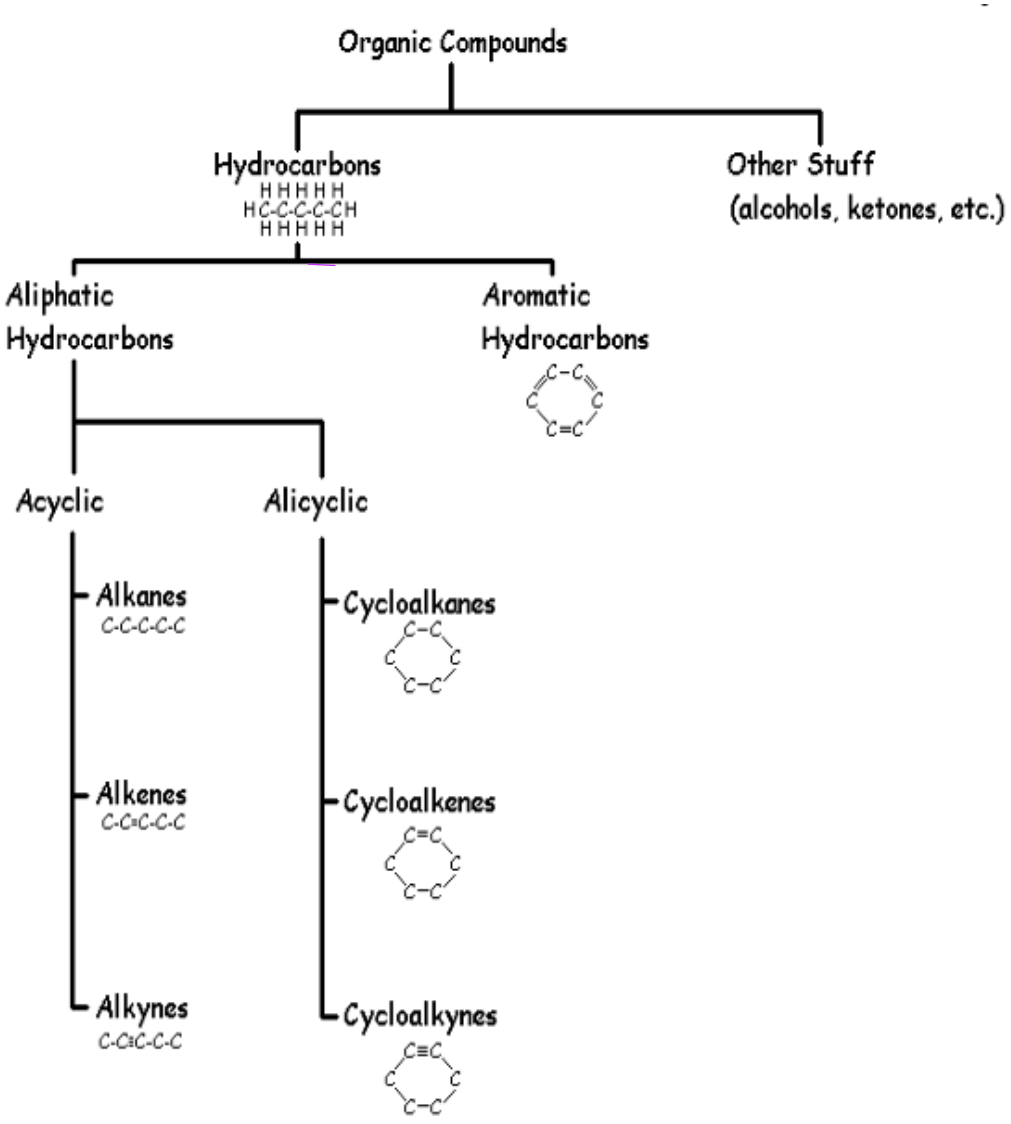
Alkane, Alkene and Alkyne

Organic compounds are classified into hydrocarbons and other stuff (alcohol, ketones,..) where hydrocarbons are compounds that consist of only carbon and hydrogen atoms, which are divided to aliphatic hydrocarbons and aromatic hydrocarbons.

Aliphatic hydrocarbons: They are compounds with straight chains, cyclic or branched chains. It may be saturated or unsaturated.

Aromatic Hydrocarbons: They are hydrocarbons that contain at least one benzene ring.



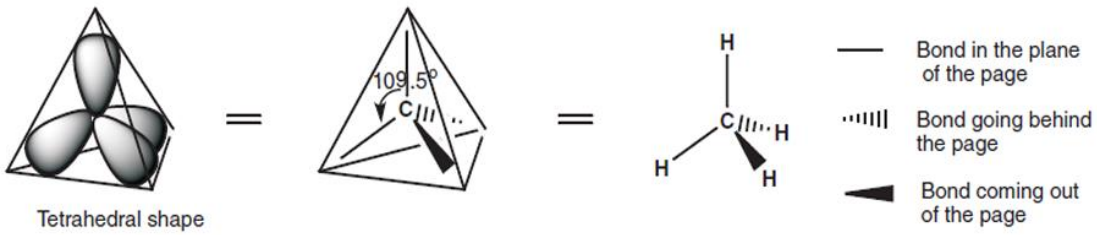
Alkanes

- Alkanes are hydrocarbons that contain only single bonds.
- Alkanes are said to be saturated hydrocarbons because their hydrogen content is at a maximum.
- Alkane general formula: C_nH_{2n+2}
- The names of alkanes all end in "-ane."
- Methane ➡ butane are gases
- Pentane ➡ $C_{17}H_{36}$ are liquids
- $C_{18}H_{38}$ and higher are solids

The first eight members of the Alkane series (C_nH_{2n+2}) :

Name	Molecular Formula	Condensed Structural Formula
Methane	CH_4	CH_4
Ethane	C_2H_6	CH_3CH_3
Propane	C_3H_8	$CH_3CH_2CH_3$
Butane	C_4H_{10}	$CH_3(CH_2)_2CH_3$
Pentane	C_5H_{12}	$CH_3(CH_2)_3CH_3$
Hexane	C_6H_{14}	$CH_3(CH_2)_4CH_3$
Heptane	C_7H_{16}	$CH_3(CH_2)_5CH_3$
Octane	C_8H_{18}	$CH_3(CH_2)_6CH_3$

All carbon atoms in alkanes have a *tetrahedral shape*, and the value of the angles between the bonds is *109.5*. The bonds in them are of the *sigma* type, strong and difficult to break. Therefore, alkanes are inactive. Although alkanes are inactive compounds, they are involved in some chemical reactions, and these often have Reactions are of limited importance to organic chemistry, but they are of great industrial importance because of their importance as fuel.



Tetrahedral shape

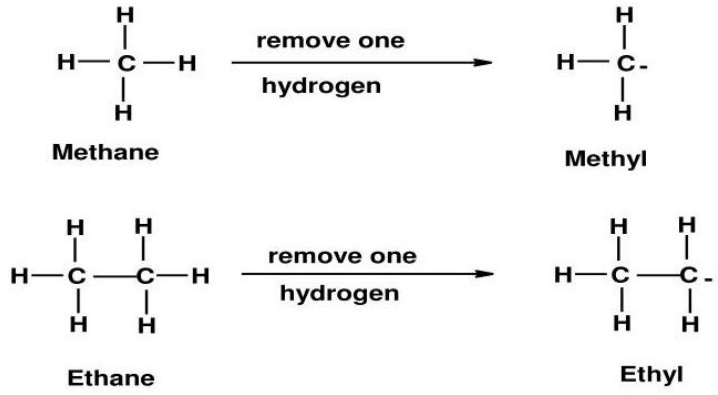
Physical Properties

- No color & odour
- Lower Alkane: gases , Middle Alkane: liquids , Higher Alkane: solid
- Higher boiling point : higher molecular wt.
- Branched chain: decrease surface area , Long chain : higher surface area.
- Even no. of carbon : higher M.P, Odd no. of carbon : lower M.P
- Higher density: higher mol. wt : decrease solubility
- Non polar : soluble in organic solvent

Alkyl Group

Alkyl group contains one less hydrogen than the corresponding alkane, this group does not exist independently but occurs bonded to another atom or molecule. In naming this group the "-ane" is dropped and "- yl" is added.

- CH_3 is "methyl" (from Methane)
- CH_2 CH_3 is "ethyl" from (Ethane)



Types of Alkyl groups:

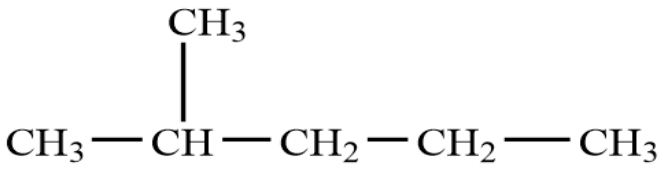
Classified by the connection site:

- a carbon at the end of a chain (primary alkyl group)
- a carbon in the middle of a chain (secondary alkyl group) , and so on…

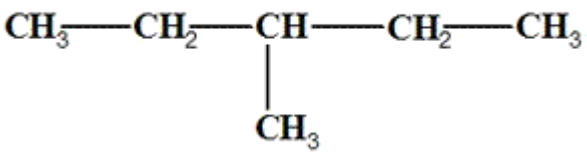
IUPAC System of Nomenclature For Alkanes

- Identify the longest chain
- Number from the end closest to first branch
- Name the groups attached to the chain, using the carbon number as the locator.
- Alphabetize substituents.
- Use di-, tri-, etc., for multiples of same substituent
- combine number and name of substituent with parent name, separating with hyphen

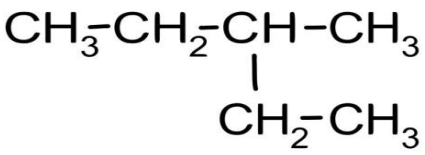
Examples:



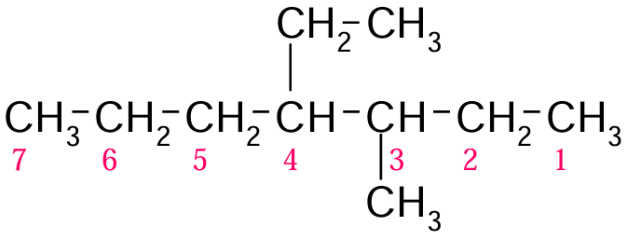
2-methylpentane.



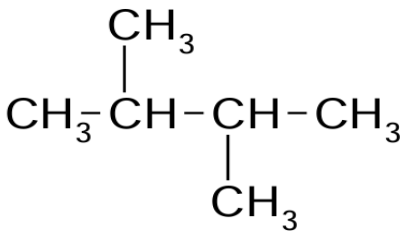
3-methylpentane



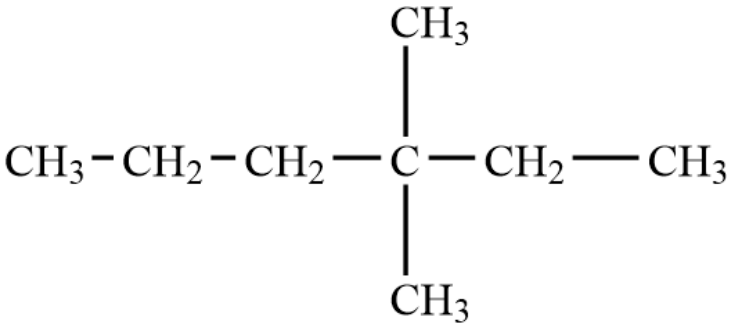
3-methylpentane



4-ethyl-3-methylheptane



2,3-dimethylbutane



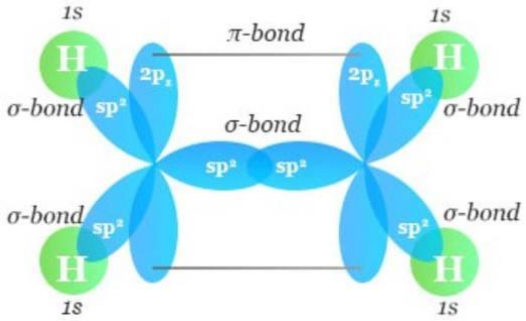
3,3-dimethylhexane

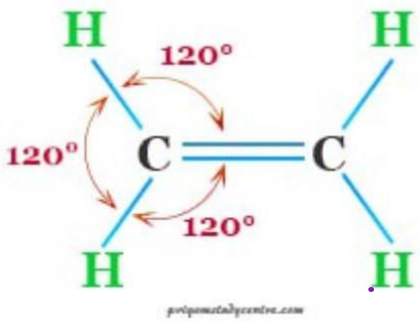
Substituents in Organic Compounds

Formula of Substituent	Name of Substituent
Br—	Bromo
Cl—	Chloro
F—	Fluoro
I—	Iodo
CH_3—	Methyl
CH_3CH_2—	Ethyl

Alkenes

Members of the alkene group have a double bond between two carbon atoms. Two hydrogen atom has been removed from carbon atoms. General formula is C_nH_{2n} Begins with Ethene (Ethylene) C_2H_4. The active group in alkenes is the double bond, which contains one sigma (δ) bond and one pi (π) bond. All orbitals are located on one level, the value of the angle between them is 120^o, and the general shape of the molecule is a plane triangle.





Some Members of the Alkene Series:

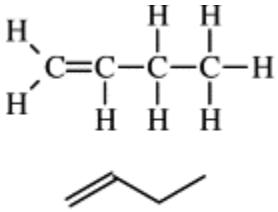
Name	Molecular Formula	Condensed Structural Formula
Ethene (ethylene)	C_2H_4	$CH_2{=}CH_2$
Propene	C_3H_6	$CH_3CH{=}CH_2$
1-Butene	C_4H_8	$CH_3CH_2CH{=}CH_2$
2-Butene	C_4H_8	$CH_3CH{=}CHCH_3$
1-Pentene	C_5H_{10}	$CH_3(CH_2)_2CH{=}CH_2$

Physical properties:

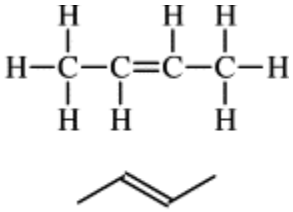
- Carbon-carbon double bond changes the physicals properties of alkenes.
- Physical state: Ethene, Propene, and Butene exists as ➡ colorless gases.
  Members of the 5 or more carbons such as Pentene, Hexene, and Heptene are ➡ liquid
  Members of the 15 carbons or more are ➡ solids.
- Density: Alkenes are lighter than water.
- Solubility: insoluble in water. (Alkenes are only soluble in nonpolar solvent like benzene, ether, chloroform).
- Boiling point: depends on more M.wt. (Higher boiling point; higher M.wt.)
- Melting point : Alkenes have similar melting points to that of alkanes.

IUPAC System of Nomenclature For Alkenes

- "-ane" suffix for the corresponding alkane is changed to "-ene" for alkenes.
- A number preceding the name indicates the C atom on which the double bond starts.
- The carbons are numbered such that the double bond has the lowest number.
- When there is a compensated group and a double bond, the priority of numbering is for the double bond.
- When there is more than one double bond on the chain, (di, tri, tetra) are used.
- For example, 1-butene and 2-butene:

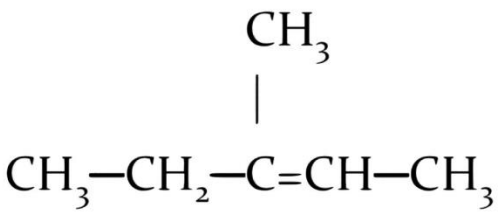


1-Butene

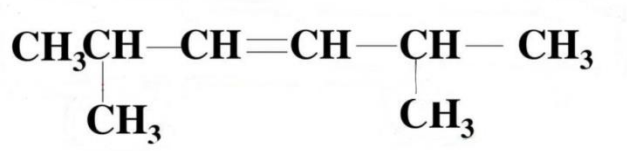


2-Butene

Examples:



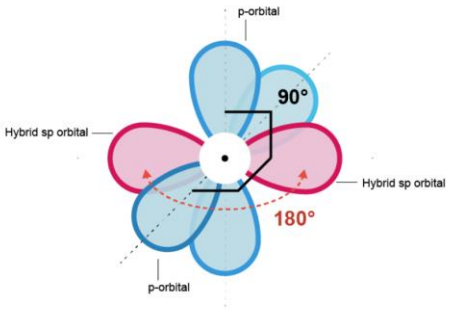
3 –methyl 2-pentene



2,5-dimethyl-3-hexene

Alkynes

Members of the alkyne group have a triple bond (consists of one **δ** bond and two **π** bonds) between two carbon atoms. It contains two fewer hydrogen atoms than alkenes and four fewer hydrogen atoms than alkanes. General formula is C_nH_{2n-2} , begins with Ethyne (Acetylene) C_2H_2 The shape of the molecule is a straight line value of the angles between the lines is 180^o.



Some Members of the Alkyne:

Name	Molecular Formula	Condensed Structural Formula
Ethyne (acetylene)	C_2H_2	$HC{\equiv}CH$
Propyne	C_3H_4	$CH_3C{\equiv}CH$
1-Butyne	C_4H_6	$CH_3CH_2C{\equiv}CH$
2-Butyne	C_4H_6	$CH_3C{\equiv}CCH_3$
1-Pentyne	C_5H_8	$CH_3(CH_2)_2C{\equiv}CH$

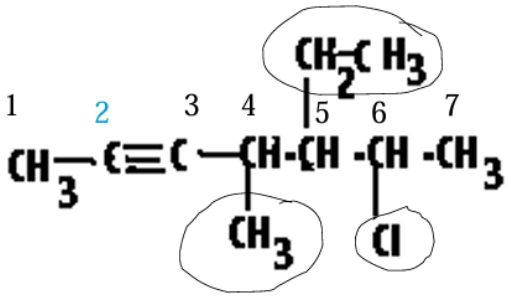
Physical properties:

- First 3 members of alkyne ➡ gaseous, form up to C8 ➡ liquid, more than 8 carbons ➡ solid.
- Colorless & except Ethyne all are odorless.
- Lighter than water
- Insoluble in polar and soluble in non-polar organic solvents.
- Melting point, Boiling point are increase with M.wt.

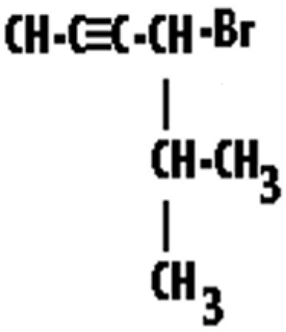
IUPAC System of Nomenclature For Alkenes

- "-ane" suffix for the corresponding alkane is changed to "-yne" for alkenes.

Example:



6-chloro-5-ethyl-4-methyl-2-heptyne



5-methyl-4-bromo-2-hexyne