**ORGANIC CHEMISTRY.**

**HYDROCARBONS**

*Alkanes*

*Alkenes*

*Alkynes*

**Learning outcomes:**

By the end of this topic the learner should be able to:

1. Define;
2. homologous series
3. Functional group
4. hydrocarbon
5. Isomer
6. Isomerism
7. Draw the structure of the compounds
8. Differentiate both the physical and chemical properties of the hydrocarbon
9. Highlight the uses of;
10. Alkanes
11. Alkenes
12. alkynes
13. Differentiate saturate and unsaturated compound
14. Understand the nomenclature of hydrocarbon

**INRODUCTION**

Hydrocarbons are organic compounds made of hydrogen and carbon. They are the simplest organic compounds and are the basis for many other organic compounds.

**Properties**

* Hydrocarbons are usually colorless, hydrophobic, and have a faint odor
* They can be gases, liquids, solids, or polymers
* Hydrocarbons are highly combustible

**Classification**

* Hydrocarbons are classified into four types: alkanes, alkenes, alkynes, and aromatic hydrocarbons
* Alkanes have only single bonds, alkenes have double bonds, and alkynes have triple bonds
* Aromatic hydrocarbons are made from plant extracts and can be arenes or nonbenzenoid aromatic hydrocarbons

**Uses**

* Hydrocarbons are the primary source of energy in the world
* They are used to make gasoline, jet fuel, propane, kerosene, and diesel
* Hydrocarbons are also used to make solvents and polymers

**Occurrence**

* Hydrocarbons are found in plants, trees, crude oil, natural gas, and coal

**Reactions**

* Alkanes can be made from alkenes or alkynes through hydrogenation
* Alcohols can be dehydrated to form alkenes using aluminum oxide or a concentrated acid as a catalyst.

**ALKANES**

Alkanes are a series of compounds that contain carbon and hydrogen atoms with single covalent bonds. These are known as saturated hydrocarbons. This group of compounds consists of carbon and hydrogen atoms with single covalent bonds. Also comprises a homologous series having a molecular formula of CnH2n+2.

* Alkanes are the simplest family of hydrocarbons. They contain only carbon and hydrogen. Each carbon atom forms four bonds and each hydrogen atom forms one bond. Chemists use line-angle formulas because they are easier and faster to draw than condensed structural formulas. Structural formulas for alkanes can be written in yet another condensed form.

The simple alkane methane contains one carbon atom and CH4 as its [molecular formula](https://byjus.com/chemistry/empirical-molecular-formula/). As this compound have just single covalent bonds only, therefore, its structural formula is

H -C-H

In a long chain alkane molecule, additional carbon atoms are attached to each other with the help of a single covalent bond. Each atom is attached to the sufficient hydrogen atoms to develop a total of four single covalent bonds. This long-chain structure is known as octane. An eight-carbon alkane has a molecular formula – C 8H 18 and structural formula-​

## Physical Properties of Alkanes

### 1. The Solubility of Alkanes

* Due to very little difference of electronegativity between carbon and hydrogen and covalent nature of C-C bond or C-H bond, alkanes are generally non-polar molecules.
* As we generally observe, polar molecules are soluble in polar solvents whereas non-polar molecules are soluble in non-polar solvents. Hence, alkanes are hydrophobic in nature that is, alkanes are insoluble in water.
* However, they are soluble in organic solvents as the energy required to overcome the existing Van Der Waals forces and generate new [Van Der Waals forces](https://byjus.com/chemistry/van-der-waals-forces/) is quite comparable.

### 2. The Boiling Point of Alkanes

* As the intermolecular Van der Waals forces increase with the increase of the molecular size or the surface area of the molecule we observe:
* The boiling point of alkanes increases with increasing molecular weight,
* The straight-chain alkanes are observed to have a higher boiling point in comparison to their structural isomers.

### 3. The Melting Point of Alkanes

* The melting point of alkanes follow the same trend as their boiling point that is, it increases with increase in molecular weight.
* This is attributed to the fact that higher alkanes are solids and it’s difficult to overcome intermolecular forces of attraction between them.
* It is generally observed that even-numbered alkanes have a higher trend in melting point in comparison to odd-numbered alkanes as the even-numbered alkanes pack well in the solid phase, forming a well-organized structure which is difficult to break.

## Alkanes Formula and its Condensed Structures

Structural formulas for alkanes can be written in condensed form. For example, the structural formula of pentane contains three CH2 methylene groups in the middle of the chain. We can group them together and write the structural formula. The first five alkanes formulas with an unbranched chain are tabulated below.

An abbreviated way to draw structural formulas in which each vertex and line terminus represents a carbon atom and each line represents a bond.

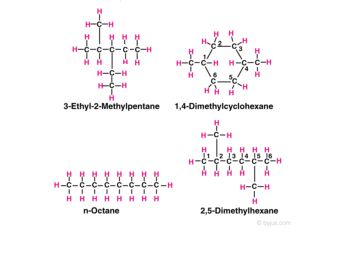
## Alkane Formula Chemistry

Formulas of organic compounds present information at several levels of sophistication. [Molecular formulas](https://byjus.com/chemistry/chemical-formula/), such as that of octane give the number of each kind of atom in a molecule of a compound. The molecular formula of C8H18 may apply to several alkanes, each one of which has unique chemical, physical and toxicological properties. These different compounds are designated by structural formulas showing the order in which the atoms in a molecule are arranged. Compounds that have the same molecular, but different structural formulas are called structural isomers.

Most organic compounds can be derived from alkanes. In addition, many important parts of organic molecules contain one or more alkane groups, minus a hydrogen atom, bonded as substituents onto the basic organic molecule. As a consequence of these factors, the names of many organic compounds are based on alkanes.

## Branched Chain Alkane Formula

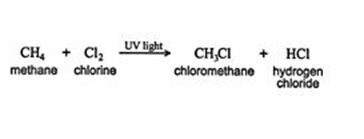
As with other organic compounds, the carbon atoms in alkanes may form straight chains, branched chains, or rings. These three kinds of alkanes are straight chain alkanes, branched chain alkanes and [cycloalkanes](https://byjus.com/chemistry/cycloalkanes/). The general molecular formula of alkane for straight and branched-chain alkanes is CnH2n+2 and that of cyclic alkanes is CnH2n.



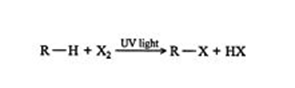
For example, in the diagram, the four hydrocarbon molecules contain 8 carbon atoms each. In one of the molecules, all the carbon atoms are in a straight chain and in two they are in branched chains, whereas in a fourth, 6 of the carbon atoms are in a ring.

## Alkyl Groups

When a substituent like halogen bonds to an alkane molecule, one carbon-hydrogen bond of the molecule gets converted to a carbon-substituent bond. It can be understood with an example- A new compound known as [chloromethane](https://byjus.com/chemistry/dichloromethane/) is formed when methane reacts with chlorine. The new compound is composed of a CH3 group that is bonded to a chlorine atom.



When an alkane having hydrogen is removed from one bond, it is called an alkyl group. This Alkyl group is often denoted by the letter R the same as halogens represent by the letter X. Here is a methane‐chlorine reaction that can be generalized as



**USES OF ALKANES**

* **Gasoline**: Alkanes are the main component of gasoline
* **Diesel and kerosene**: Alkanes with higher viscosity, such as nonane and hexadecane, are used in diesel and kerosene
* **Natural gas**: Methane and ethane are natural gases used for cooking, utilities, and fuel

Lubricants and oils

* **Lubricating oils**: Alkanes with 17 to 35 carbon atoms are the main component of lubricating oils
* **Paraffin wax**: Solid alkanes are used in paraffin wax candles

Solvents

* **Volatile liquids**: Alkanes with 6-8 carbon atoms are volatile and are used as solvents for nonpolar solutions

Anti-corrosive agents

* **Metal protection**: Alkanes with a high number of carbon atoms are used as anti-corrosive agents because their hydrophobic nature protects metal surfaces from water

Other uses

* **Liquefied gas**: Propane and butane are used as liquefied gas
* **Plastics, cosmetics, and pharmaceuticals**: Derivatives of alkanes are used in these products

**ALKENES**

Alkenes are a class of hydrocarbons (e.g. containing only carbon and hydrogen) unsaturated compounds with at least one carbon-to-carbon double bond. Another term used to describe alkenes is olefins. Alkenes are more reactive than alkanes due to the presence of the double bond.

## General Properties of Alkenes

1. **Physical state**– The members containing two or four carbon atoms are gases, five to seventeen, liquids, eighteen onwards, solids at room temperature and they burn in air with a luminous smoky flame.
2. **Density –** Alkenes are lighter than water.
3. **Solubility –** Alkenes are insoluble in water and soluble in organic solvents such as benzene etc.
4. **Boiling point –** The boiling points of alkenes show a gradual increase with an increase in the molecular mass or chain length, this indicates that the intermolecular attractions become stronger with the increase in the size of the molecule.

## Classification of Alkenes

Alkyl groups bonded to the sp2 hybridized carbon atoms of alkenes affect the stability of the double bond. The chemical reactivity of alkenes also is often affected by the number of alkyl groups bonded to the sp2 hybridized [carbon atoms](https://byjus.com/chemistry/carbon/). Thus, it is useful to classify alkenes by the number of alkyl groups attached to the C=C structural unit. This feature is called the degree of substitution.

An alkene that has a single alkyl group attached to the sp2 hybridized carbon atom of the double bond is monosubstituted. An alkene whose double bond is at the end of the chain of carbon atoms is also sometimes called a terminal alkene. Alkenes that have two, three and four alkyl groups bonded to the carbon atoms of the double bond are substituted, trisubstituted and tetra substituted respectively.

## Uses of Alkenes

The list of uses of various alkenes like ethane, propene etc., is given below.

* Manufacture of plastics like polythene for making buckets, bowls, bags etc.
* Manufacture of polystyrene used in making car battery cases and parts of the refrigerator.
* Making ethane-1,2-diol used as anti-freezing for motor car radiators.
* Manufacture of ethanol and synthetic fiber terylene.
* Making an anti-knock for car engines.
* Manufacture of plastic, polypropene for making ropes and packaging material.
* Manufacture of propanol used in making acetone.
* Manufacture of acrylic fibers.

**ALKYNES**

What are Alkynes? In organic chemistry, an alkyne is an unsaturated hydrocarbon containing at least one carbon-carbon triple bond. The alkynes are unsaturated hydrocarbons that contain one triple bond, the general formula of alkynes CnH2n-2 and the triple bond is known as the 'acetylenic bond'.

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In organic chemistry, an alkyne is an unsaturated hydrocarbon containing at least one carbon-carbon triple bond. Like other [hydrocarbons](https://byjus.com/jee/hydrocarbons/), alkynes are generally hydrophobic. Ethyne is more commonly known under the trivial name acetylene. It is the simplest of the alkynes, consisting of two carbon atoms connected by a triple bond, leaving each carbon able to bond to one hydrogen atom.

## Isomerism in Alkynes

Alkynes show three types of isomerism

1. Chain isomerism
2. Position isomerism
3. Functional isomerism

### 1. Chain isomerism

It is due to the different arrangement of carbon atoms in the chain that is straight-chain or branched.

**Example:** 4-methylpent-2-yne and hex-2-yne

### 2. Position isomerism

It is due to the difference in the location of the triple bond

**Example:** Pent-1-yne and pent-2-yne

### 3. Functional isomerism

Alkynes are isomeric with alkadienes both being represented by the general formula CnH2n-2.

**Example:** But-1-yne and buta-1,3-diene

The triple bond present in alkynes is the functional group for alkynes. The property of alkynes is largely determined by the triple bond. In ethyne, the triple bonded carbon atoms exhibit sp hybridization. Therefore, the ethylene molecule is a linear molecule.

## Alkynes Homologous Series

A homologous series is a collection of carbon compounds in which the same functional group replaces the hydrogen atom. Owing to the addition of the same type of [functional group](https://byjus.com/chemistry/functional-groups/) in the chain, these compounds have similar chemical properties.

A homologous series is a group of hydrocarbons that share the same general formula and have similar chemical properties. They are organic compounds with structural and functional groups that are identical. The homologous series’ constituents exhibit a gradation of physical properties.

The first ten carbon straight chain alkynes’ molecular formulas and names are tabulated below.

The linear or straight geometry is a primary characteristic of alkynes with a carbon-carbon triple bond. A part of the molecule is in a single-dimensional straight line. Ethyne is used to make a variety of other compounds. The following are a few examples of these applications: Ethyne is most commonly used to make organic compounds such as ethanol, ethanoic acid, and acrylic acid.

## Tests for the Presence of a Triple Bond

The presence of a triple bond in any hydrocarbon makes it unsaturated and the compound gives Baeyer’s test. However, alkynes are characterized by certain specific tests described below.

1. **With ammoniacal silver nitrate:** Alkynes give a white precipitate of silver acetylide with ammoniacal silver nitrate.
2. **With ammoniacal cuprous chloride:** Alkynes give a red precipitate of cuprous acetylide with ammoniacal cuprous chloride.

## Uses of Alkyne

* Since ethyne has a very hot flame, it is commonly used in oxyacetylene gas welding and oxyacetylene gas cutting. As ethyne is burned with oxygen, the resulting flame is known to have a temperature of about 3600 Kelvin.
* The overriding alkyne in acetylene is used as a fuel, with millions of kilograms created annually by fractional oxidation of natural gases. Chemical compounds such as ethanoic acid, acrylic acid, and ethanol are made from some of these alkynes.
* Ethyne is most commonly used to make organic compounds such as ethanol, ethanoic acid, and acrylic acid. It’s also used to make polymers and the raw materials for them.
* Acetylene is broken down into its two components, carbon and hydrogen. This reaction creates a lot of heat, which can cause the gas to ignite even if there is no air or oxygen present.
* Alkynes are generally used as the starting materials for the manufacture of a large number of organic compounds of industrial importance such as chloroprene, vinyl chloride etc.

**Exercise:**

1. Define the following terms; (10 mks)
   1. Hydrocarbon
   2. Isomer
   3. Isomerism
   4. Functional group
   5. Homologous series
2. Differentiate the following; (4mks)
   1. Saturated and Unsaturated
   2. Isomer and Isomerism
3. Give two uses of the following; (6mks)
   1. Alkane
   2. Alkene
   3. Alkyne
4. Draw the skeletal structure of the following; (4mks)
   1. CH3CH2CH(CH2CH3)CH3
   2. CH3CHCH2CH3
   3. CH2CH2
   4. CH3CH2CH(CH2CH2CH3)CH3
5. Give the IUPAC name of the above compounds (4mks)
6. Name three types of isomerism (2mks)