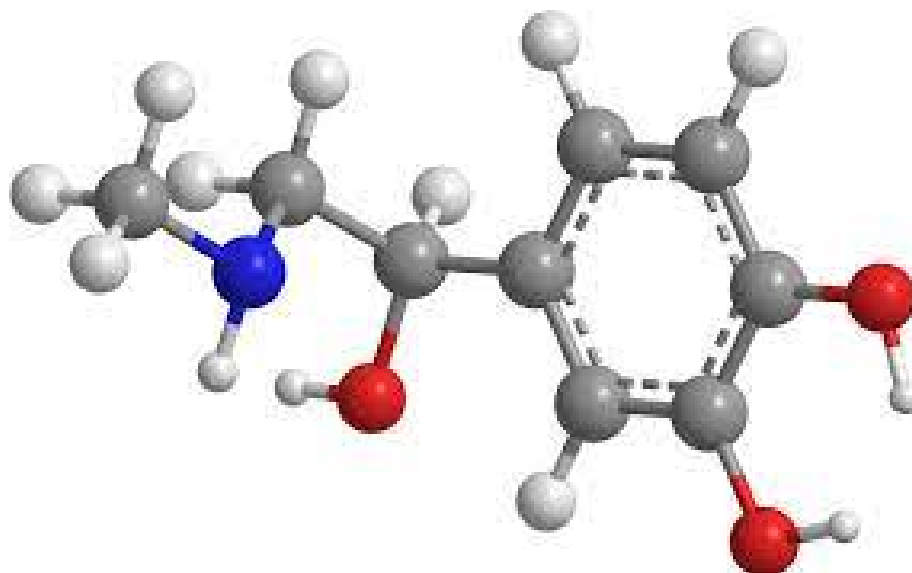




Alkanes

By

Dr.Tabarek Alnqib



Chemistry

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graph TD; A[Chemistry] --> B[Organic compounds]; A --> C[Inorganic compounds];
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Organic
compounds

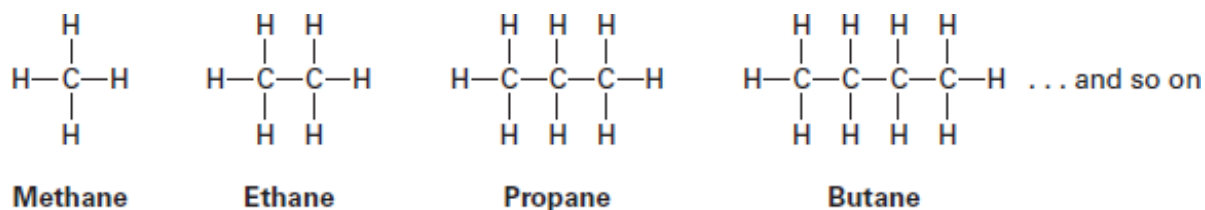
obtained from
living organisms

Inorganic
compounds

obtained from
non-living sources

Alkanes

Alkanes are simplest family of molecules that contain the carbon–carbon single bond results from σ (head-on) overlap of carbon ***sp*³** hybrid orbitals. Alkanes are often described as *saturated hydrocarbons*: **hydrocarbons** because they contain only carbon and hydrogen; **saturated** because they have only C-C and C-H single bonds and thus contain the maximum possible number of hydrogens per carbon. They have the general formula **C_nH_{2n+2}** , where ***n*** is an integer. Alkanes are also occasionally called **aliphatic** compounds.



Think about the ways that carbon and hydrogen might combine to make alkanes. With one carbon and four hydrogens, only one structure is possible: methane, CH₄. Similarly, there is only one combination of two carbons with six hydrogens (ethane, CH₃CH₃) and only one combination of three carbons with eight hydrogens (propane, CH₃CH₂CH₃).

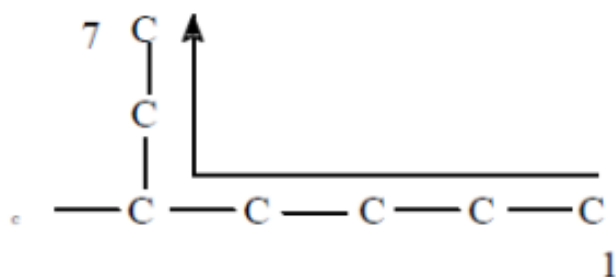
Alkanes – Nomenclature

Table of alkanes

<u>Alkane</u>	<u>Formula</u>
<u>Methane</u>	<u>CH₄</u>
<u>Ethane</u>	<u>C₂H₆</u>
<u>Propane</u>	<u>C₃H₈</u>
<u>Butane</u>	<u>C₄H₁₀</u>
<u>Pentane</u>	<u>C₅H₁₂</u>
<u>Hexane</u>	<u>C₆H₁₄</u>
<u>Heptane</u>	<u>C₇H₁₆</u>
<u>Octane</u>	<u>C₈H₁₈</u>
<u>Nonane</u>	<u>C₉H₂₀</u>
<u>Decane</u>	<u>C₁₀H₂₂</u>

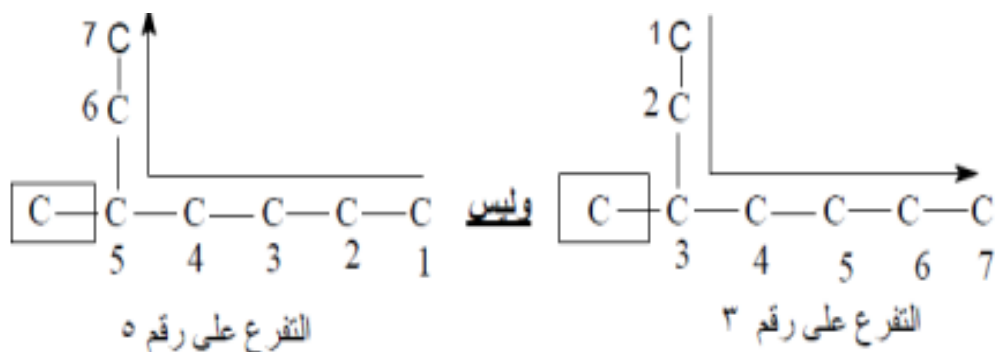
Alkanes – Nomenclature steps

1. Specify the long chain.

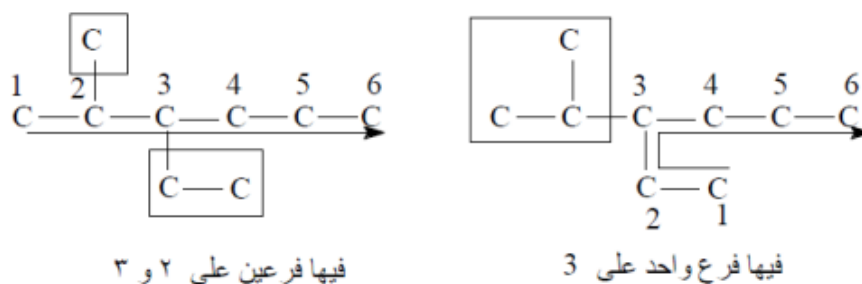


اطول سلسلة هي سبعة ذرات

2. Specify the branching circles



3. If I have two chains of equal length, choose the chain that contains the most number of branches.



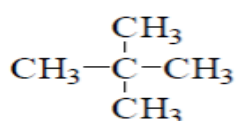
4. The numbering is based on the nearest branching.
5. Adopt the numbering that gives the smallest number by branching.
6. The name is according to the alphabet. We start with a branch first, then a chain name.
7. Separates between a word and a number (-) and between a number and a number (,).

Note

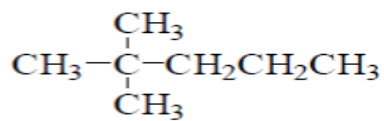
(di) : means two similar branchesIt .

(tri) : means three similar branches .

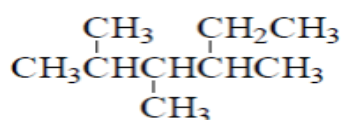
(tetra): means four similar branches .



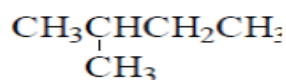
2,2-Dimethyl propane



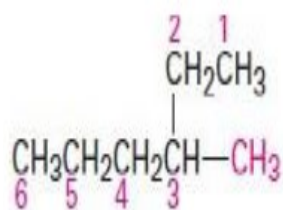
2,2-Dimethyl pentane



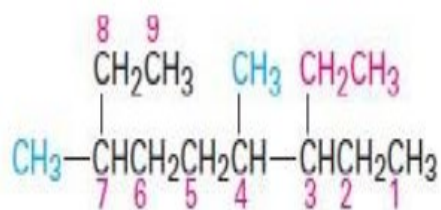
2,3,4-Trimethyl hexane



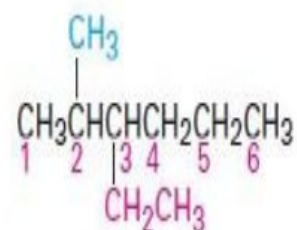
2-Methyl butane



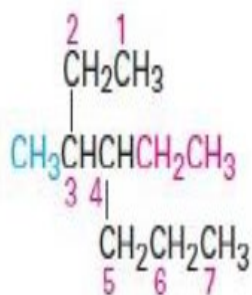
3-Methylhexane



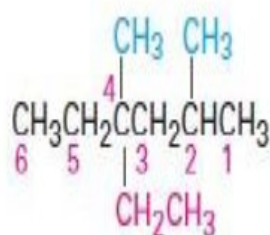
3-Ethyl-4,7-dimethylnonane



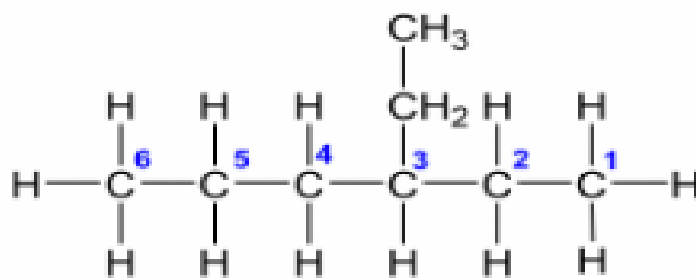
3-Ethyl-2-methylhexane



4-Ethyl-3-methylheptane



4-Ethyl-2,4-dimethylhexane



3-ethylhexane

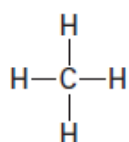
Alkyl Groups

- If you imagine removing a hydrogen atom from an alkane, the partial structure that remains is called an **alkyl group**. Alkyl groups are not stable compounds themselves; they are simply parts of larger compounds. Alkyl groups are named by replacing the *-ane* ending of the parent alkane with an *-yl* ending.
- For example, removal of hydrogen from methane, CH₄, generates a *methyl* group, -CH₃, and removal of hydrogen from ethane, CH₃CH₃, generates an *ethyl* group, -CH₂CH₃. Similarly, removal of a hydrogen atom from the end carbon of any straight-chain alkane gives the series of straight-chain alkyl groups shown in **Table**

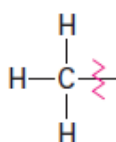
TABLE 3-4 Some Straight-Chain Alkyl Groups

Alkane	Name	Alkyl group	Name (abbreviation)
CH ₄	Methane	-CH ₃	Methyl (Me)
CH ₃ CH ₃	Ethane	-CH ₂ CH ₃	Ethyl (Et)
CH ₃ CH ₂ CH ₃	Propane	-CH ₂ CH ₂ CH ₃	Propyl (Pr)
CH ₃ CH ₂ CH ₂ CH ₃	Butane	-CH ₂ CH ₂ CH ₂ CH ₃	Butyl (Bu)
CH ₃ CH ₂ CH ₂ CH ₂ CH ₃	Pentane	-CH ₂ CH ₂ CH ₂ CH ₂ CH ₃	Pentyl, or amyl

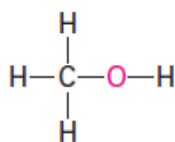
Combining an alkyl group with any of the functional groups listed earlier makes it possible to generate and name many thousands of compounds. For example:



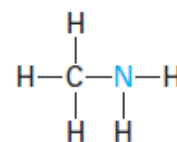
Methane



A methyl group



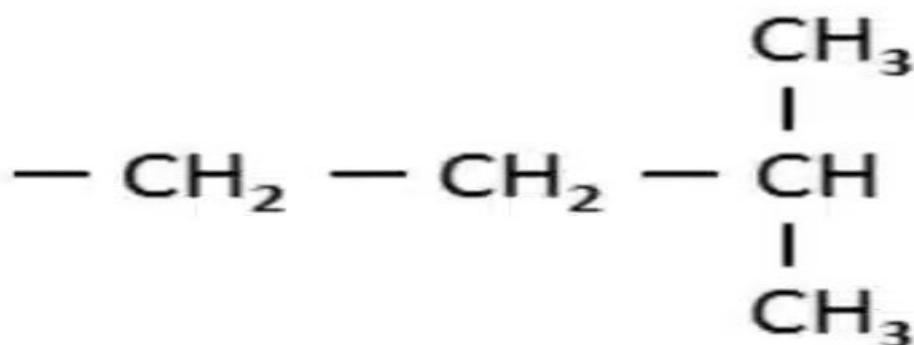
Methyl alcohol
(methanol)



Methylamine

Note

1. If the loss of hydrogen (H) from the middle is called **Iso**



isopentyl



Isopropyl

Single bond	Double bond	Triple bond
$\begin{array}{c} \\ -C - C - \\ \quad \end{array}$	$\begin{array}{c} \diagup \quad \diagdown \\ C = C \\ \diagdown \quad \diagup \end{array}$	$-C \equiv C -$
$\begin{array}{c} \\ -C - O - \\ \end{array}$	$\begin{array}{c} \diagup \quad \diagdown \\ C = O \\ \diagdown \end{array}$	$-C \equiv N$
$\begin{array}{c} \\ -C - H \\ \end{array}$	$\begin{array}{c} \diagup \quad \diagdown \\ C = S \\ \diagdown \end{array}$	
$\begin{array}{c} \\ -C - X^* \\ \end{array}$	$\begin{array}{c} \diagup \quad \diagdown \\ C = N - \\ \diagdown \end{array}$	
$\begin{array}{c} \\ -C - N \begin{array}{l} \diagup \\ \diagdown \end{array} \\ \end{array}$		
$\begin{array}{c} \\ -C - P \begin{array}{l} \diagup \\ \diagdown \end{array} \\ \end{array}$		

* X = halogens

One further comment about naming alkyl groups: the prefixes *sec-* (for secondary) and *tert-* (for tertiary) used for the C4 alkyl groups in refer to *the number of other carbon atoms attached to the branching carbon atom*. There are four possibilities: primary (1°), secondary (2°), tertiary (3°), and quaternary (4°).



Primary carbon (1°)
is bonded to one
other carbon.



Secondary carbon (2°)
is bonded to two
other carbons.



Tertiary carbon (3°)
is bonded to three
other carbons.



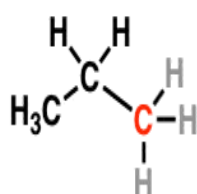
Quaternary carbon (4°)
is bonded to four
other carbons.

The name depends on the number of **carbons** directly attached to the **red carbon** (not hydrogens!)

CH₄

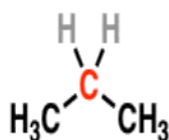
0 carbons
attached

Methane
(unique)



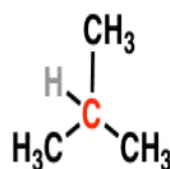
1 carbon
directly
attached

**Primary (1°)
carbon**
("methyl")



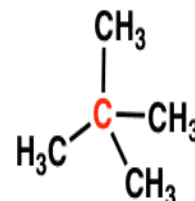
2 carbons
attached

**Secondary (2°)
carbon**
("methylene")



3 carbons
attached

**Tertiary (3°)
carbon**
("methine")



4 carbons
attached

**Quaternary (4°)
carbon**
("quaternary")

Physical Properties of Alkanes

1. It does not dissolve in water because it is nonpolar.
2. Alkanes are less dense than water.
3. Alkanes are metal preservatives because they keep water away from the metal and prevent corrosion.

4. By increasing the chain of alkanes, the melting point and boiling point increase.

Reactions of Alkanes

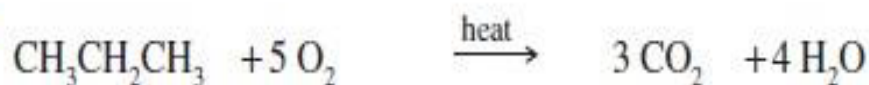
Reaction with oxygen occurs during combustion in an engine or furnace when an alkane is used as a fuel. Carbon dioxide and water are formed as products, and a large amount of heat is released. For example, methane (natural gas) reacts with oxygen according to the equation:



Combustion: is a rapid oxidation that takes place at high temperatures, converting alkanes to carbon dioxide and water. Little control over the reaction is possible, except for moderating the temperature and controlling the fuel/air ratio to achieve efficient burning.

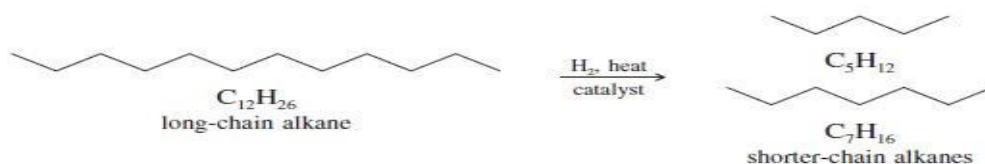


Example

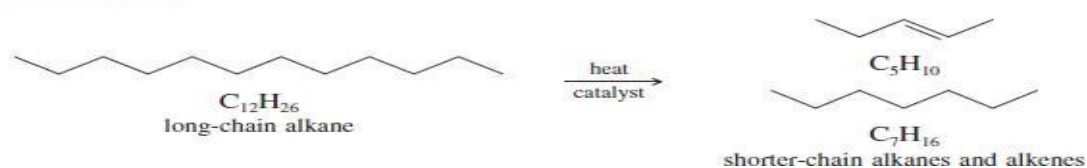


2. Cracking and Hydrocracking catalytic **cracking** of large hydrocarbons at high temperatures produces smaller hydrocarbons. The cracking process usually operates under conditions that give the maximum yields of gasoline. In **hydrocracking**, hydrogen is added to give saturated hydrocarbons; cracking without hydrogen gives mixtures of alkanes and alkenes.

Catalytic hydrocracking



Catalytic cracking

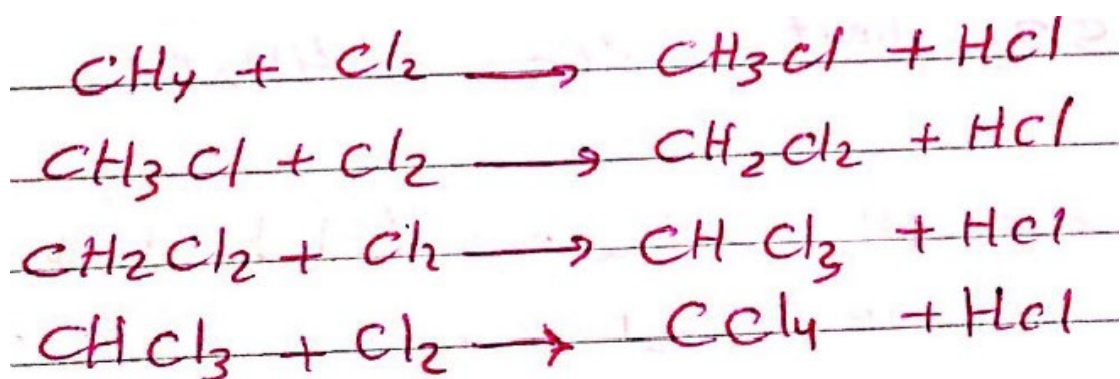


3. Halogenation

- Alkanes can react with halogens (F₂, Cl₂, Br₂, I₂) to form alkyl halides. For example, methane reacts with chlorine to form

chloromethane (methyl chloride), dichloromethane (methylene chloride), trichloromethane (chloroform), and tetrachloromethane (carbon tetrachloride).

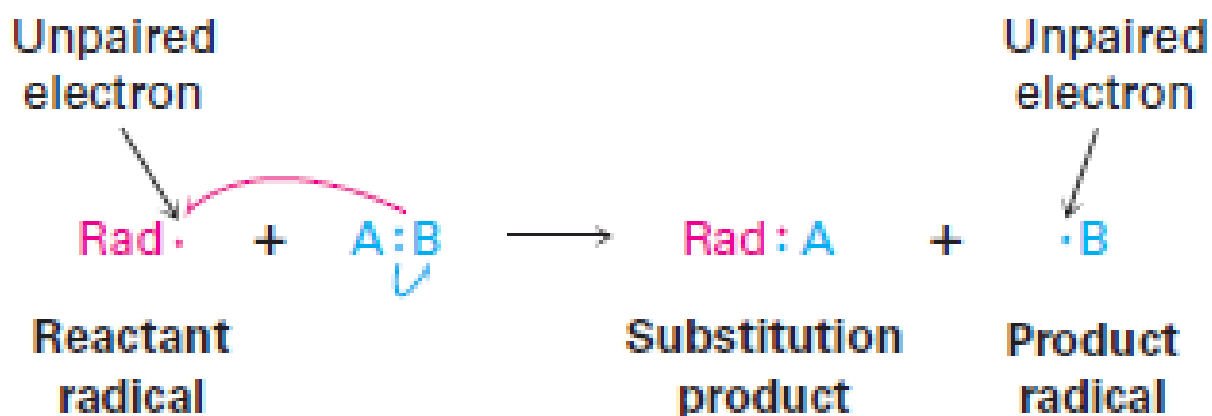
- The reaction of an alkane with Cl₂ occurs when a mixture of the two is irradiated with ultraviolet light (denoted *hν*, where *ν* is the Greek letter *nu*). Depending on the time allowed and the relative amounts of the two reactants, a sequential substitution of the alkane hydrogen atoms by chlorine occurs, leading to a mixture of chlorinated products. Methane, for instance, reacts with Cl₂ to yield a mixture of CH₃Cl, CH₂Cl₂, CHCl₃, and CCl₄.



4.Free-radical : refers to a species that is formed when a molecule undergoes.

homolytic fission: two electrons of a covalent bond are split evenly between two atoms resulting in two atoms with a single electron.

Heterolytic fission: both electrons in the bond are transferred to one atom resulting in cation and anion.



Three stages to free-radical substitution:

- 1.Initiation
- 2.Propagation
- 3.Termination

