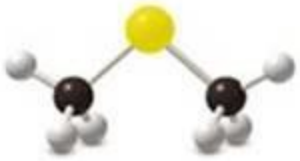
Hydrocarbons

Type of compound	General structure	Example	Functional group
Alkane	R—H	CH_3CH_3	– –
Alkene			double bond
Alkyne	—C≡C—	H—C≡C—H	triple bond
Aromatic compound			phenyl group

Compounds containing C=O

Type of compound	General structure	Example	3-D structure	Functional group
Aldehyde				C=O carbonyl group
Ketone				C=O carbonyl group
Carboxylic acid				−COOH carboxy group
Ester				−COOR
Amide				$-CONH_2$, −CONHR, or $-CONR_2$
Acid chloride				−COCl

Compounds containing C-Z σ bonds

Type of compound	General structure	Example	3-D structure	Functional group
Alkyl halide	R—X: (X = F, Cl, Br, I)	CH_3—Br:		–X halo group
Alcohol	R—OH	CH_3—OH		–OH hydroxy group
Ether	R—O—R	CH_3—O—CH_3		–OR alkoxy group
Amine	R—NH_2 or R_2NH or R_3N	CH_3—NH_2		–NH_2 amino group
Thiol	R—SH	CH_3—SH		–SH mercapto group
Sulfide	R—S—R	CH_3—S—CH_3		–SR alkylthio group