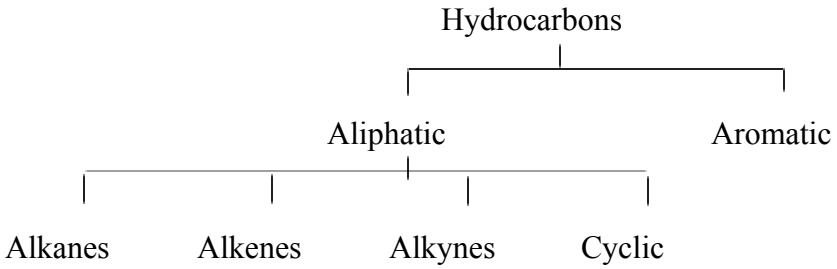
SCH4U1 Name:
OC01 Date:

HYDROCARBONS

Certain organic compounds contain only two elements - hydrogen and carbon. These are known as hydrocarbons. Hydrocarbons are divided into two main classes - **aliphatics** and **aromatics**. Aliphatic hydrocarbons are further divided into four families: alkanes, alkenes, alkynes, and their cyclic analogs (cycloalkanes, etc.).



A series of compounds in which each member differs from the next member by a constant amount is called a *homologous series* and the members of the series are known as *homologs*.

ALKANES

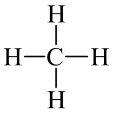
The family of alkanes forms a homologous series. Each member differs from the next by CH_2. Also, in each alkane, the number of hydrogen atoms equals two more than twice the number of carbon atoms. Therefore, the general formula for an alkane is $\mathbf{C_nH_{2n+2}}$. A list of the first 10 alkanes is given below.

CH_4	methane
C_2H_6	ethane
C_3H_8	propane
C_4H_{10}	butane
C_5H_{12}	pentane
C_6H_{14}	hexane
C_7H_{16}	heptane
C_8H_{18}	octane
C_9H_{20}	nonane
$C_{10}H_{22}$	decane

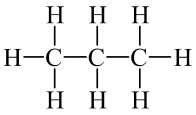
Note in each case the Greek or Latin prefix is used to indicate the number of carbons in the particular alkane. Also note that every one ends in -ane. Learn the above list very well as these root names are the basis of all hydrocarbons.

Expanded Structural Diagrams

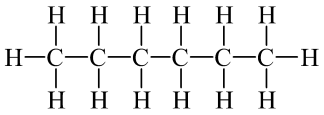
The normal structures (n-alkanes) of a few alkanes are shown below.



methane

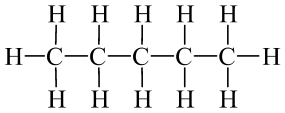


n-propane

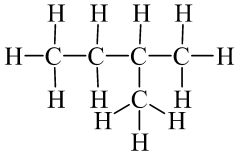


n-hexane

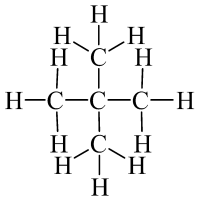
Different compounds that have the same molecular formula are called **isomers**. The three different isomers of pentane (C_5H_{12}) are shown below. Since they are unique compounds, they have unique names and properties.



n-pentane
(bp 36°C)



isopentane
(bp 28°C)



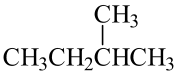
neopentane
(bp 9°C)

Structures can also be shown using condensed or line diagrams.

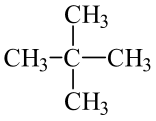
Condensed Structural Diagrams:
These diagrams all carbon atoms and the number of hydrogens bonded to each.

$CH_3CH_2CH_2CH_2CH_3$

n-pentane



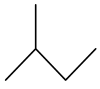
isopentane



neopentane

Line Diagrams:
These diagrams show only the carbon-carbon bonds themselves.

n-pentane



isopentane

neopentane

In line diagrams, it is assumed that each carbon has four bonds and that hydrogens are attached at the appropriate locations. The number of hydrogens present must be determined by completing the bonding capacity of carbon (4).

Using prefixes such as (n) or (iso) or (neo) might appear as a suitable method of nomenclature. This works for simple alkanes such as butane (C_4H_{10}) and pentane (C_5H_{12}). However, it becomes hopeless when larger alkanes are considered. For example there are 5 isomers of hexane (C_6H_{14}), 9 isomers of heptane (C_7H_{16}) and 75 isomers of decane ($C_{10}H_{22}$).

Another problem arises as far as nomenclature is concerned. Hydrogens can be replaced or *substituted* by other elements or groups. For example a hydrogen of methane (CH_4) may be replaced by a chlorine atom to form chloromethane (CH_3Cl). Branched alkanes contain substitutions derived from smaller alkanes.

These substituted groups are named by dropping the -ane from the name of the corresponding alkane and replacing it by -yl. They are known collectively as **alkyl groups**. The general formula for an alkyl group is C_nH_{2n+1} since it contains one less hydrogen than the parent alkane with the formula C_nH_{2n+2}.

To devise a system of nomenclature that could be used for even the most complicated compounds, the International Union of Pure and Applied Chemists (IUPAC) developed a system that is used throughout the world today. Since this system follows much the same pattern for all families of organic compounds, we shall consider it in some detail as applied to alkanes.

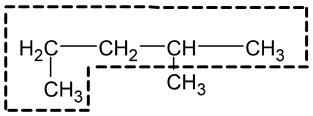
ALKANES AND ALKYL RADICALS

Alkane	Formula	Melting Point (°C)	Phase at Room Temperature	Alkyl Group	Formula
Methane	CH_4	-183	gas	methyl	CH_3
Ethane	C_2H_6	-172	gas	ethyl	C_2H_5
Propane	C_3H_8	-187	gas	propyl	C_3H_7
Butane	C_4H_{10}	-135	gas	butyl	C_4H_9
Pentane	C_5H_{12}	-130	liquid	pentyl(amyl)	C_5H_{11}
Hexane	C_6H_{14}	-94	liquid	hexyl	C_6H_{13}
Heptane	C_7H_{16}	-91	liquid	heptyl	C_7H_{15}
Octane	C_8H_{18}	-57	liquid	octyl	C_8H_{17}
Nonane	C_9H_{20}	-54	liquid	nonyl	C_9H_{19}
Decane	$C_{10}H_{22}$	-30	liquid	decyl	$C_{10}H_{21}$

Naming Branched Alkanes

Branched alkanes can be named by following a simple sequence of steps:

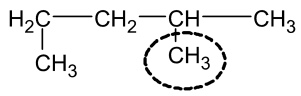
1. Find the longest continuous chain of carbon atoms (the main chain). It is not necessary that the longest chain be written in a straight line.



The longest continuous chain contains 5 carbon atoms.

2. Name this chain by adding "-ane" to the stem name (e.g. **pentane**).

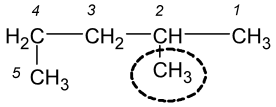
3. Pick out the alkyl groups attached to the main chain.



This is an alkyl group.

4. Name the alkyl groups (**methyl**).

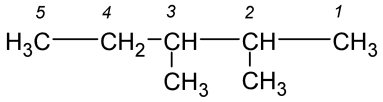
5. Number the carbon atoms of the main chain consecutively from the end nearest to a substituted group.



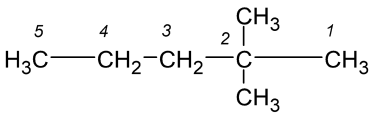
6. Attach the names of the alkyl groups as prefixes to the name of the main chain (**methylpentane**).

7. Indicate the positions of the alkyl groups according to the numbers of the carbon atoms in the main chain to which they are attached. These numbers precede the names of the alkyl groups and are connected to them by hyphens (**2-methylpentane**).

8. If two or more alkyl groups of the same type occur, indicate how many there are by the prefixes di-, tri-, tetra-, etc., and locate the position of each by a separate number. Use commas to separate consecutive numbers from each other. Thus,

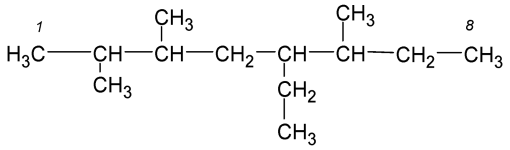


is 2,3-dimethylpentane
(**not** 2-methyl-3-methylpentane)

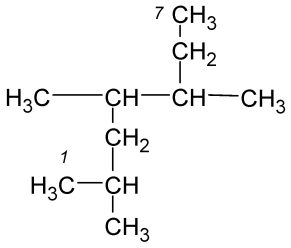


is 2,2-dimethylpentane
(**not** 2-dimethylpentane)

9. If different alkyl groups are present, arrange their names in **alphabetical order** as prefixes to the name of the main chain. Use numbers to indicate the position of each group, with commas between numbers and hyphens between numbers and letters.

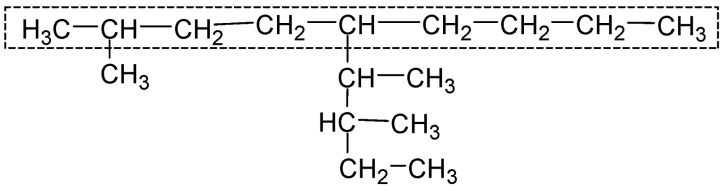


5-ethyl-2,3,6-trimethyloctane

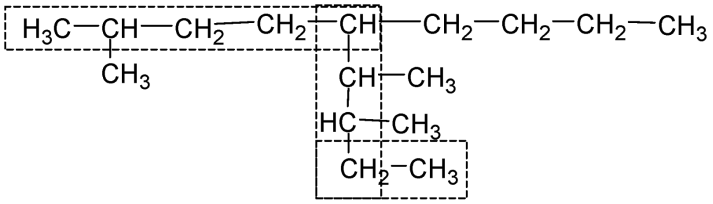


2,4,5-trimethylheptane
(*not* 2-ethyl-3,6-dimethylhexane)

10. If chains of equal length are competing for selection as the main chain, choose that chain which has the greatest number of alkyl groups on the main chain.



2 alkyl groups (incorrect)



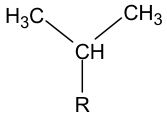
4 alkyl groups (correct)

5-butyl-2,6,7-trimethylnonane

11. Other common groups are frequently found attached to hydrocarbon chains. Their names are:

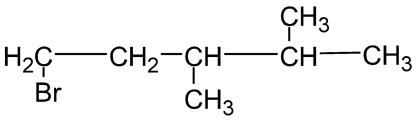
F- fluoro; Cl- chloro; Br- bromo; I- iodo;

NO_2- nitro; NH_2- amino

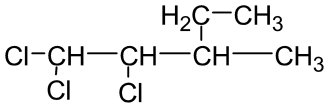


- isopropyl
(R = the main chain)

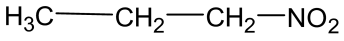
Examples of compounds containing these groups are:



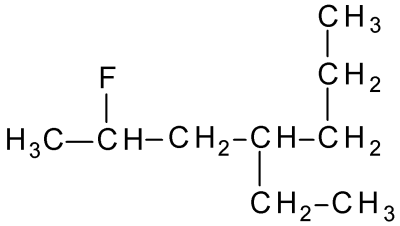
1-bromo-3,4-dimethylpentane



1,1,2-trichloro-3-methylpentane



1-nitropropane



4-ethyl-2-fluoroheptane