SCH4U1 Name:
OC02 Date:

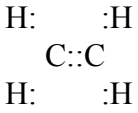
ALKENES

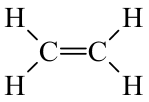
The alkenes are a class of compounds that contain less hydrogen than the alkanes and which can be converted into alkanes by the addition of hydrogen.

Since alkenes evidently contain less than the maximum quantity of hydrogen, they are referred to as unsaturated hydrocarbons (alkanes are saturated hydrocarbons since they contain the maximum number of hydrogens per carbon atom).

All alkenes contain a carbon to carbon double bond (that is two carbons share two pairs of electrons instead of the normal sharing of one pair of electrons).

The simplest alkene is ethene (ethylene)

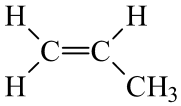




C_2H_4

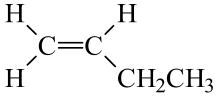
Its structure is very comparable to that of ethane with the single bond replaced by a double bond

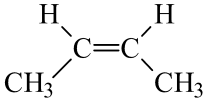
The next alkene is propene (propylene).



C_3H_6

In butene (butylene), the double bond may be found in more than one location.



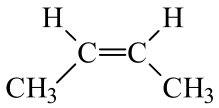


1-butene 2-butene

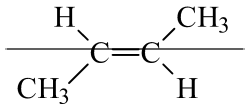
Note that for all three alkenes mentioned so far, the number of hydrogens is exactly double the number of carbons (C_2H_4, C_3H_6, C_4H_8 etc.). Therefore, the general formula for alkenes is $\mathbf{C_nH_{2n}}$.

Geometric (*cis-trans*) Isomers

The structure of 2-butene can be represented in two ways:

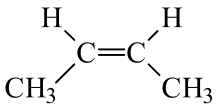


I

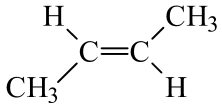


II

Since a carbon-carbon double bond (or sigma + pi bond) is not free to rotate, these represent two unique geometric forms of 2-butene. If a plane is drawn through form I above, both methyl groups are on the same side of the plane. In form II, the methyl groups lie on opposite sides of the plane. These two froms are known as *cis* (from Latin "on this side") and *trans* (from Latin "across") isomers of 2-butene.

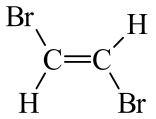


cis-2-butene

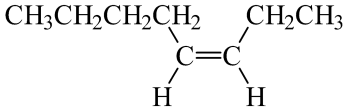


t*rans*-2-butene

This type of isomerism can occur around any C=C bond as long as two different groups are bonded to each carbon involved in the double bond.

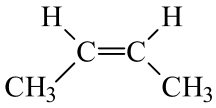


trans-1,2-dibromoethene

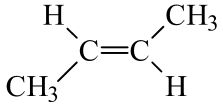


cis-3-octene

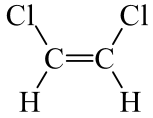
Geometric isomers are closely related but do have distinct properties.



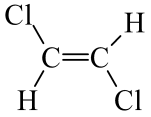
cis-2-butene (bp = 4°C)



t*rans*-2-butene (bp = 1°C)



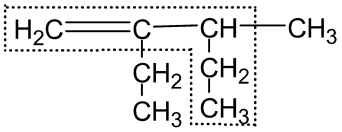
cis-1,2-dichloroethene
(mp = -81°C; bp =60°C)



trans-1,2dichloroethene
(mp = -49°C; bp =49°C)

Common names of alkenes are seldom used except for three simple alkenes: ethylene, propylene, and butylene. Most alkenes today are named by using the IUPAC naming system which is similar to that used for alkanes.

Alkenes are named in the same way as alkanes, except that the ending "-ene" is used. The main chain must contain both carbon atoms of the double bond, even if it is possible to find a longer continuous chain which does not pass through both double bonded carbon atoms.



2-ethyl-3-methyl-1-pentene

Thus, in this example the main chain has five carbon atoms even though a six-carbon chain can be found. The atoms of the main chain are numbered to give the double-bonded carbon atoms the lowest numbers, but we write only the lower of the two numbers to locate the double bond. The name of the main chain in the above example is therefore 1-pentene. The complete name of the alkene is 2-ethyl-3-methyl- l-pentene.

ALKYNES

Alkanes have the general formula C_nH_{2n+2}; alkenes have the general formula C_nH_{2n}. Now we will discuss the kinds of hydrocarbons that have the general formula $\mathbf{C_nH_{2n-2}}$, the alkynes.

The carbon-carbon triple bond (or sigma + 2 pi bonds) is the characteristic feature of the alkynes. The simplest member of the alkynes is ethyne (acetylene).

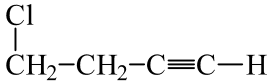
H:C:::C:H H—C≡C—H ethyne (acetylene)

Like the alkanes and alkenes, the alkynes form a homologous series, the increment again being the $-CH_2-$ group.

The rules for IUPAC nomenclature are exactly the same as for the naming of alkenes except that the ending –yne replaces the -ene of alkenes. The parent structure is the longest continuous chain that contains the triple bond, and the positions both of substituents and of the triple bond are indicated by numbers. The triple bond is given the number of the first triple bonded carbon encountered, starting from the end of the chain nearest the triple bond.

Examples of alkynes are:

$CH_3-C\equiv C-CH_3$ 2-butyne

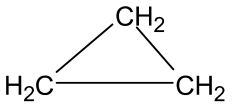


4-chloro-1-butyne (*note that the triple bond is C-1*)

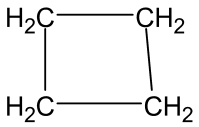
CYCLIC ALIPHATICS

In the compounds that we have studied in previous sections, the carbon atoms are attached to one another to form *chains*; these are called open chain compounds. In many compounds, however, the carbon atoms are arranged to form *rings*; these are called **cyclic compounds**.

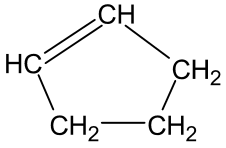
Cyclic aliphatic hydrocarbons are named by prefixing **cyclo-** to the name of the corresponding open chain hydrocarbon having the same number of carbon atoms as the ring.



cyclopropane

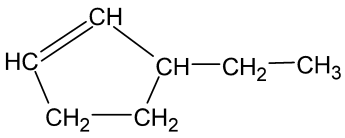


cyclobutane

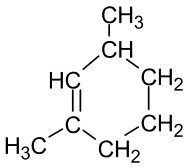


cyclopentene

Substituents on the ring are named, and their positions are indicated by numbers, the lowest combination of numbers being used. In simple cycloalkenes and cycloalkynes, the double-and triple-bonded carbons are considered to be carbons 1 and 2. Therefore, numbering always begins at the start of the double or triple bond in such a way as to give the first substitution the lowest carbon number.



3-ethylcyclopentene

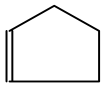


1,3-dimethylcyclohexene

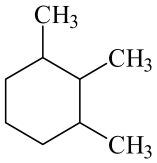
For convenience, aliphatic rings are often represented by simple geometric figures (line diagrams). A triangle represents cyclopropane, a square for cyclobutane, a pentagon for cyclopentane, a hexagon for cyclohexane, and so on. It is understood that the appropriate number of hydrogens are at each corner of the figure, unless some other group is indicated.

For example:

cyclobutane (C_4H_8)



cyclopentene (C_5H_8)



1,2,3-trimethylcyclohexane (C_9H_{18})

Note that the formation of the ring removes two hydrogens from the formula of any cyclic hydrocarbon. For example, the alkane butane has the formula C_4H_{10} whereas cyclobutane has the formula C_4H_8.