

## Organic Molecules Hydrocarbons

### Key Concepts

This lesson will focus on the following;

- Organic chemistry
- Hydrocarbons
- Saturated hydrocarbons
- Unsaturated hydrocarbons
- Isomers
- Homologous series
- Functional groups

### Terminology & definitions

- Organic chemistry - is the study of carbon compounds
- Hydrocarbons – are compounds that consist of hydrogen and carbon only.
- Saturated hydrocarbon – are hydrocarbons in which all carbon to carbon bonds are single bonds.
- Unsaturated hydrocarbons - are hydrocarbons with double or triple covalent bonds between two carbon atoms.
- Isomers – are two substances with the same molecular formula, but different structures.
- Homologous series – is a group of organic compound all of which have the same general formula.
- Functional groups – are individual atoms or group of atoms attached to carbon chains or rings that give organic molecules their characteristic properties.

### X-planation of key concepts and terminologies

Organic chemistry is the chemistry of carbon compounds. Carbon is an element in group IV of the periodic table and it has four valence electrons. Carbon forms covalent bonds with other carbon atoms and these bonds can be single, double or triple. Carbon can also bond covalently with other carbons to form long chains, branches or ring structures. Hydrogen is often present in organic chemistry, the compound with only the carbon and hydrogen is called the hydrocarbon. The organic compounds can also contain oxygen, halogens, sulphur, nitrogen and phosphorous.

Organic compounds are classified as aliphatic or aromatic. Aliphatic compounds can either be saturated or unsaturated. The saturated hydrocarbons contain only the carbon and hydrogen atoms and all carbon to carbon bonds are single bonds. Unsaturated hydrocarbons are hydrocarbons with double or triple covalent bonds between two carbon atoms.

### The alkanes

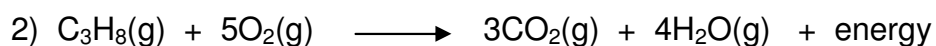
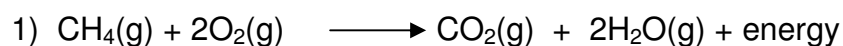
Alkanes are chain like structures with each carbon atom having four single covalent bonds. These compounds contain the maximum number of hydrogen atoms and are thus saturated. The general formula for alkanes in a chain structure is  $C_nH_{2n+2}$  and in a ring structure is  $C_nH_{2n}$ .

The first eight members of alkanes homologous series

number of carbon atoms	Molecular formula	Name	Condensed formula	Structural formula
1	$C_1H_{2(1)+2}$ $CH_4$	Methane	$CH_4$	<pre>       H             H-C-H               H           </pre>
2	$C_2H_{2(2)+2}$ $C_2H_6$	Ethane	$CH_3CH_3$	<pre>       H   H                 H-C- C-H                   H   H           </pre>
3	$C_3H_{2(3)+2}$ $C_3H_8$	Propane	$CH_3CH_2CH_3$	<pre>       H   H   H                     H-C- C- C-H                       H   H   H           </pre>
4	$C_4H_{2(4)+2}$ $C_4H_{10}$	Butane	$CH_3CH_2CH_2CH_3$ $CH_3(CH_2)_2CH_3$	
5	$C_5H_{2(5)+2}$ $C_5H_{12}$	Pentane	$CH_3(CH_2)_3CH_3$	
6	$C_6H_{2(6)+2}$ $C_6H_{14}$	Hexane	$CH_3(CH_2)_4CH_3$	
7	$C_7H_{2(7)+2}$ $C_7H_{16}$	Heptane	$CH_3(CH_2)_5CH_3$	
8	$C_8H_{2(8)+2}$ $C_8H_{18}$	Octane	$CH_3(CH_2)_6CH_3$	

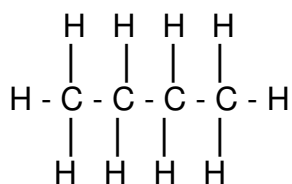
Alkanes have little affinity for most chemical reactants, i.e. they are not very reactive. As the molecular masses of the alkanes increase, the corresponding intermolecular forces become stronger and thus the boiling points increase. The first four members of the alkanes are gases at room temperature, the next are liquids and those with seventeen or more carbons are solid at room temperature. The alkanes are insoluble in water because of their non-polar nature. All alkanes are comparatively unreactive because of their strength of the single bonds. When they burn in excess oxygen they produce carbon dioxide + water + energy.

Examples

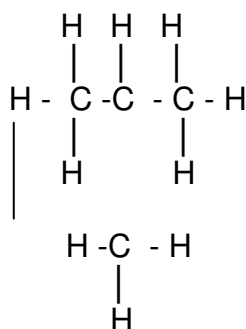


### Alkanes with branched chain structures

Methyl propane has a molecular formula  $C_4H_{10}$ . This is the same as the molecular formula of butane. Two substances with the same molecular formula but different structures are called isomers of one another. Butane and methyl propane are isomers.



**Butane**



**methyl propane**

### Naming of alkanes

Select the longest carbon chain in the structure as the basic structure (even if it is bent) and count the number of carbon atoms in the chain to determine the prefix then add the suffix as **-ane** to indicate the functional group. Number each carbon atom in the chain, starting from the end closest to the branch, if any. Names of substitution groups or branched groups are written in alphabetic order before the name of the basic structure.

- The alkyl groups which consist of radicals formed when one hydrogen is removed from an alkane e.g methyl  $-CH_3$ , ethyl  $-C_2H_5$
- The halides e.e.  $-Cl$  chloro,  $-Br$  bromo,  $-I$  iodo
- If the substitution group appears more than once in a molecule, the prefixes di-, tri-, tetra- etc are used and numbers are used to indicate their position

When halides groups are substituted into the alkane structure, the new compound formed is a member of the haloalkane series.

### The alkenes

The alkenes are unsaturated hydrocarbons characterized by one or more double bonds between two carbon atoms. Their general formula is  $C_nH_{2n}$ . The alkenes burn in the same way as alkanes producing more energy. The naming of the alkenes is the same as the naming of alkanes. Count the number of the carbon atoms in the longest chain, select the correspondence prefix then add **-ene** which indicates the presence of the double bond. Number the carbon atoms from end closest to the double bond. Indicate the position of the double bond by specifying the number of the double bond. e.g.  $-C = C - C - C$ - but-1-ene and  $-C - C = C - C$  - but-2-ene.

### The alkynes

The alkynes are unsaturated hydrocarbons characterized by one or more triple bonds between carbon atoms. Their general formula is  $C_nH_{2n-2}$ .

The rules of naming are similar to the naming of alkenes, but the triple bond is indicated by the suffix **-yne**. The alkynes burn in the same way as alkanes and alkenes, producing a lot of energy.

## X-ample Questions

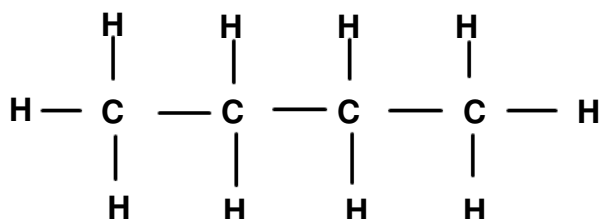
- The molecular formulae of three hydrocarbons are given below:
  - $\text{CH}_4$
  - $\text{C}_2\text{H}_4$
  - $\text{C}_3\text{H}_4$
  - Draw the structural formula of each molecule.
  - Write down the IUPAC name of each molecule.
  - Identify the homologous series to which each molecule belong.

- Draw the structural formulae of the following hydrocarbons:

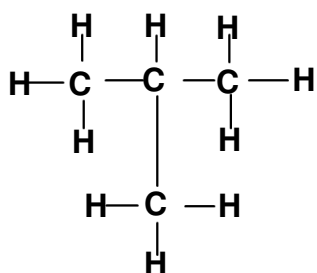
- 2-methylbutane.
- 3-ethyl-2-methylpent-2-ene.
- 3,4-dimethylpent-1-yne.
- cyclobutane.
- cyclobutene

- Give the IUPAC names of the following organic molecules:

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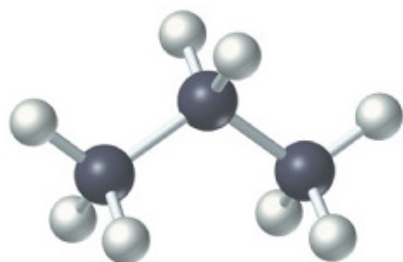


- Draw and name five isomers of  $\text{C}_5\text{H}_{10}$ .
- The following table provides boiling and melting points of alkanes.
  - Identify a hydrocarbon that is a liquid at  $25^\circ\text{C}$ .
  - Describe what happens to the melting points and boiling points of alkanes when their molecular mass increases.
  - Explain the trend you have identified.

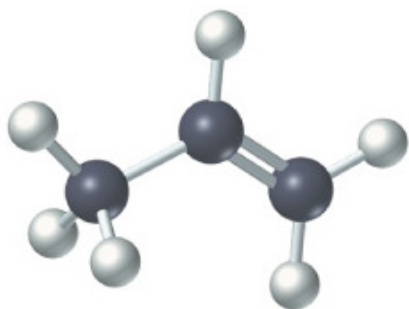
## X-ercise

The alkenes are a series of hydrocarbons that form a homologous series.

- 1.1 What is a hydrocarbon?
- 1.2 Write down the structural formula for the simplest member of the alkenes.
- 1.3 Write down the condensed formula for the alkene with three carbon atoms in its molecule.
- 1.4 Write the structural formula for 3,4-dichloro-4-ethyl-5-methylhept-1-ene
- 1.5 Study the following ball and stick structures representing organic compounds. Specify whether they are saturated or unsaturated. Give their condensed structural formulae and give their IUPAC names.
  - 1.5.1



1.5.2



1.5.3

