Hydrocarbons

In organic chemistry, a hydrocarbon is an organic compound consisting entirely of **hydrogen** and **carbon**.

Classifications of hydrocarbons.

Aliphatic and Aromatic

1- Saturated hydrocarbons : (alkanes).

2- Unsaturated hydrocarbons: have one or more double or triple bonds between carbon atoms. Those with double bond are called alkenes. Those with one double bond have the formula $\mathbf{C_nH_{2n}}$(assuming non-cyclic structures). Those containing triple bonds are called alkynes, with general formula $\mathbf{C_nH_{2n-2}}$.

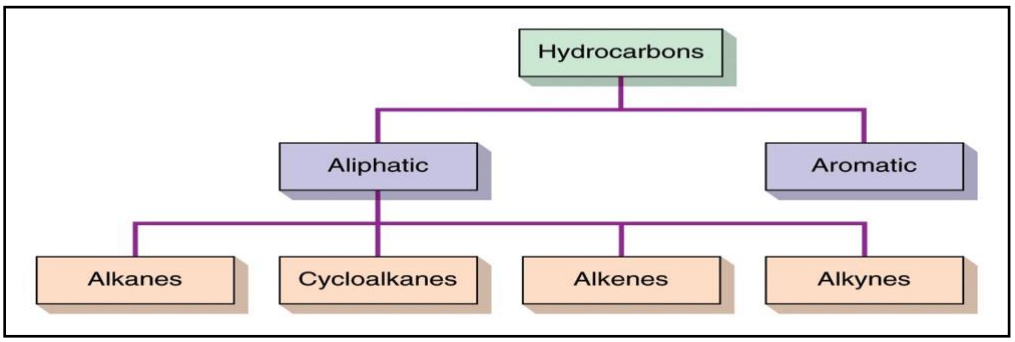
3- Cycloalkanes are hydrocarbons containing one or more carbon rings to which hydrogen atoms are attached. The general formula for a saturated hydrocarbon containing one ring is $\mathbf{C_nH_{2n}}$.

4- Aromatic hydrocarbons, also known as arenes, are hydrocarbons that have at least one aromatic ring.

1-Aliphatic compound:

Aliphatic compound is a compound containing carbon and hydrogen joined together in straight chains, branched or non-aromatic rings. Aliphatic compounds can be saturated, joined by single bonds (alkanes), or unsaturated, with double bonds (alkenes) or triple bonds (alkynes). Besides hydrogen, other elements can be bound to the carbon chain, the most common being oxygen, nitrogen, sulphur, and chlorine.

Hydrocarbons can be divided into aromatic and aliphatic hydrocarbons.



Alkanes :

1- A lkanes are the simplest of the hydrocarbon species. The general formula for saturated hydrocarbons is $\mathbf{C_nH_{2n+2}}$.

2- Alkanes are the hydrocarbons of aliphatic row.

3- Alkanes are hydrocarbons in which all the bonds are single covalent bonds (σ-bonds).

4- Alkanes are called saturated hydrocarbons.

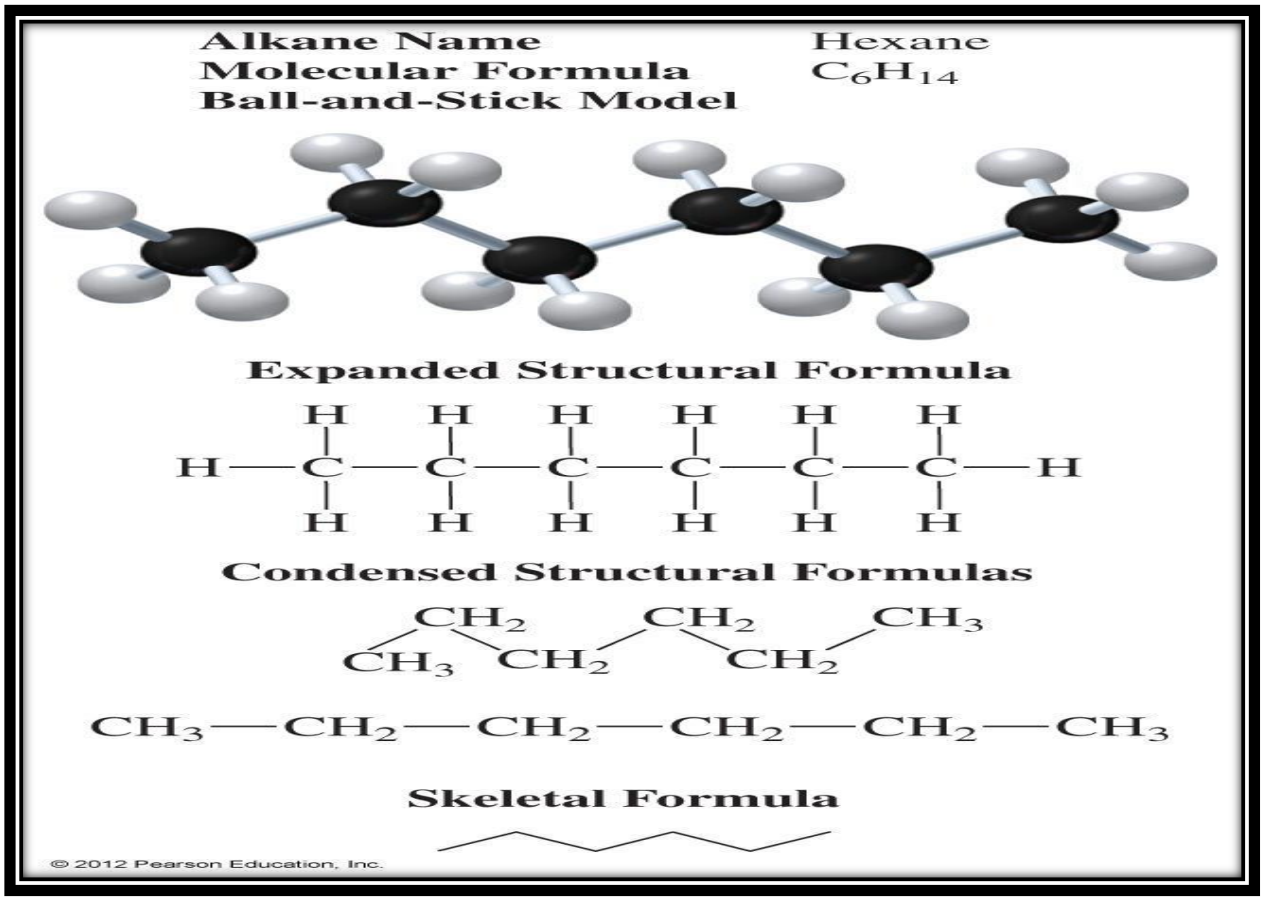
Structure of alkanes :

Alkanes are written with structural formulas that are :

1- Expanded formula to show each bond

2- Condensed formula to show each carbon atom and its attached hydrogen atoms

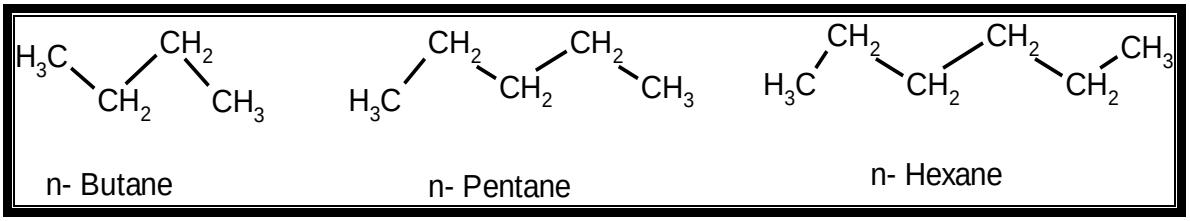
3- Line-angle formula: is a form of the structural formula. A line represents a carbon-carbon bond and a vertex represents a carbon atom. A line ending in space represents a –CH3 group.



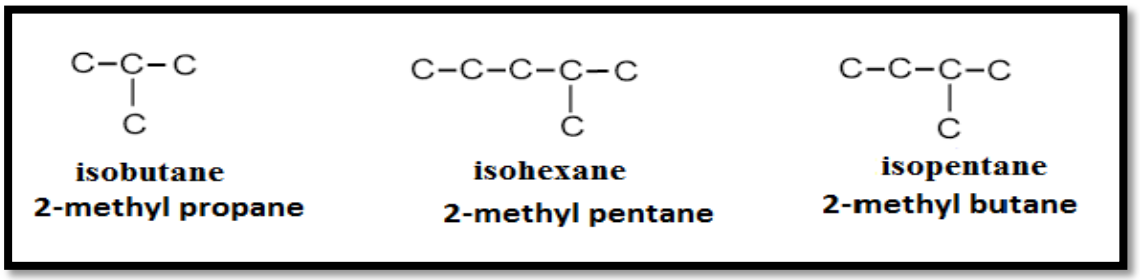
Nomenclature :

Certain branched alkanes have common names that are still widely used today. These common names make use of prefixes, such as ***normal*** , ***iso-***, ***sec-***, ***tert-***, and ***neo-***.

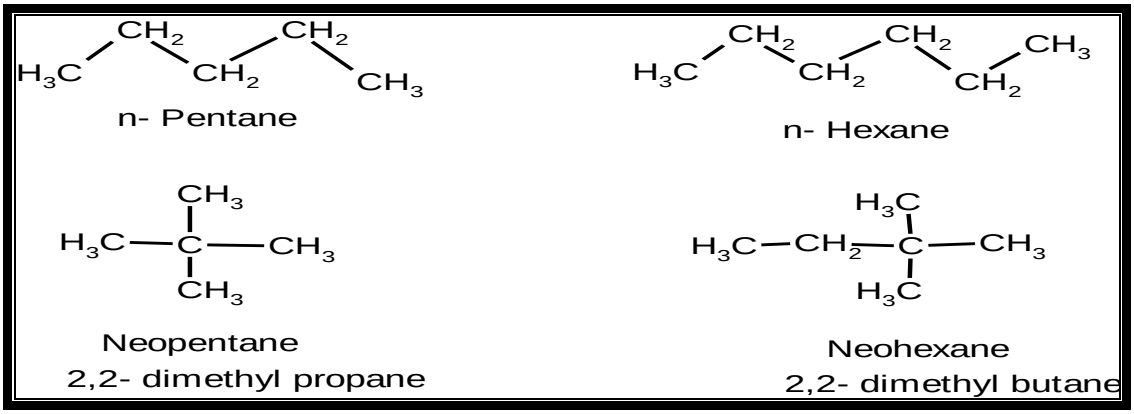
1- Noranal (n- alkane) : which have continuous carbon chain.



2- isoalkane : The prefix ***iso-***, which stands for isomer, is commonly given to 2-methyl alkanes. In other words, if there is methyl group located on the second carbon of a carbon chain, we can use the prefix ***iso-***. The prefix will be placed in front of the alkane name that indicates the *total* number of carbons. Examples isobutane which is the same as 2-methylpropane .



3- **neo alkane** : when two methyl group bonded on the same carbon atom in the carbon chain .



Systematic name :

IUPAC name (*International Union of Pure and Applied Chemistry*)

Prefix-Parent-Suffix :

Parent- number of carbons in the continuous carbon chain .

Prefix- substituent's on the continuous carbon chain .

Suffix- functional groups of hydrocarbons .

Naming Alkanes :

General Formula: $\mathbf{C_nH_{(2n+2)}}$

suffix: **-ane**

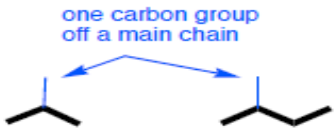
Parent Names:

No	No of C	Parent Names	General Formula	Structure	IUPAC name
1	1	Meth	CH_4	CH_4	Methane
2	2	Eth	C_2H_6	CH_3CH_3	Ethane
3	3	Prop	C_3H_8	$CH_3\ CH_2CH_3$	Propane
4	4	But	C_4H_{10}	$CH_3(CH_2)_2CH_3$	Butane
5	5	Pent	C_5H1_2	$CH_3(CH_2)_3CH_3$	Pentane
6	6	hex	C_6H_{14}	$CH_3(CH_2)_4CH_3$	Hexane
7	7	Pent	C_7H1_6	$CH_3(CH_2)_5CH_3$	Heptane
8	8	Oct	C_8H_{18}	$CH_3(CH_2)_6CH_3$	Octane
9	9	Non	C_9H_{20}	$CH_3(CH_2)_7CH_3$	Nonane
10	10	Dec	$C_{10}H_{22}$	$CH_3(CH_2)_8CH_3$	Decane

The prefixes are **undec-** (11), **dodec-** (12), **tridec-** (13), **tetradec-** (14), **pentadec-** (15), **hexadec-** (16), **heptadec-** (17), **octadec-** (18), **nonadec-** (19), and **eicosane-** (20).

Perfix : name and position number of alkyl group which sub on the carbon chain (**Substituent's** are atoms or groups of atoms attached to the carbon chain and include alkyl and halo groups. **Alkyl groups** are carbon branches attached to carbon chains named with a ***yl*** ending).

Alkyl substituents (group): carbon chains which are a substructue of a molecule



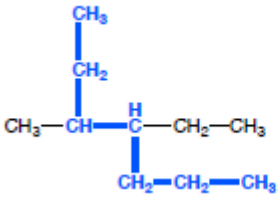
R= Rest of the molecule (mainchain)

1	CH_3-R	**Methyl**
2	CH_3CH_2-R	**Ethyl**
3	$CH_3CH_2CH_2$-R	**Propyl**
4	$CH_3(CH_2)_2CH_2$-R	**Butyl**
5	$CH_3(CH_2)_3CH_2$-R	**Pentyl**
6	$CH_3(CH_2)_4CH_2$-R	**Hexyl**
7	$CH_3(CH_2)_5CH_2$-R	**Heptyl**
8	$CH_3(CH_2)_6CH_2$-R	**Octyl**
9	$CH_3(CH_2)_7CH_2$-R	**Nonyl**
10	$CH_3(CH_2)_8CH_2$-R	**Decyl**

Rules for Systematic Nomenclature of Alkanes

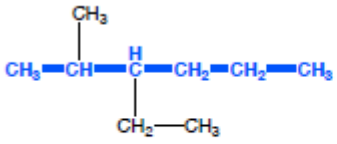
1. Find the parent chain :

a. Identify the longest continuous carbon chain as the parent chain.

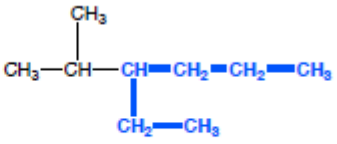


7 carbons = hept-

b. If more than one different chains are of equal length (number of carbons), choose the one with the greater number of branch points (substituent's) as the parent.



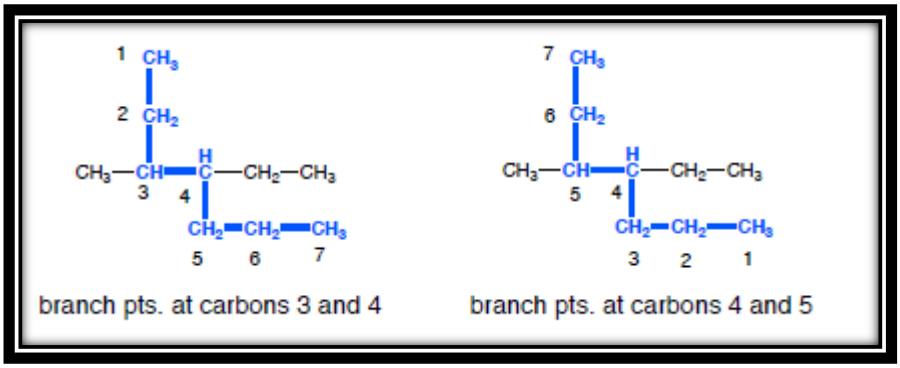
2 branch pts.



1 branch pt.

2. Numbering the carbons of the parent chain :

a. Number the carbon atoms of the parent chain so that any branch points have the lowest possible number

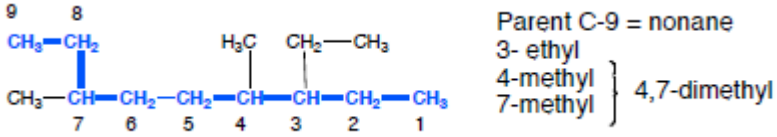


b. If there is branching equidistant from both ends of the parent chain, number so the second branch point has the lowest number.

3. Substituents :

a. Identify and number the substituents and list them in alphabetical order.

b. If there are two substituents on the same carbon, assign them the same number.

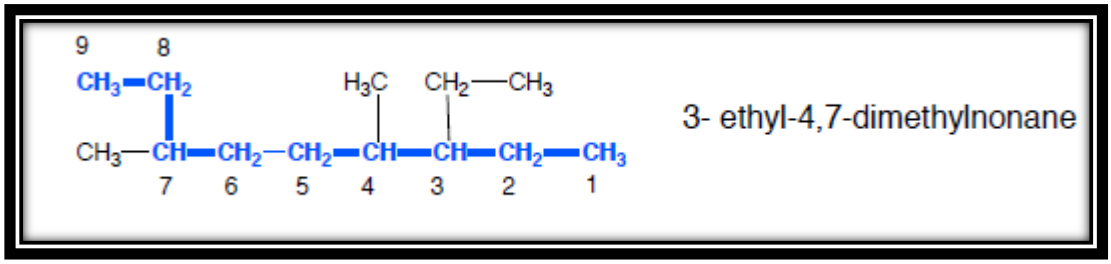


4. Write out the name :

a. Write out the name as a single word:
hyphens (-) separate prefixes
commas (,) separate numbers

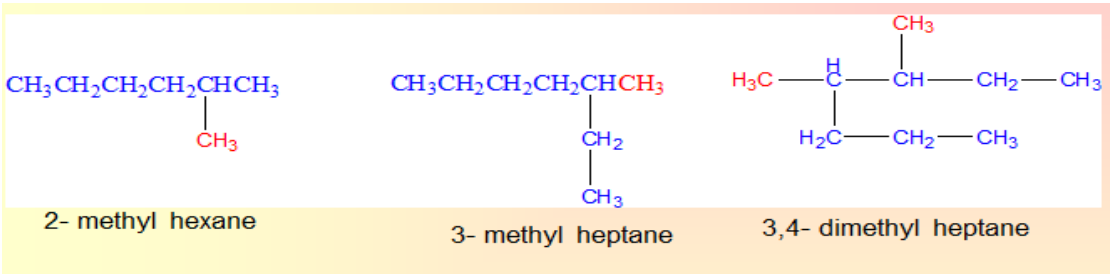
b. Substituents are listed in alphabetical order

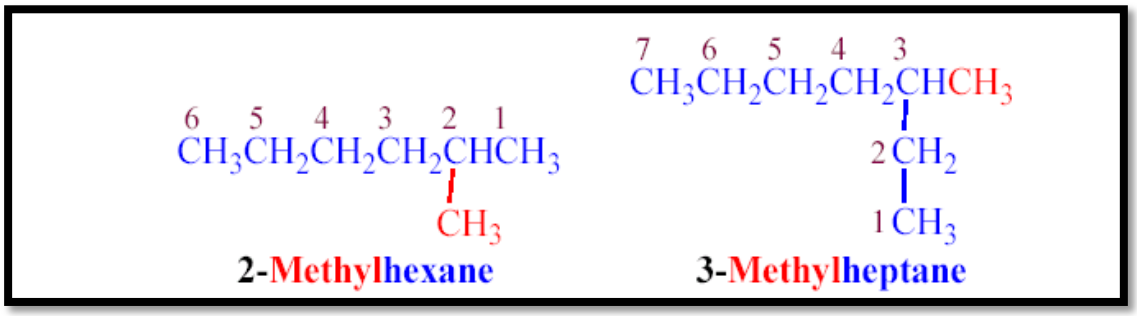
c. If two or more identical substituents are present use the prefixes: di- for two , tri- for three , tetra- for four

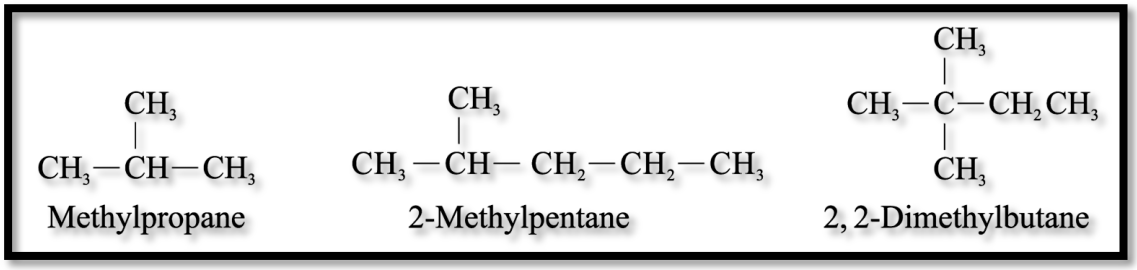


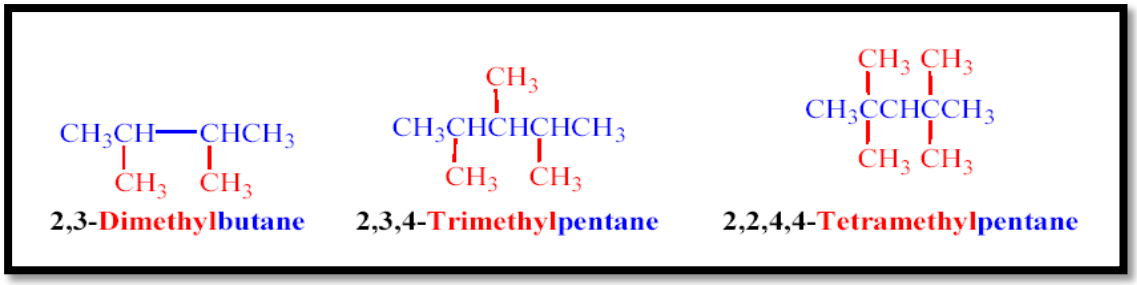
5- **Halo substituents** are halogens attached to the carbon chain named as **fluoro, chloro, bromo, or iodo.**

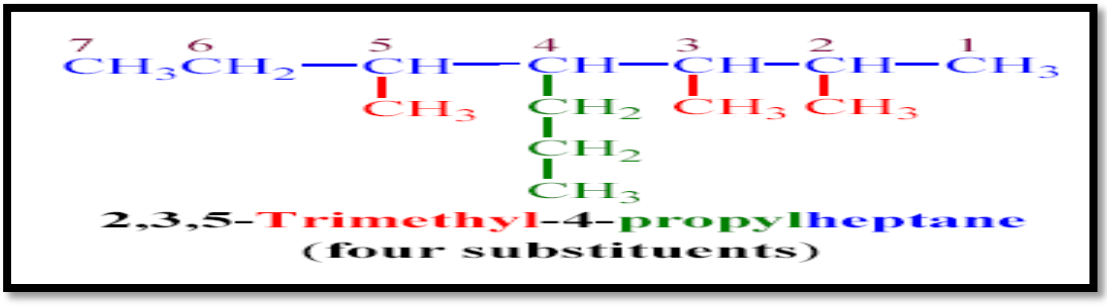
Examples :

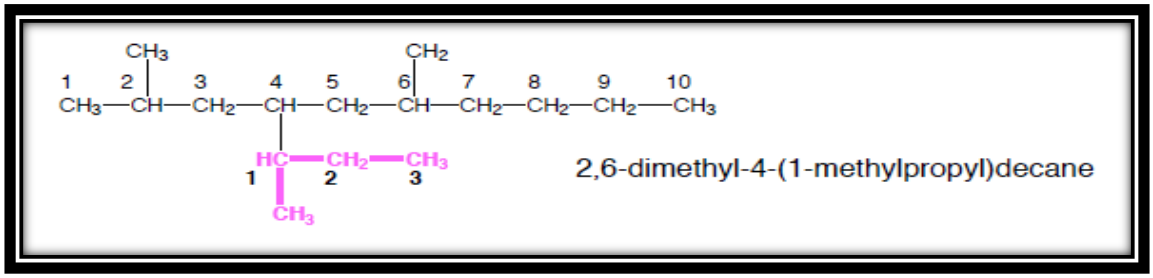

2- methyl hexane
3- methyl heptane
3,4- dimethyl heptane


2-Methylhexane
3-Methylheptane


Methylpropane
2-Methylpentane
2, 2-Dimethylbutane


2,3-Dimethylbutane
2,3,4-Trimethylpentane
2,2,4,4-Tetramethylpentane


2,3,5-Trimethyl-4-propylheptane
(four substituents)



$CH_3CH_2CH_2CH_2CH_2CH_3$
(*n*-hexane)
n-hexane

$CH_3CH(CH_3)CH_2CH_2CH_3$
(isohexane)
2-methylpentane

$CH_3CH_2CH(CH_3)CH_2CH_3$
(no common name)
3-methylpentane

$CH_3C(CH_3)_2CH_2CH_3$
(neohexane)
2,2-dimethylbutane

$CH_3CH(CH_3)CH(CH_3)CH_3$
(no common name)
2,3-dimethylbutane

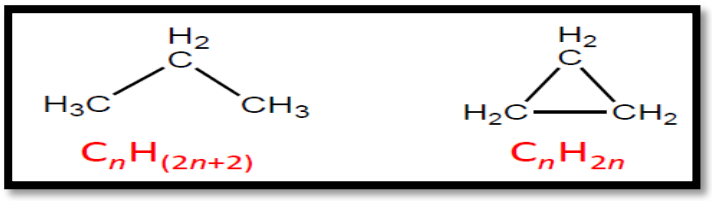
Cycloalkanes:

• Are cyclic alkanes.

• Have two less hydrogen atoms than the open chain.

• Are named by using the prefix ***cyclo*** before the name of the alkane chain with the same number of carbon atoms .

propane, C_3H_8 **cyclopropane, C_3H_6**



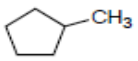
Naming Cycloalkanes

General Formula: $C_nH_{(2n)}$

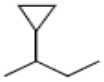
1. Parent Chain

a. Use the cycloalkane as the parent chain if it has a greater number of carbons than any alkyl substituent.

b. If an alkyl chain off the cycloalkane has a greater number of carbons, then use the alkyl chain as the parent and the cycloalkane as a **cycloalkyl-** substituent.



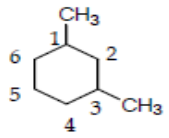
Methylcyclopentane



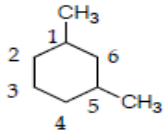
2-Cyclopropylbutane

2. Numbering the Cycloalkane

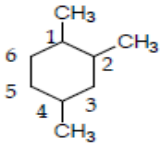
a. When numbering the carbons of a cycloalkane, start with a substituted carbon so that the substituted carbons have the lowest numbers (sum).



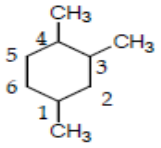
1,3-Dimethylcyclohexane



-not-
1,5-Dimethylcyclohexane



1,2,4-Trimethylcyclohexane
(1 + 2 + 4 = 7)



-not-
1,3,4-Trimethylcyclohexane
(1 +3 + 4 = 8)

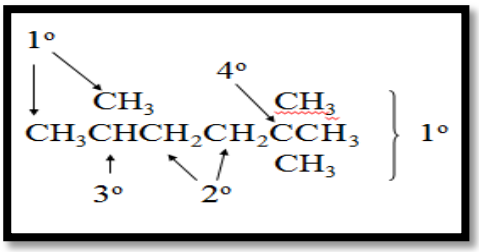
Classes of carbons

primary carbon (1^o) – a carbon bonded to one carbon.

secondary carbon (2^o) – a carbon bonded to two carbons.

tertiary carbon (3^o) – a carbon bonded to three carbons.

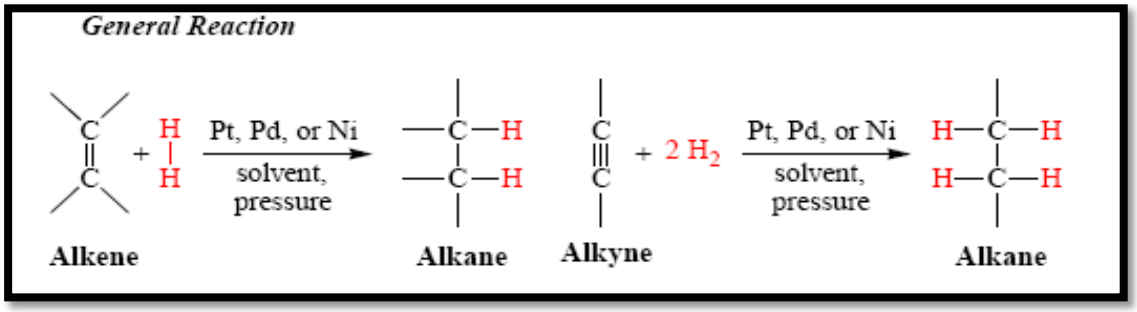
quaternary carbon (4^o) – a carbon bonded to four carbons.

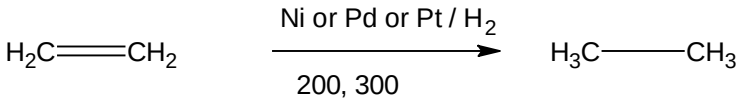


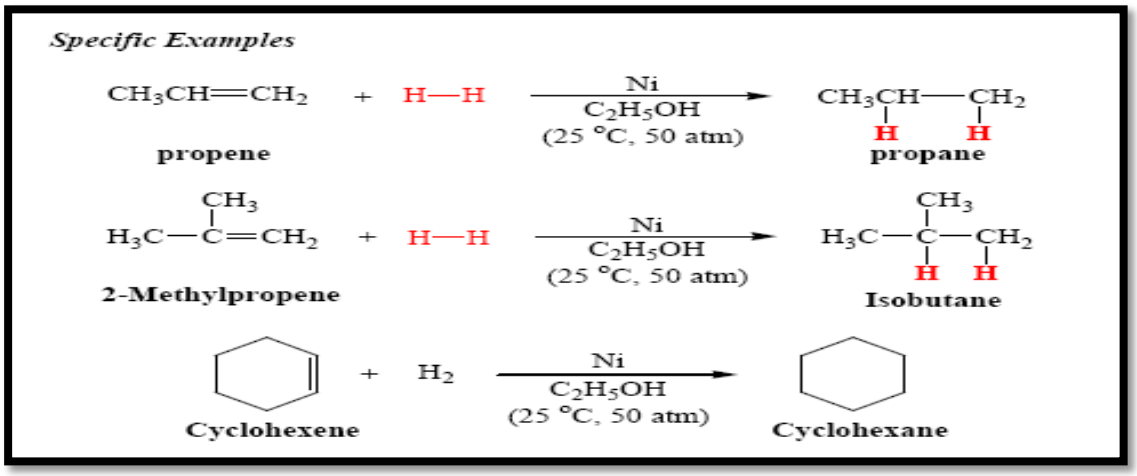
Synthesis of alkanes :

1-From Alkenes & Alkynes .

Hydrogenation of unsaturated hydrocarbon produce alkane with the same carbon chain .





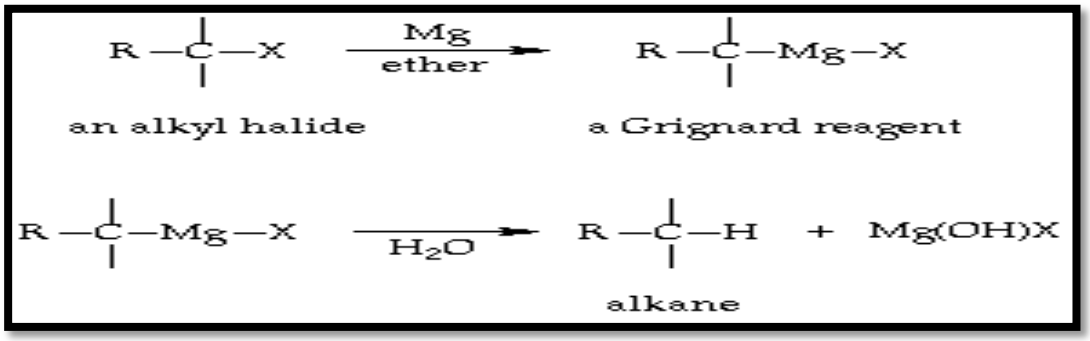


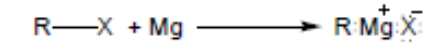
2- Hydrolysis of Grignard Reagent :

Grignard reagent is an alkyl magnesium halide compound, **R-Mg-X.**

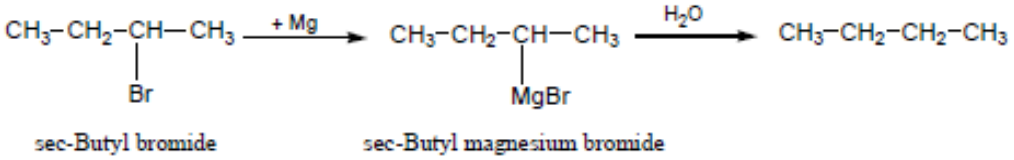
The Grignard reagent is formed when a solution of an Alkyl Halide (R-X) is allowed to stand over a metallic magnesium in the presence of dry ether.

Then Grignard reagent react with water or alcohol to form alkane.



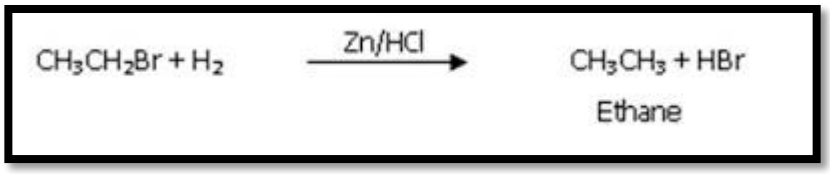


R = 1°, 2°, 3° alkyl, aryl, or alkenyl & X = Cl, Br or I

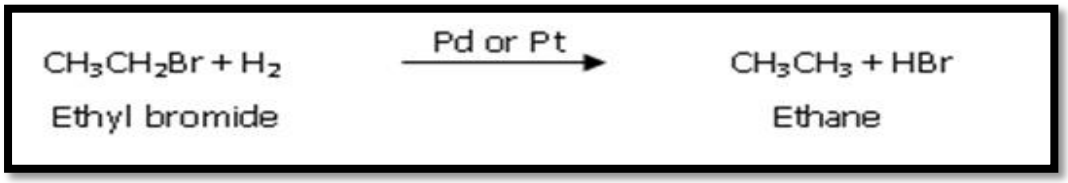


3. Reduction of alkyl halides. Alkyl halides are reduced to alkanes by suitable reducing agents. For example,

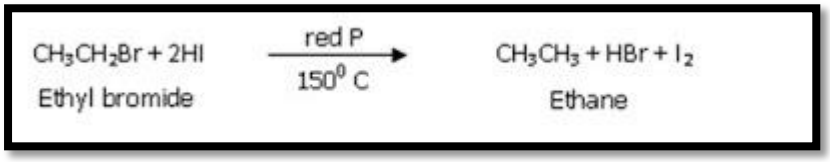
i. With zinc and HCl:



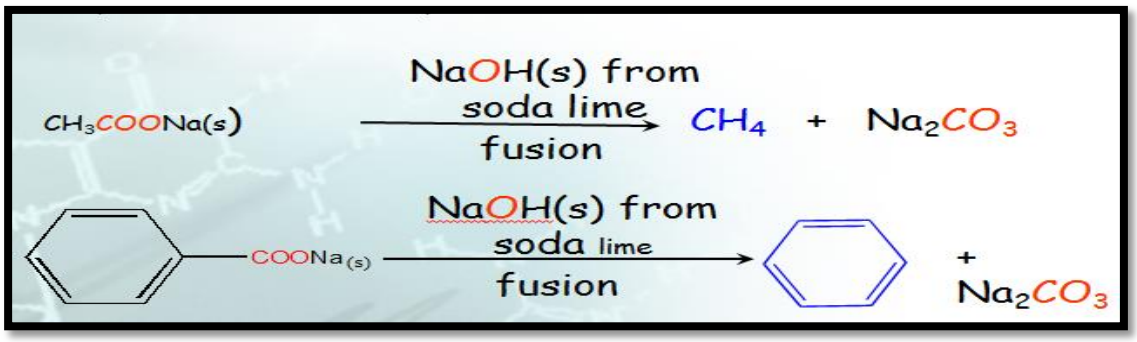
ii. With hydrogen in the presence of platinum or palladium (catalytic hydrogenation):



iii. With hydrogen iodide in the presence of red phosphorus.



5- **Decarboxylation of sodium alkanoate** such as sodium ethanoate or sodium benzoate by heating with soda lime (NaOH + CaO)



Alkanes Reactions:

1- Halogenation :

The reaction of a halogen with an alkane in the presence of ultraviolet (UV) light or heat leads to the formation of **a haloalkane (alkyl halide).**

$$CH_4(g) + Cl_2(g) \xrightarrow{\text{UV light}} CH_3Cl(g) + HCl(g)$$

$$CH_3Cl(g) + Cl_2(g) \xrightarrow{\text{UV light}} CH_2Cl_2(g) + HCl(g)$$

$$CH_2Cl_2(g) + Cl_2(g) \xrightarrow{\text{UV light}} CHCl_3(g) + HCl(g)$$

$$CHCl_3(g) + Cl_2(g) \xrightarrow{\text{UV light}} CCl_4(g) + HCl(g)$$

2-***Combustion*:**

Complete combustion : Alkanes react with sufficient oxygen to give carbon dioxide and water through a series of reaction with the release of a large amount of energy.

General formula $C_nH_{2n+2} + \left(\frac{3n+1}{2}\right)O_2 \longrightarrow nCO_2 + (n+1)H_2O$

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$ + heat energy

Methane