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جامــــــعة المــــــستـقـبـل
AL MUSTAQBAL UNIVERSITY

# كلية العلـــــوم
# قــســــــــــــم الادلة الجنائية

# المحاضرة الثالثة

# Saturated Hydrocarbons(Alkanes)

**المادة : عضوية**
**المرحلة : الثانية**
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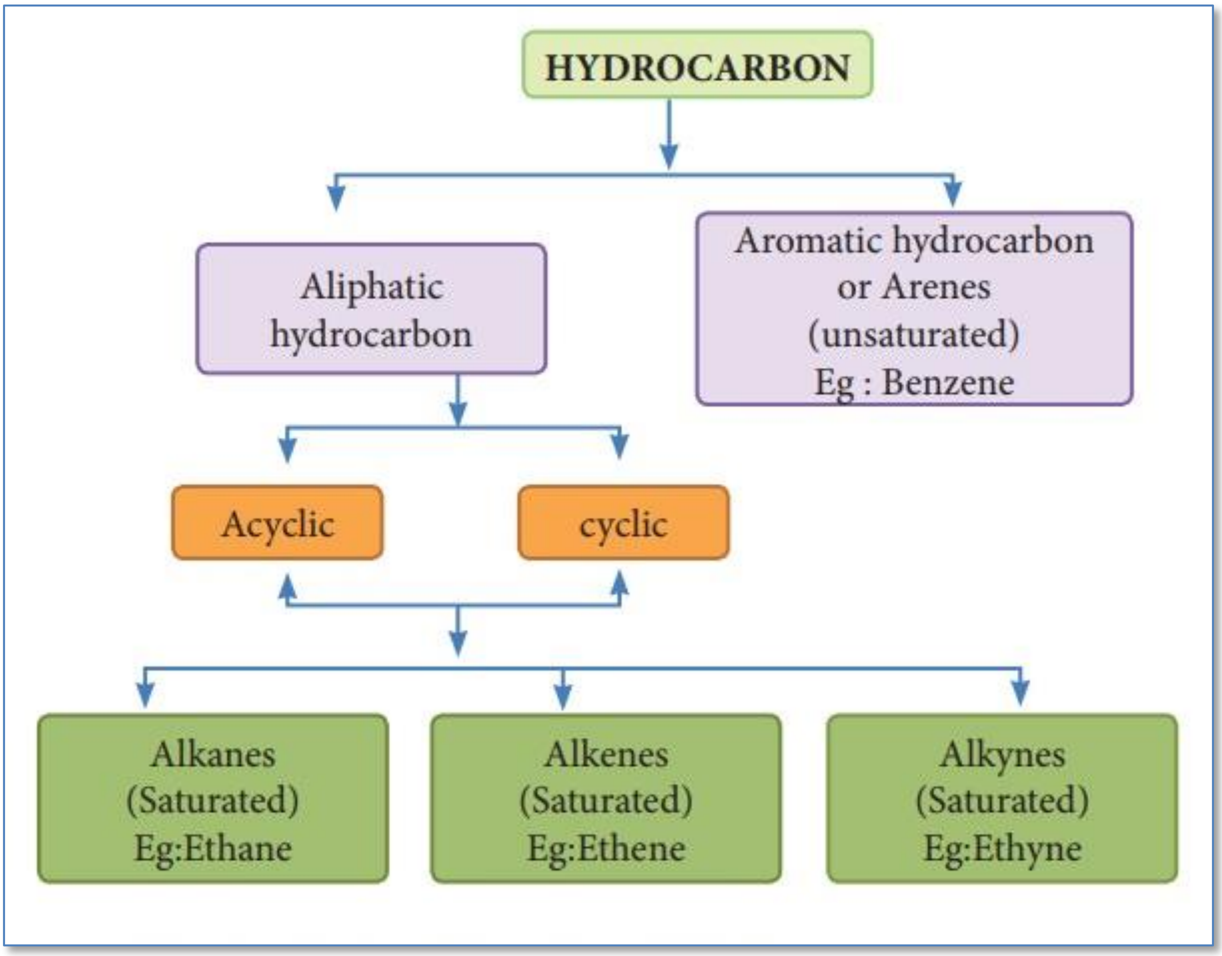
# Alkane

A hydrocarbon is a compound composed of only carbon and hydrogen. Figure1 shows the four classes of hydrocarbons, along with the characteristic type of bonding between carbon atoms in each class.




Alkanes are the simplest type of organic compounds and member of a larger class of organic compounds called saturated hydrocarbons that contains only carbon–carbon single bonds. Alkanes have the general molecular formula $CnH_2n+2$. we can determine the number of hydrogens in the molecule and its molecular formula. For example, decane, with ten carbon atoms, must have (2×10)+2=22hydrogen atoms and a molecular formula of $C_{10}H_{22}$ .

## Nomenclature of Alkanes and the IUPAC System:

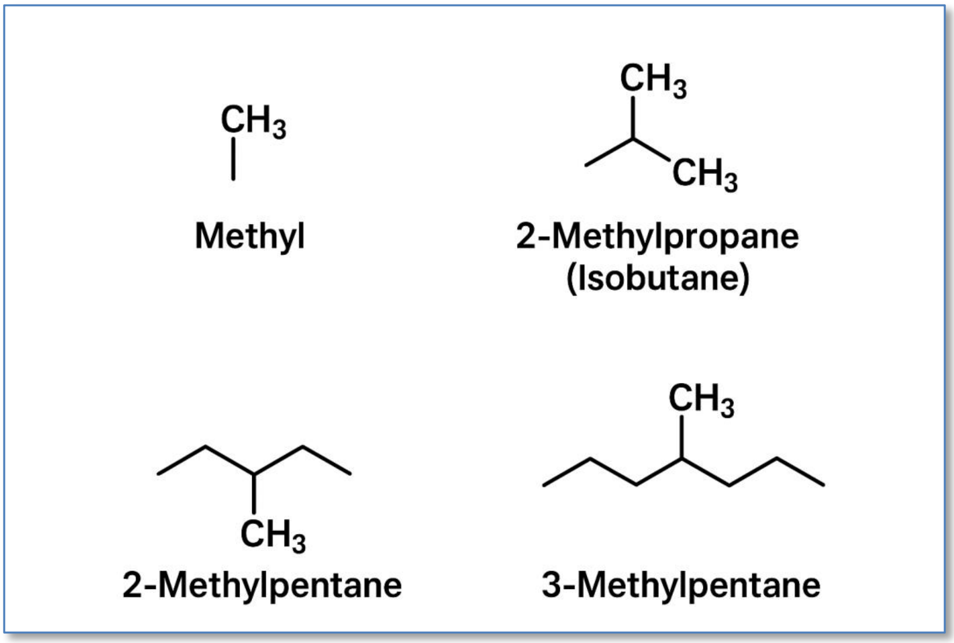
The rules of the IUPAC system for naming alkanes follow:

1. The name for an alkane with an unbranched chain of carbon atoms consists of a prefix showing the number of carbon atoms in the chain and the ending -ane. The simplest member of Alkane family is methane

| Name | Molecular Formula ($C_nH_{2n+2}$) | Condensed Structural Formula | Number of Possible Isomers |
|---|---|---|---|
| methane | $CH_4$ | $CH_4$ | — |
| ethane | $C_2H_6$ | $CH_3CH_3$ | — |
| propane | $C_3H_8$ | $CH_3CH_2CH_3$ | — |
| butane | $C_4H_{10}$ | $CH_3CH_2CH_2CH_3$ | 2 |
| pentane | $C_5H_{12}$ | $CH_3CH_2CH_2CH_2CH_3$ | 3 |
| hexane | $C_6H_{14}$ | $CH_3CH_2CH_2CH_2CH_2CH_3$ | 5 |
| heptane | $C_7H_{16}$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$ | 9 |
| octane | $C_8H_{18}$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$ | 18 |
| nonane | $C_9H_{20}$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$ | 35 |
| decane | $C_{10}H_{22}$ | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$ | 75 |

2. For branched-chain alkanes, select the longest chain of carbon atoms as the parent chain; its name becomes the root name. If there is one substituent, number the parent chain from the end that gives the substituent the lower number.

3. Give each substituent on the parent chain a name and a number. The number shows the carbon atom of the parent chain to which the substituent is bonded. Use a hyphen (-) to connect the number to the name.




A substituent group derived from an alkane by the removal of a hydrogen atom is called an alkyl group; it is commonly represented by the symbol R-. We name alkyl groups by dropping the (ane) from the name of the parent alkane and adding the suffix -yl. The substituent derived from methane, for example, is methyl.

4-If there are two or more identical substituents, number the parent chain from the end that gives the lower number to the substituent encountered first. The number of times the substituent occurs is indicated by the prefix di-, tri-, tetra-, and so on. A comma is used to separate position numbers.

$$\begin{array}{c} CH_3 \quad CH_3 \\ | \qquad | \\ CH_3CH_2CHCH_2CHCH_3 \end{array}$$

2, 4-Dimethylhexane (not 3,5-dimethylhexane)

5-If there are two or more different substituents, list them in alphabetical order and number the chain from the end that gives the lower number to the substituent encountered first.

3-Ethyl-5-methylheptane (not 3-methyl-5-ethylheptane)

```
          CH3
           |
CH3CH2CHCH2CHCH2CH3
       |
       CH2CH3
```

| Symble | Name |
|---|---|
| **F-** | Fluoro |
| **Cl-** | Chloro |
| **Br-** | Bromo |
| **I-** | Iodo |
| **$NO_2$-** | Nitro |

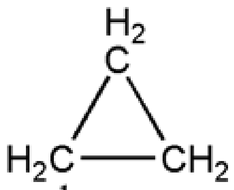
## B. Common Names

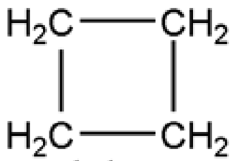
In an alternative system known as common nomenclature, the total number of carbon atoms in an alkane, regardless of their arrangement, determines the name. The first three alkanes are methane, ethane, and propane. All alkanes with the molecular formula $C_4H_{10}$ are called butanes, all those with the molecular formula $C_5H_{12}$ are called pentanes, all those with the molecular formula $C_6H_{14}$ are called hexanes, The fact that an alkane chain is unbranched is sometimes indicated by the prefix n- (normal); an example is n-pentane for $CH_3CH_2CH_2CH_2CH_3$. For branched-chain alkanes beyond propane, iso- indicates that one end of an otherwise unbranched chain terminates in a $(CH_3)_2CH$- group and neo- indicates that it terminates in-$C(CH_3)_3$. Following are examples of common name.

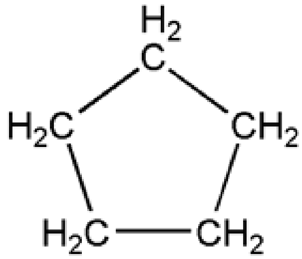
| IUPAC Name | Structural formula | Common name |
|---|---|---|
| Ethane | $CH_3 – CH_3$ | Ethane |
| Propane | $CH_3 – CH_2 – CH_3$ | n-Propane |
| Butane | $CH_3 – CH_2 – CH_2 – CH_3$ | n-Butane |
| 2-Methylpropane | $CH_3 – CH – CH_3$<br>\|<br>$CH_3$ | Iso-Butane |
| 2,2-Dimethylpropane | $CH_3$<br>\|<br>$CH_3 – C – CH_3$<br>\|<br>$CH_3$ | Neo-Pentane |

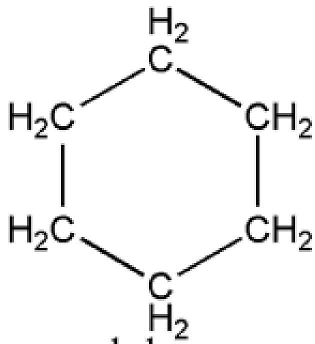
**Cycloalkanes**

A hydrocarbon that contains carbon atoms joined to form a ring is called a cyclic hydrocarbon. When all carbons of the ring are saturated, the hydrocarbon is called a cycloalkane

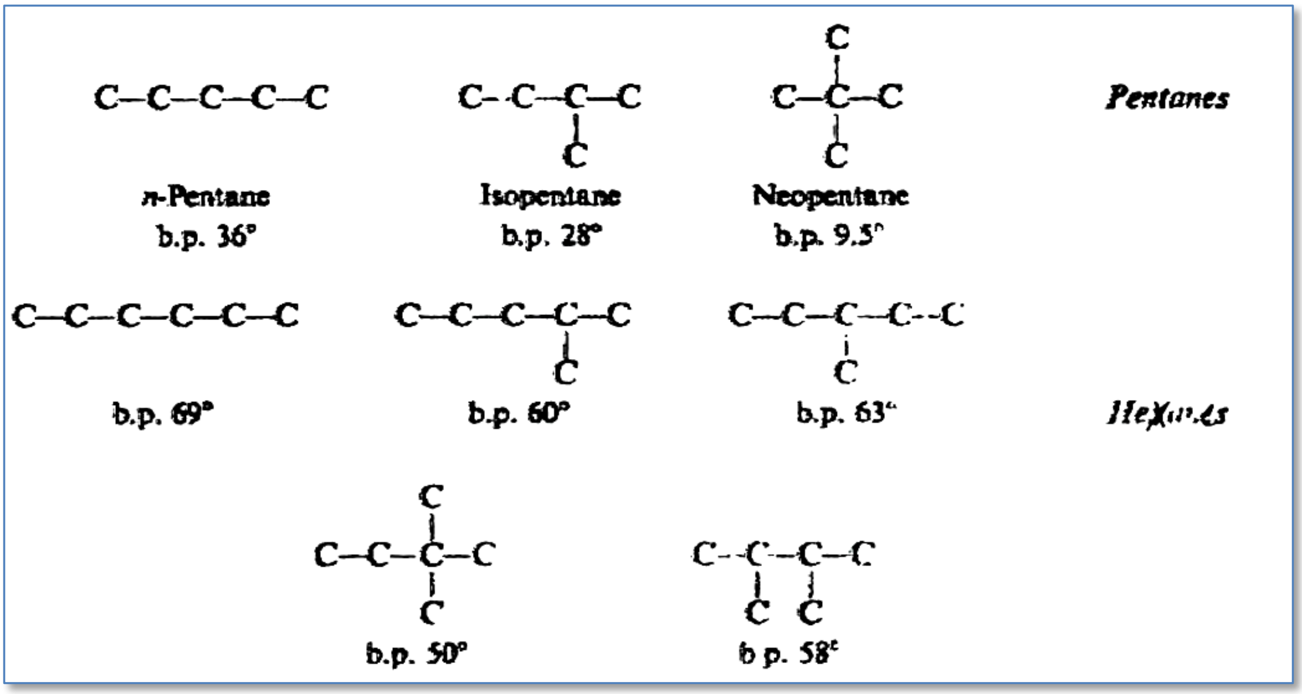

cyclopropane


cyclobutane


cyclopentane

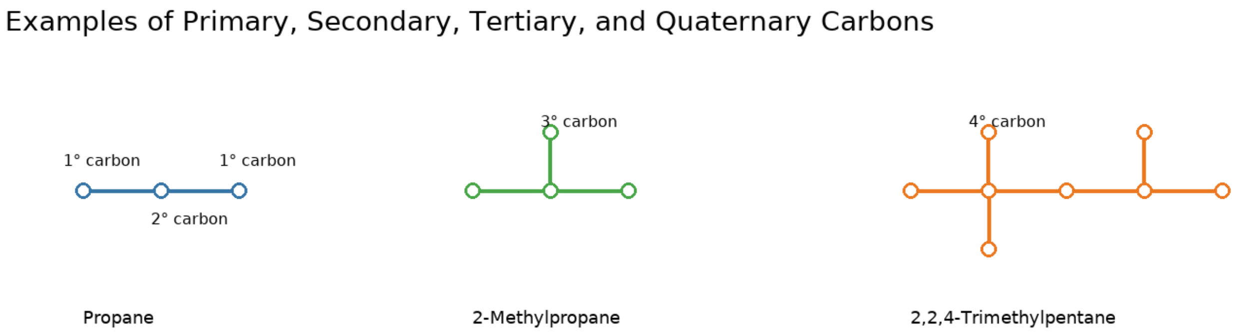

cyclohexane

Isomers: These are different compounds that have the same molecular formula. Isomers may be structural isomers or geometrical isomersor others
Example of structural isomers



## Classification of Carbon and Hydrogen Atoms

We classify a carbon atom as primary (1°), secondary (2°), tertiary (3°), or quaternary(4°)depending on the number of carbon atoms bonded to it. A carbon bonded to one carbon atom is a primary carbon; a carbon bonded to two carbon atoms is a secondary carbon, and so forth For example:




Hydrogens are also classified as primary, secondary, or tertiary depending on the type of carbon to which each is bonded. Those bonded to a primary carbon are primary hydrogens, those bonded to a secondary carbon are secondary hydrogens, and those bonded to a secondary carbon are secondary hydrogens, and those bonded to a tertiary carbon are tertiary hydrogens.

# Preparation of Alkane:

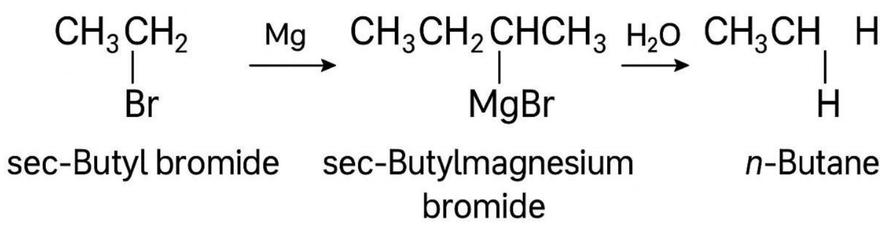
**1- Hydrogenation of Alkene**

$$CH_3 - CH = CH - CH - CH_3 \xrightarrow{H_2/Pt} CH_3 - CH_2 - CH_2 - CH - CH_3$$

**2- Reduction with Alkyl Halide**

A) Hydrolysis with **Grignard reagent**.

$$RX + Mg \xrightarrow{RMgX} H_2O \xrightarrow{RH}$$




**b) Reduction with metal and acid**

$$RX + Zn + H^+ \longrightarrow RH + Zn^+ + X$$

***example:***

$$\underset{Br}{CH_3CH_2CHCH_3} \longrightarrow CH_3CH_2CH_3$$

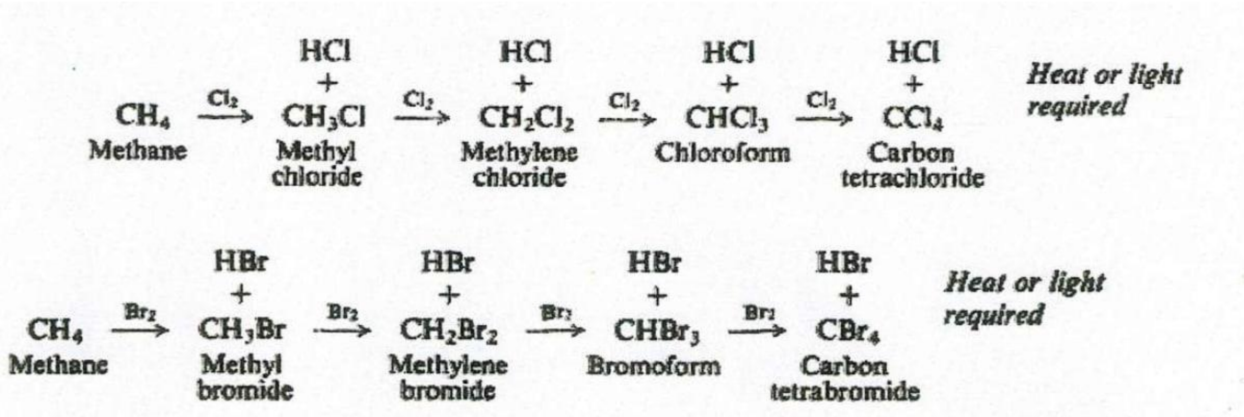
**sec-Butyl bromide** **_n_-Butane**

**Reaction of Alkanes:**

They are quite unreactive toward most reagents, a behavior consistent with the fact that they are nonpolar compounds containing only strong sigma bonds.

**1-Reaction with Halogens: Halogenation**

If we mix methane with chlorine or bromine in the dark at room temperature, nothing happens. If, however, we heat the mixture to 100∘100∘ C or higher or expose it to light, a reaction begins at once. The products of the reaction between methane and chlorine are chloromethane and hydrogen chloride. What occurs is a substitution reaction—in this case, the substitution of chlorine for hydrogen in methane.




**physical properties of alkanes**:

**1. State at Room Temperature**

**C1–C4 (Methane to Butane):** Gases

**C5–C17:** Liquids

**C18 and above:** Solids

This is because as the carbon chain length increases, the van der Waals forces increase, leading to higher melting and boiling points.

**2. Boiling and Melting Points**

**Trend:** Both increase with increasing molecular weight (number of carbon atoms).

**Reason:** Larger molecules have stronger **London dispersion forces**, requiring more energy to separate.

**Branching Effect:** Branched alkanes have **lower boiling points** than straight-chain isomers due to less surface area, reducing van der Waals forces.

**3. Density**

Alkanes are **less dense than water** (≈0.6–0.8 g/cm³).

Density increases slightly with molecular weight.

**4. Solubility**

Alkanes are **nonpolar**, so they are:

**Insoluble in water**

**Soluble in nonpolar solvents** (like hexane, benzene)

**5. Viscosity**

Viscosity **increases with molecular weight**.

Long-chain alkanes flow more slowly than short-chain ones.

**6. Color and Odor**

**Colorless** in pure form.

**Odorless** for lower alkanes (methane, ethane), slight smell for higher ones.

**7. Surface Tension**

Increases slightly with molecular weight due to stronger intermolecular forces.

**Least Polar** **Most Polar**

{*alkane*, *alkene*, *alkyne*} < ether < {*aldehyde*, *ketone*} < ester < {*alcohol*, *phenol*} < carboxyl

**Lowest b.p.** Highest b.p

**Lowest water solubility** Highest water solubi