CHAPTER

8

Nomenclature of Alkenes & Alkynes

ALKENES

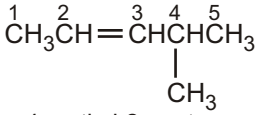
Alkenes are named using a series of rules similar to those for alkanes with the suffix -ene used instead of -ane to identify the functional group. There are two steps.

1. **Name the parent hydrocarbon:** Find the longest carbon chain containing the double bond.
2. **Number the carbon atoms in the chain:** Begin at the end nearer the double bond or, if the double bond is equidistant from the two ends, begin at the end nearer the first branch point. This rule ensures that the doublebond carbons receive the lowest possible numbers.
   Functional group suffix = **–ene**
   Substituent name = **alkenyl**
   Structural unit : alkenes contain C = C bonds.

Solved Example

$CH_3CH_2CH{=}CH_2$

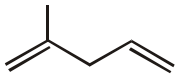
- Functional group is an alkene, therefore suffix = **–ene**
- The longest continuous chain is C4 therefore root = but
- In order to give the alkene the lowest number, number from the right as drawn.
- The C = C is between C1 and C2 so the locant is **but-1-ene** or **1-butene.**



4-methyl-2-pentene

☞ For a compound with two double bonds, the “ne” ending of the corresponding alkane is replaced with “diene.”

Solved Example



$CH_3C(CH_3)=CHCH=CH_2$

- Functional group is an alkene, therefore suffix = **–ene.**
- There are two alkenes, so insert the multiplier di.
- The longest continuous chain is C5 therefore root plus "a" = penta.
- The substituent is a C1 alkyl group i.e. a methyl group.
- The first point of difference doesn't distinguish the C = C.
- So, need to apply the first point of difference to the alkyl substituent.
- The first point of difference requires that we number from the left as drawn.
- The methyl group locant is 2-.
- Therefore the locants for C = C units are 1- and 4-

Name : 2-methylpenta-1,4-diene or 2-methyl-1,4-pentadiene

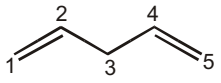
Solved Example

$\overset{1}{C}H_3\overset{2}{C}H=\overset{3}{C}H-\overset{4}{C}H=\overset{5}{C}H\overset{6}{C}H_2\overset{7}{C}H_3$

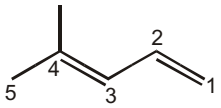
2, 4-heptadiene

$\overset{5}{C}H_3\overset{4}{C}H=\overset{3}{C}H-\overset{2}{C}H=\overset{1}{C}H_2$

1, 3-pentadiene



1,4-pentadiene

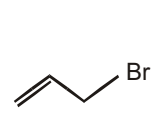


4-methyl-1,3-pentadiene

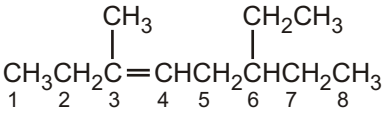
☞ Groups which always have less priority than multiple bonds :

1.	– F	Fluoro	**2.**	– Cl	Chloro
3.	– Br	Bromo	**4.**	– I	Iodo
5.	$-NO_2$	Nitro	**6.**	– NO	Nitroso
7.	– OR	Alkoxy	**8.**	$-OCH_3$	Methoxy
9.	– OEt	ethoxy	**10.**	– OPh	Phenoxy
11.	– R	Alkyl	**12.**	$-N_3$	Azido

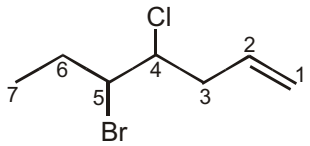
Solved Example



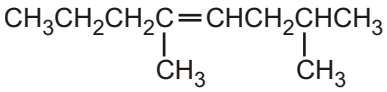
3-bromoprop-1-ene



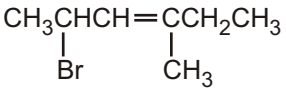
6-ethyl-3-methyl-3-octene



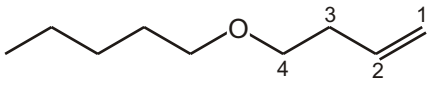
5-bromo-4-chloro-1-heptene



2,5-dimethyl-4-octene
not
4,7-dimethyl-4-octene
because 2 < 4



2-bromo-4-methyl-3-hexene
not
5-bromo-3-methyl-3-hexene
because 2 < 3



4-pentoxy-1-butene

NOMENCLATURE OF CYCLIC ALKENE

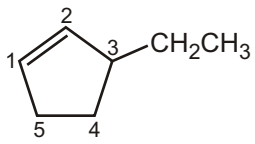
Solved Example

- Functional group is an alkene, therefore suffix = **–ene.**
- The longest continuous chain is C6 therefore root = **hex.**
- The C = C is unambiguously between C1 and C2 therefore the locant isn't required.

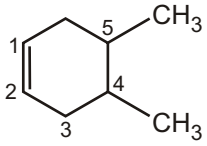
Name: Cyclohexene

☞ A number is not needed to denote the position of the double bond in a cyclic alkene because the ring is always numbered so that the double bond is between carbons 1 and 2. To assign numbers to any substituents, count around the ring in the direction (clockwise or counterclockwise) that puts the lowest number into the name.

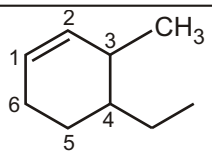
Solved Example



3-ethylcyclopentene



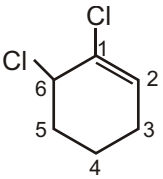
4,5-dimethylcyclohexene



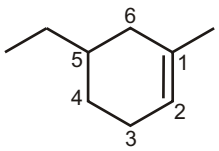
4-ethyl-3-methylcyclohexene

❑ **NOTE :** 1,6-dichlorocyclohexene is not called 2,3-dichlorocyclohexene because the former has the lowest substituent number (1), even though it does not have the lowest sum of substituent numbers (1 6 7 versus 3 2 5).

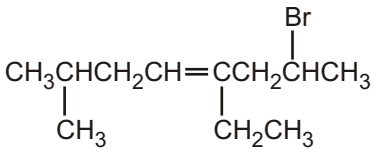
Solved Example



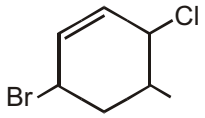
1,6-dichlorocyclohexene
not
2,3-dichlorocyclohexene
because 1 < 2



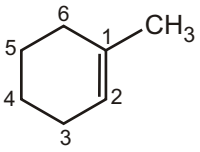
5-ethyl-1-methylcyclohexene
not
4-ethyl-2-methylcyclohexene
because 1 < 2



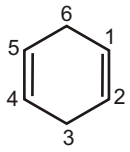
2-bromo-4-ethyl-7-methyl-4-octene
not
7-bromo-5-ethyl-2-methyl-4-octene
because 4 < 5



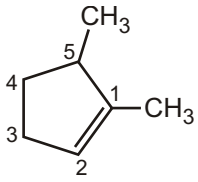
6-bromo-3-chloro-4-methylcyclohexene
not
3-bromo-6-chloro-5-methylcyclohexene
because 4 < 5



1-Methyl cyclohexene



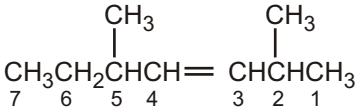
1,4-Cyclohexadiene
(New: Cyclohexa-1,4-diene)

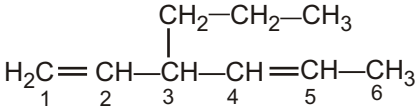


1,5-Dimethylene cyclopent

☞ We should also note that IUPAC changed their naming recommendations in 1993 to place the locant indicating the position of the double bond immediately before the -ene suffix rather than before the parent name: but-2-ene rather than 2-butene, for instance. This change has not been widely accepted by the chemical community in the United States, however, so we'll stay with the older but more commonly used names. Be aware, though, that you may occasionally encounter the newer system.

Solved Example





Older naming system :	2,5-Dimethyl-3-heptene	3-Propyl-1,4-hexadiene
(Newer naming system:	2,5-Dimethylhept-3-ene	3-Propylhexa-1,4-diene

Common names of Some Alkenes

Compound	Systematic name	Common name
H_2C CH_2	Ethene	Ethylene
CH_3CH CH_2	Propene	Propylene
$CH_3C(CH_3)=CH_2$	2-Methylpropene	Isobutylene
$H_2C=C(CH_3)-CH=CH_2$	2-Methyl-1,3-butadiene	Isoprene

ALKENES AS SUBSTITUENTS

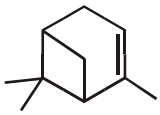
- In some cases, a group containing an alkene may need to be treated as a substituent.
- In these cases the substituent is named in a similar fashion to simple alkyl substituents.

Alkenyl group	Common name	Systematic name
CH_2 CH —	Vinyl-	ethenyl
CH_2 $CHCH_2$ —	allyl-	2-propenyl
CH_3CH CH —	—	1-propenyl

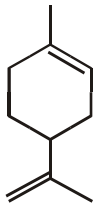
☑ SPECIAL TOPIC

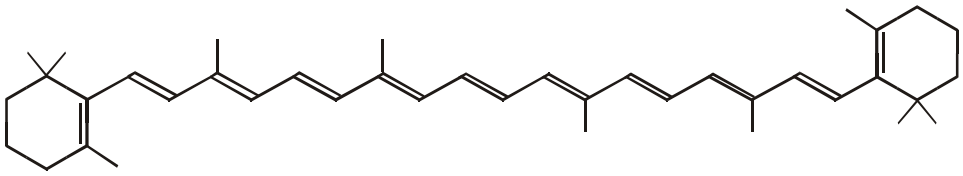
ALKENES (SOMETIMES CALLED OLEFINS) CONTAIN C C DOUBLE BONDS

It may seem strange to classify a type of bond as a functional group, but you will see later that C C double bonds impart reactivity to an organic molecule just as functional groups consisting of, say, oxygen or nitrogen atoms do. Some of the compounds produced by plants and used by perfumers are alkenes (see Chapter 1). For example, pinene has a smell evocative of pine forests, while limonene smells of citrus fruits.



α-pinene

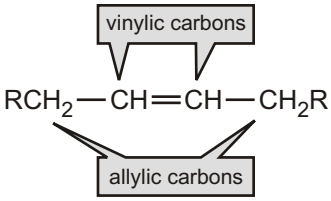




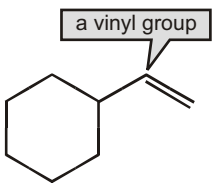
β-carotene

ALLYLIC AND VINYLIC CARBON

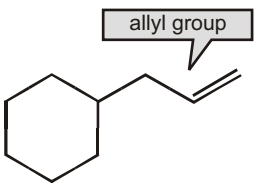
The sp^2 carbons of an alkene are called vinylic carbons . An sp^3 carbon that is adjacent to a vinylic carbon is called an allylic carbon. A hydrogen bonded to a vinylic carbon is called a vinylic hydrogen , and a hydrogen bonded to an allylic carbon is called an allylic hydrogen.



	$CH_2=CHCl$	$CH_2=CHCH_2Br$
common name:	vinyl chloride	allyl bromide
systematic name:	chloroethene	3-bromopropene



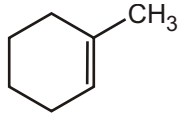
vinylcyclohexane

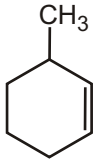


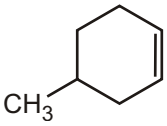
allylcyclohexane

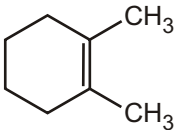
Special Example

- How many carbons are in the planar double-bond system in each of the following compounds?

(a) 

(b) 

(c) 

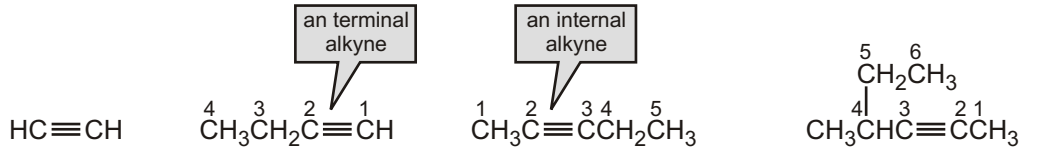
(d) 

Sol. (a) 5 (b) 4 (c) 4 (d) 6

THE NOMENCLATURE OF ALKYNES

Because of its triple bond, an alkyne has four fewer hydrogens than an alkane with the same number of carbons. Therefore, while the general molecular formula for an acyclic alkane is $C_nH_{2n\ 2}$, the general molecular formula for an acyclic alkyne is $C_nH_{2n\ 2}$ and that for a cyclic alkyne is $C_nH_{2n\ 4}$.

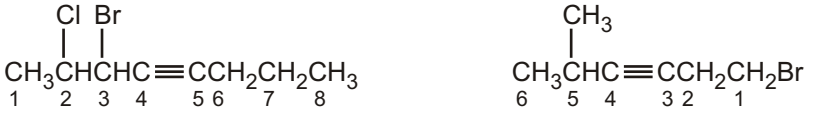
The systematic name of an alkyne is obtained by replacing the "ane" ending of the alkane name with "yne." Analogous to the way compounds with other functional groups are named, the longest continuous chain containing the carbon–carbon triple bond is numbered in the direction that gives the functional group suffix as low a number as possible. If the triple bond is at the end of the chain, the alkyne is classified as a terminal alkyne . Alkynes with triple bonds located elsewhere along the chain are internal alkynes.



Systematic:	ethyne	1-butyne	2-pentyne	4-methyl-2-hexyne
Common:	acetylene	ethylacetylene	ethylmethylacetylene	*sec*- butylmethylacetylene

☞ If counting from either direction leads to the same number for the functional group suffix, the correct systematic name is the one that contains the lowest substituent number. If the compound contains more than one substituent, the substituents are listed in alphabetical order.

Solved Example

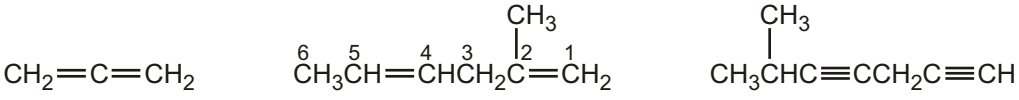


3-bromo-2-chloro-4-octyne
not 6-bromo-7-chloro-4-octyne
because 2 < 6

1-bromo-5-methyl-3-hexyne
not 6-bromo-2-methyl-3-hexyne
because 1 < 2

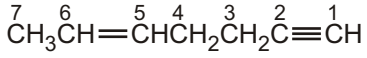
HOW TO NAME A COMPOUND THAT HAS MORE THAN ONE FUNCTIONAL GROUP

The rules for naming compounds with two triple bonds, using the ending ''diyne'', are similar to the rules for naming compounds with two double bonds.

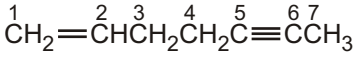


Systematic:	propadiene	2-methyl-1,4-hexadiene	6-methyl-1,4-heptadiyne
Common:	allene	or	or
		2-methylhexa-1,4-diene	6-methylhepta-1,4-diyne

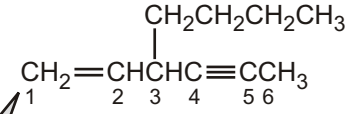
☞ If the two functional groups are a double bond and a triple bond , number the chain in the direction that produces a name containing the lower number. Thus, in the following examples, the lower number is given to the alkyne suffix in the compound on the left and to the alkene suffix in the compound on the right.



5-hepten-1-yne *not* 2-hepten-6-yne
because 1 < 2



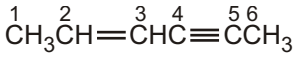
1-hepten-5-yne *not* 6-hepten-2-yne
because 1 < 2



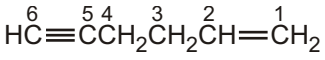
3-butyl-1-hexen-4-yne

the longest continuous chain has 8 carbons, but the 8-carbon chain does not contain both functional groups; therefore, the compound is named as a hexenyne because the longest continuous chain containing both functional groups has 6 carbons

Solved Example



2-hexen-4-yne
not 4-hexen-2-yne

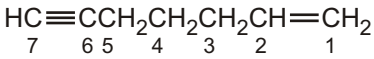


1-hexen-5-yne
not 5-hexen-1-yne

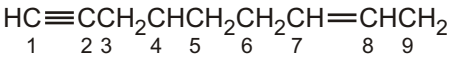
☞ If there is a tie between a double bond and a triple bond, the double bond gets the lower number.

☞ Compounds with more than one triple bond are called diynes, triynes, and so forth; compounds containing both double and triple bonds are called enynes (not ynenes). Numbering of an enyne chain starts from the end nearer the first multiple bond, whether double or triple. When there is a choice in numbering, double bonds receive lower numbers than triple bonds.

Solved Example

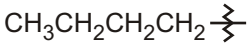


1-Hepten-6-yne
(New : Hept-1-en-6-yne)

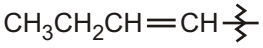


4-Methyl-7-nonen-1-yne
(New : 4-Methyl-7-nonen-1-yne)

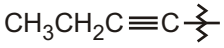
☞ As with alkyl and alkenyl substituents derived from alkanes and alkenes, respectively, alkynyl groups are also possible.



Butyl
(an alkyl group)



1-Butenyl
(a vinylic group)
(New : But-1-enyl)



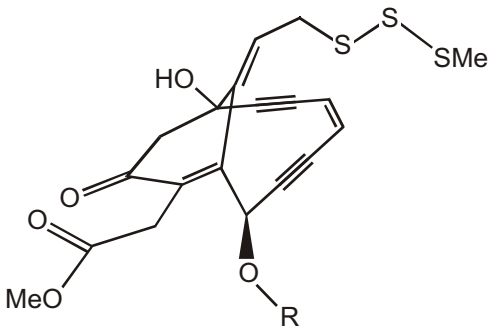
1-Butynyl
(an alkynyl group)
(New : But-1-ynyl)

☑ SPECIAL TOPIC

ALKYNES CONTAIN C C TRIPLE BONDS

Just like C C double bonds, C C triple bonds have a special type of reactivity associated with them, so it's useful to call a C C triple bond a functional group. Alkynes are linear so we draw them with four carbon atoms in a straight line. Alkynes are not as widespread in nature as alkenes, but one fascinating class of compounds

containing C C triple bonds is a group of antitumour agents discovered during the 1980s. Calicheamicin is a member of this group. The highreactivity of this combination of functional groups enables calicheamicin to attack DNA and prevent cancer cells from proliferating. For the first time we have drawn a molecule in three dimensions, with two bonds crossing one another—can you see the shape?

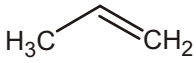
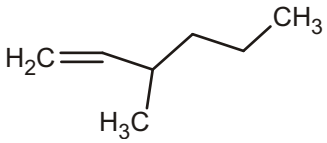
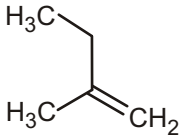
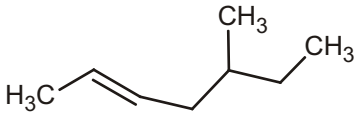
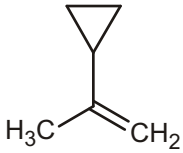
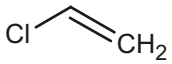
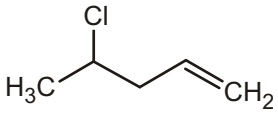


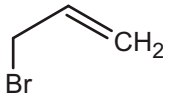
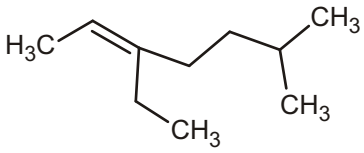
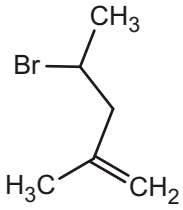
calicheamicin
(R = a string of sugar molecules)

► **Saturated and unsaturated carbon atoms**
In an alkane, each carbon atom is joined to four other atoms (C or H). It has no potential for forming more bonds and is therefore saturated. In alkenes, the carbon atoms making up the C=C double bond are attached to only three atoms each. They still have the potential to bond with one more atom, and are therefore unsaturated. In general, carbon atoms attached to four other atoms are saturated; those attached to three, two, or one are unsaturated.

EXERCISE

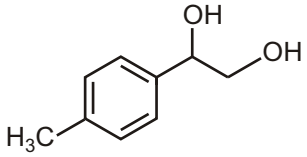
WORK SHEET - 1

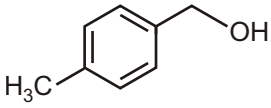
S.No.	Compounds	Write IUPAC - Name
1.		
2.		
3.		
4.		
5.		
6.		
7.		

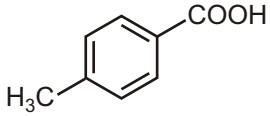
8.		
9.		
10.		

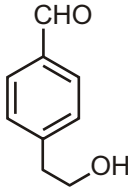
SUBJECTIVE TYPE QUESTIONS

1. The reaction of 50% aq. KOH on an equimolar mixture of 4 -methylbenzaldehyde and formaldehyde followed by acidification gives :

(a) 

(b)  + HCOOH

(c)  + CH_3OH

(d) 

Answers

Work Sheet - 1

1. propene **2.** 3-methylhex-1-ene **3.** 2-methylbut-1-ene **4.** 5-methylhept-2-ene
5. 2-cyclopropylpropene **6.** chloroethene **7.** 4-chloropent-1-ene **8.** 3-bromoprop-1-ene
9. 3-ethyl-6-methylhept-2-ene **10.** 4-bromo-2-methylpent-1-ene

Subjective Type Questions

1. (b)

❑❑❑