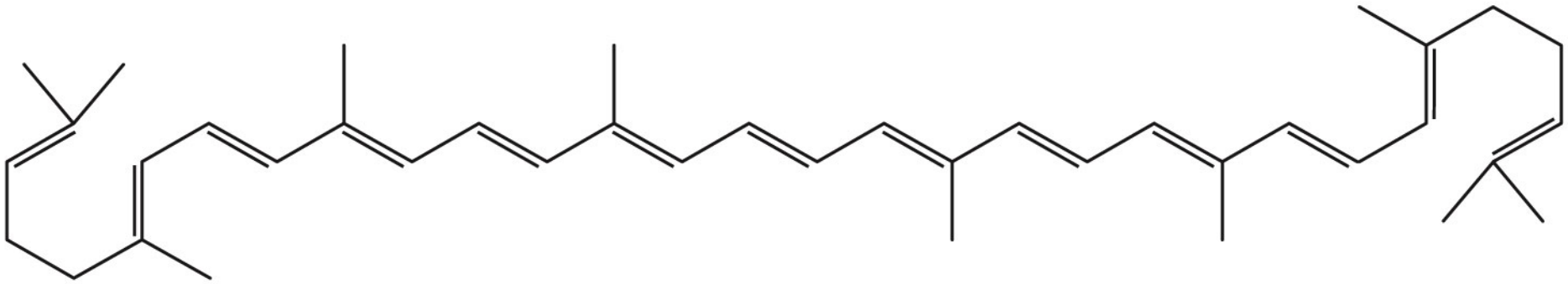
Chapter 3: Alkenes and Alkynes



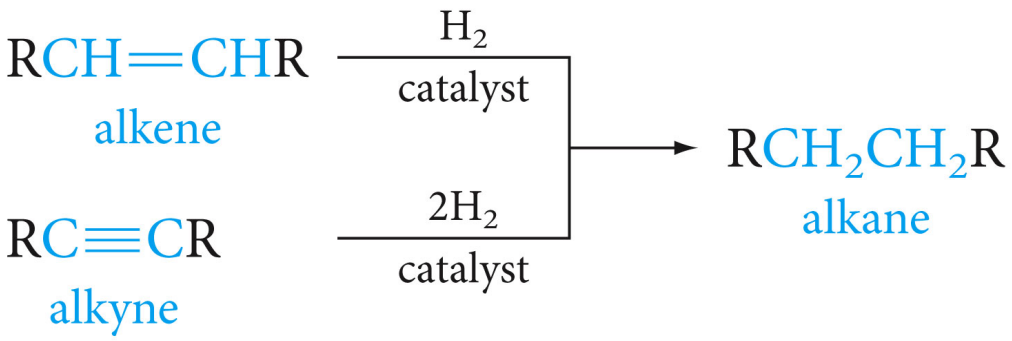
lycopene

Hydrogenation of Alkenes and Alkynes

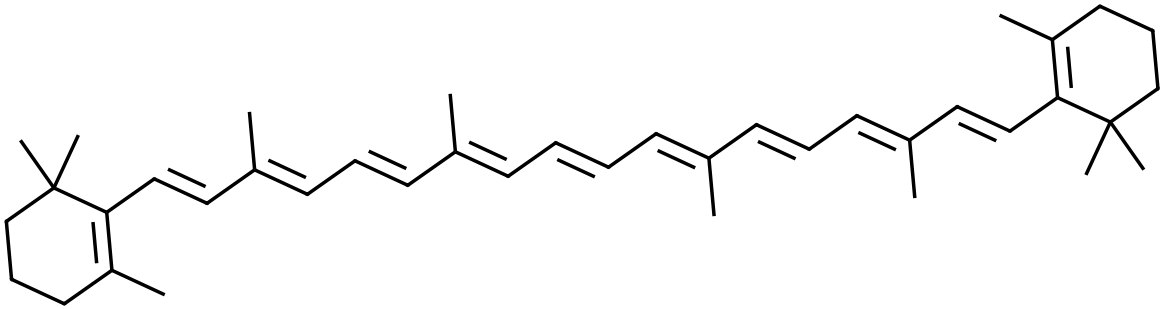
Hydrocarbons that have carbon-carbon double bond are called alkenes; those with a carbon-carbon triple bond are alkynes

Their general formulas are **C_nH_{2n} alkenes** and **C_nH_{2n-2} alkynes**

Both alkenes and alkynes are unsaturated hydrocarbons



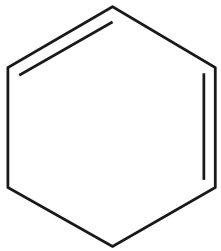
Compounds with more than one double or triple bonds exist. Multiple double bonds may lead to dienes, trienes, tetraenes and polyenes. β-carotene and lycopene are examples of polyenes

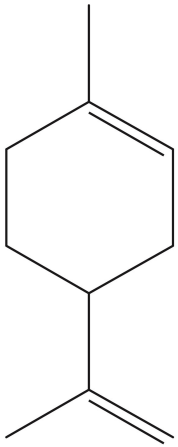


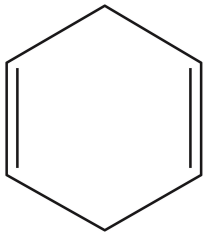
When two or more multiple bonds re present in a molecule, they can be classified depending on the relative positions of the bonds

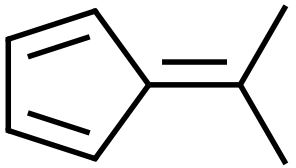
C=C=C	C=C—C=C	C=C—C—C=C
C=C=C=C	C=C—C≡C	C≡C—C—C—C≡C
cumulated	conjugated	nonconjugated (isolated)

Which of the following compounds have conjugated multiple bonds?



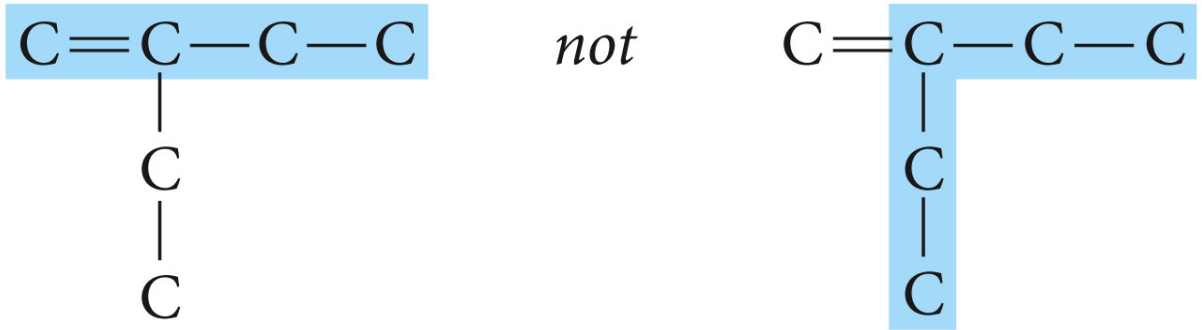






Nomenclature

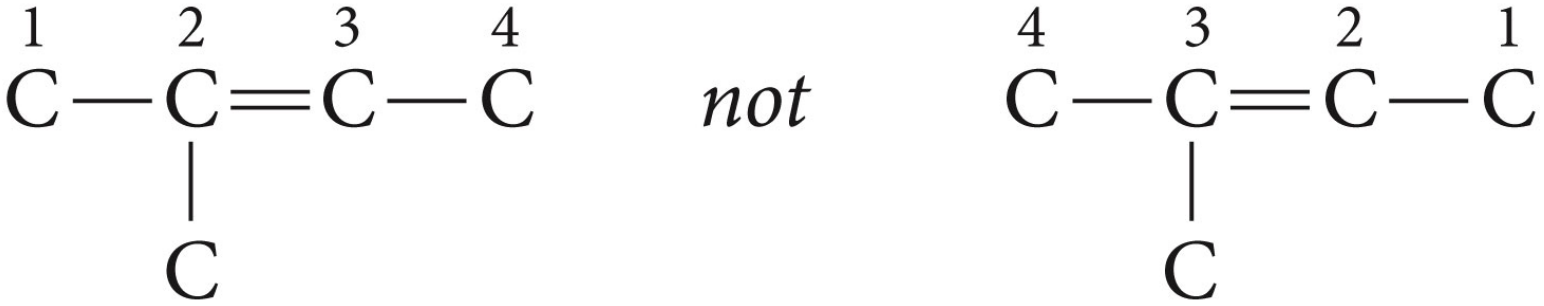
1. The ending –*ene* is used to designate carbon-carbon double bond. When more than one double bond is present, the ending is –*diene, triene, tetraene* and so on. The ending –yne is used for triple carbon-carbon bond.
2. Select the longest chain that includes both carbons of the double bond or triple bond.



named as a butene, not as a pentene

Number the chain from the end nearest the multiple bond so that the carbon atoms in that bond have the lowest possible numbers.

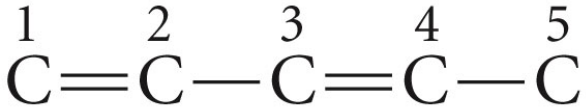
If the multiple bond is equidistant from both ends of the chain, number the chain from the end nearest the first branch point.



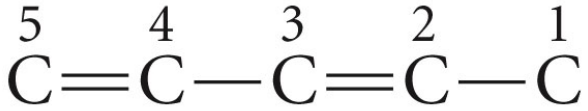
Indicate the position of the multiple bond using the lower numbered carbon atom of that bond.

1-butene, *not* 2-butene

If more than one multiple bond is present, number the chain from the end nearest the first multiple bond.



not

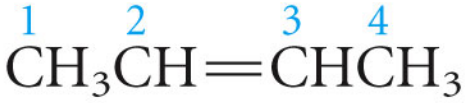


If the double bond and the triple bond are equidistant from the end of the chain, the double bond receives the lowest number.

The root name is from the longest carbon chain containing the multiple bond

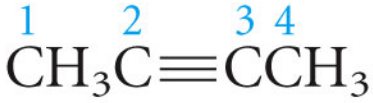
CH_3CH_3	$CH_2{=}CH_2$	$HC{\equiv}CH$
ethane	ethene	ethyne
$CH_3CH_2CH_3$	$CH_2{=}CHCH_3$	$HC{\equiv}CCH_3$
propane	propene	propyne

1-butene

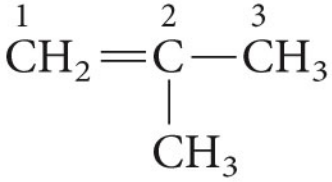


2-butene

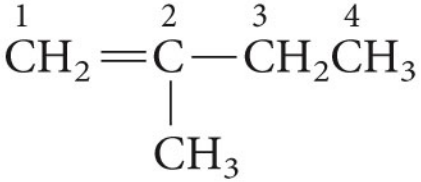
1-butyne



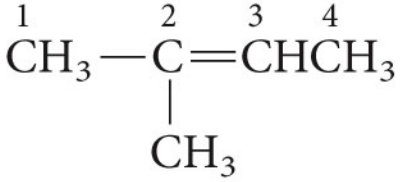
2-butyne



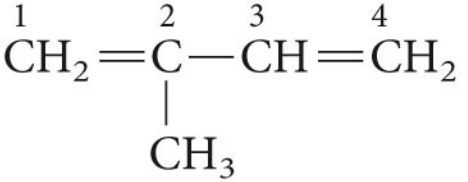
methylpropene
(isobutylene)



2-methyl-1-butene

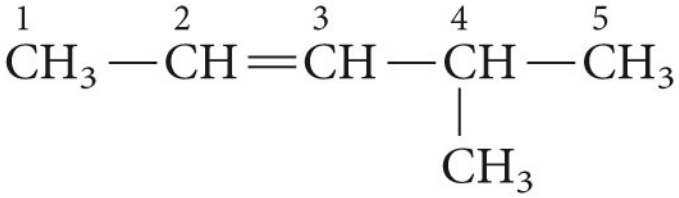


2-methyl-2-butene



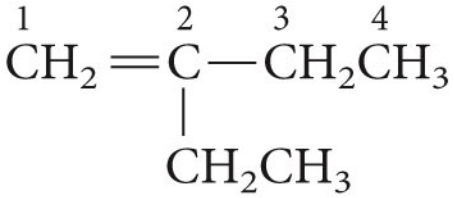
2-methyl-1,3-butadiene
(isoprene)

The numbering rules applied



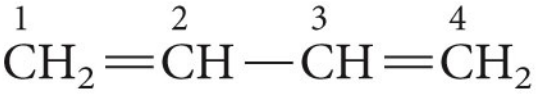
4-methyl-2-pentene

(*Not* 2-methyl-3-pentene; the chain is numbered so that the double bond gets the lower number.)



2-ethyl-1-butene

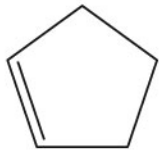
(Named this way, even though there is a five-carbon chain present, because that chain does not include both carbons of the double bond.)



1,3-butadiene

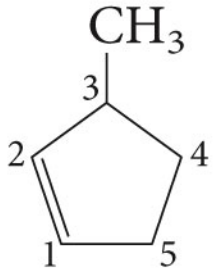
(Note the *a* inserted in the name, to help in pronunciation.)

With the cyclic hydrocarbons, we start numbering the ring with the carbons of the multiple bond.



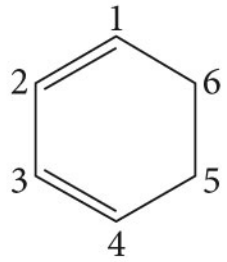
cyclopentene

(No number is necessary, because there is only one possible structure.)

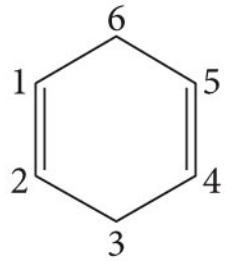


3-methylcyclopentene

(Start numbering at, and number through the double bond; 5-methylcyclopentene and 1-methyl-2-cyclopentene are incorrect names.)



1,3-cyclohexadiene



1,4-cyclohexadiene

Write the structural formula for

3-methyl-2-pentene

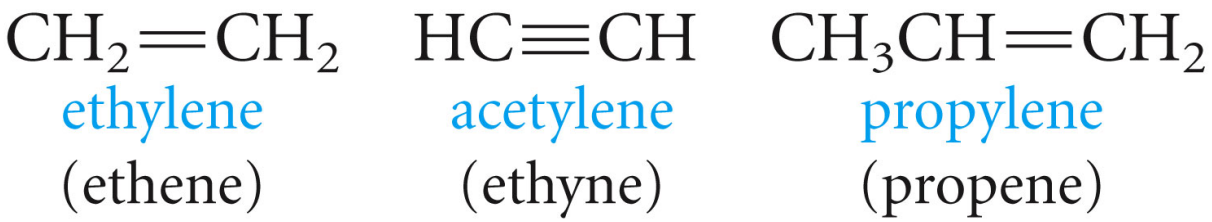
1,4-dichloro-2-pentene

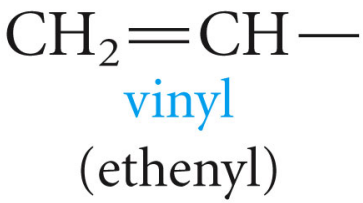
3-hexyne

1,2-dimethylcyclobutene

2-bromo-1,3-pentadiene

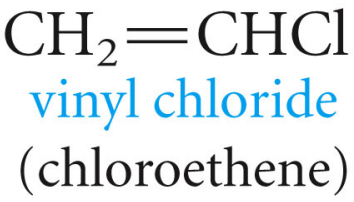
Some Common names





vinyl

(ethenyl)



vinyl chloride

(chloroethene)

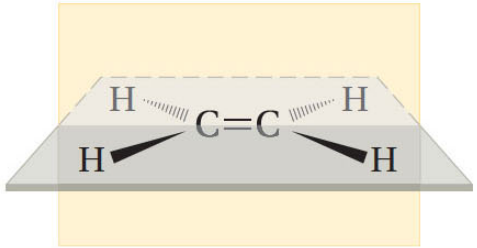
allyl

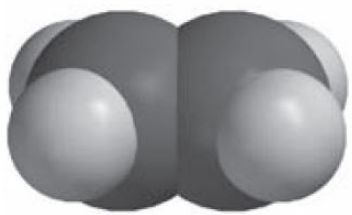
(2-propenyl)

allyl chloride

(3-chloropropene)

Some Facts about Double Bonds





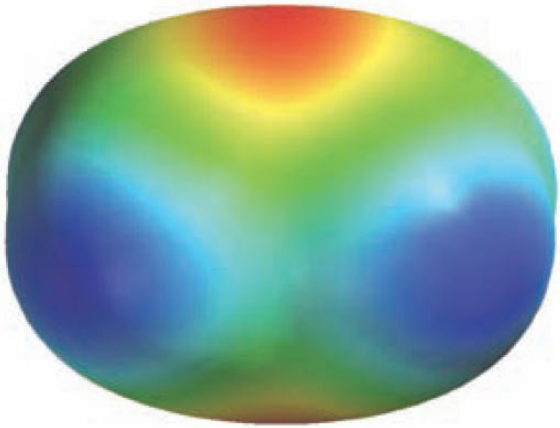
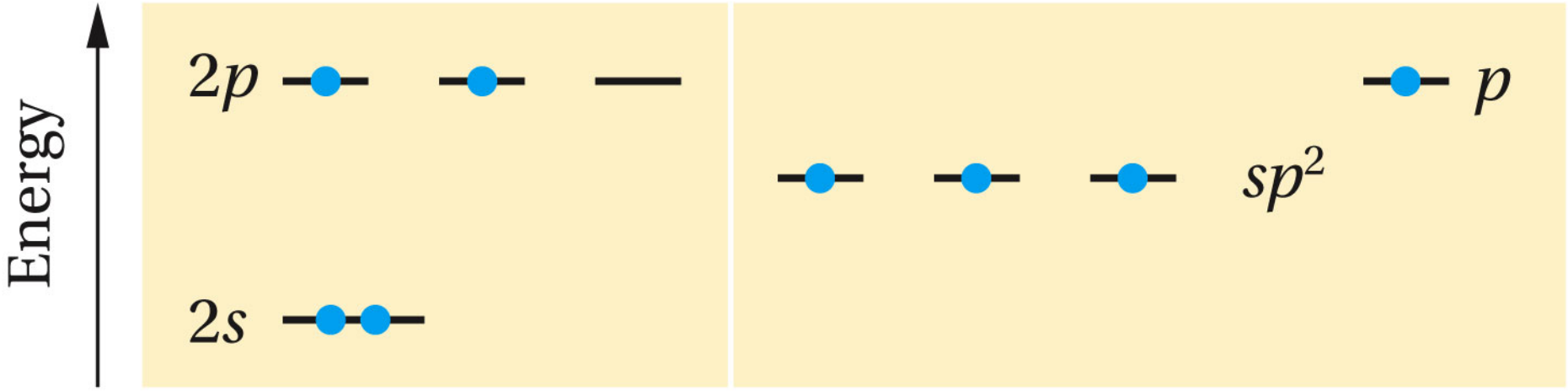


TABLE 3.1 Comparison of C—C and C═C Bonds

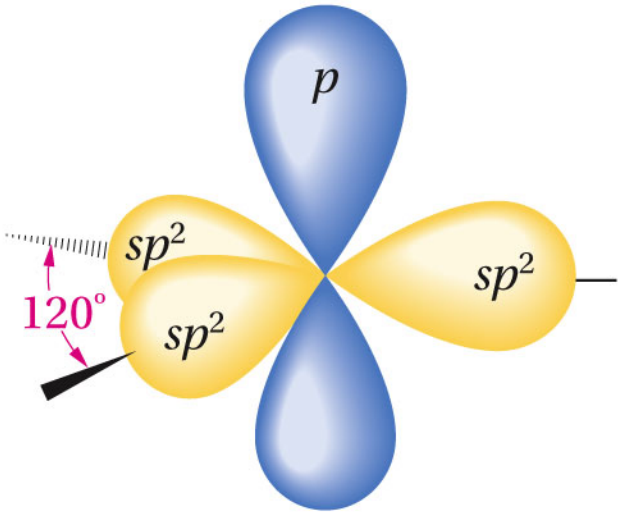
Property	C—C	C═C
1. Number of atoms attached to a carbon	4 (tetrahedral)	3 (trigonal)
2. Rotation	relatively free	restricted
3. Geometry	many conformations are possible; staggered is preferred	planar
4. Bond angle	109.5°	120°
5. Bond length	1.54 Å	1.34 Å

The Orbital Model of a Double Bond; the pi Bond

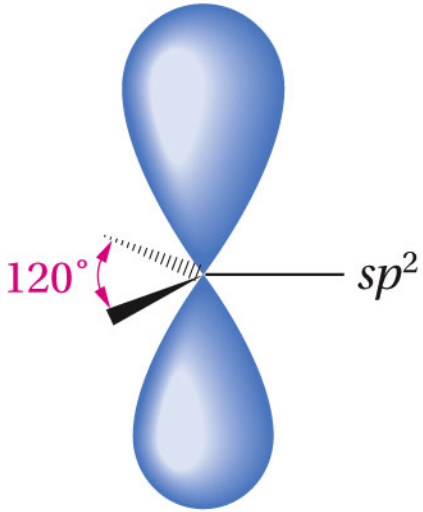


Atomic orbitals of carbon

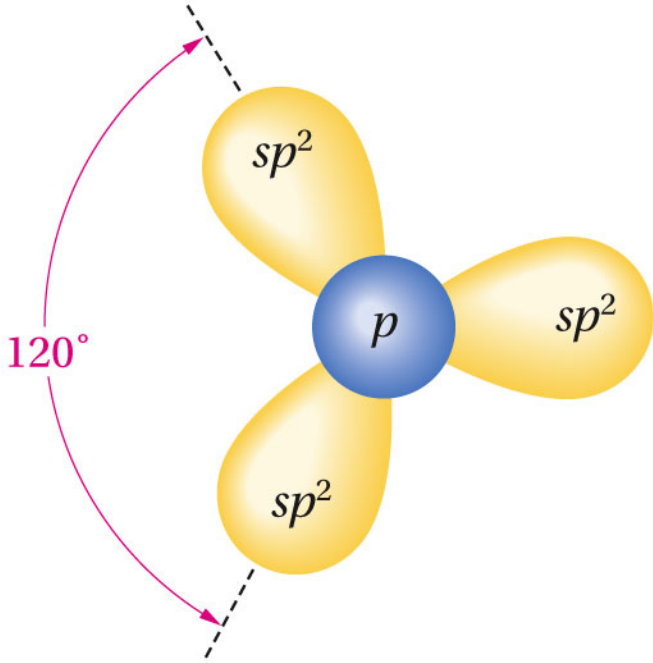
The 2*s* and two 2*p* orbitals are combined to form three hybrid sp^2 orbitals, leaving one electron still in a *p* orbital.



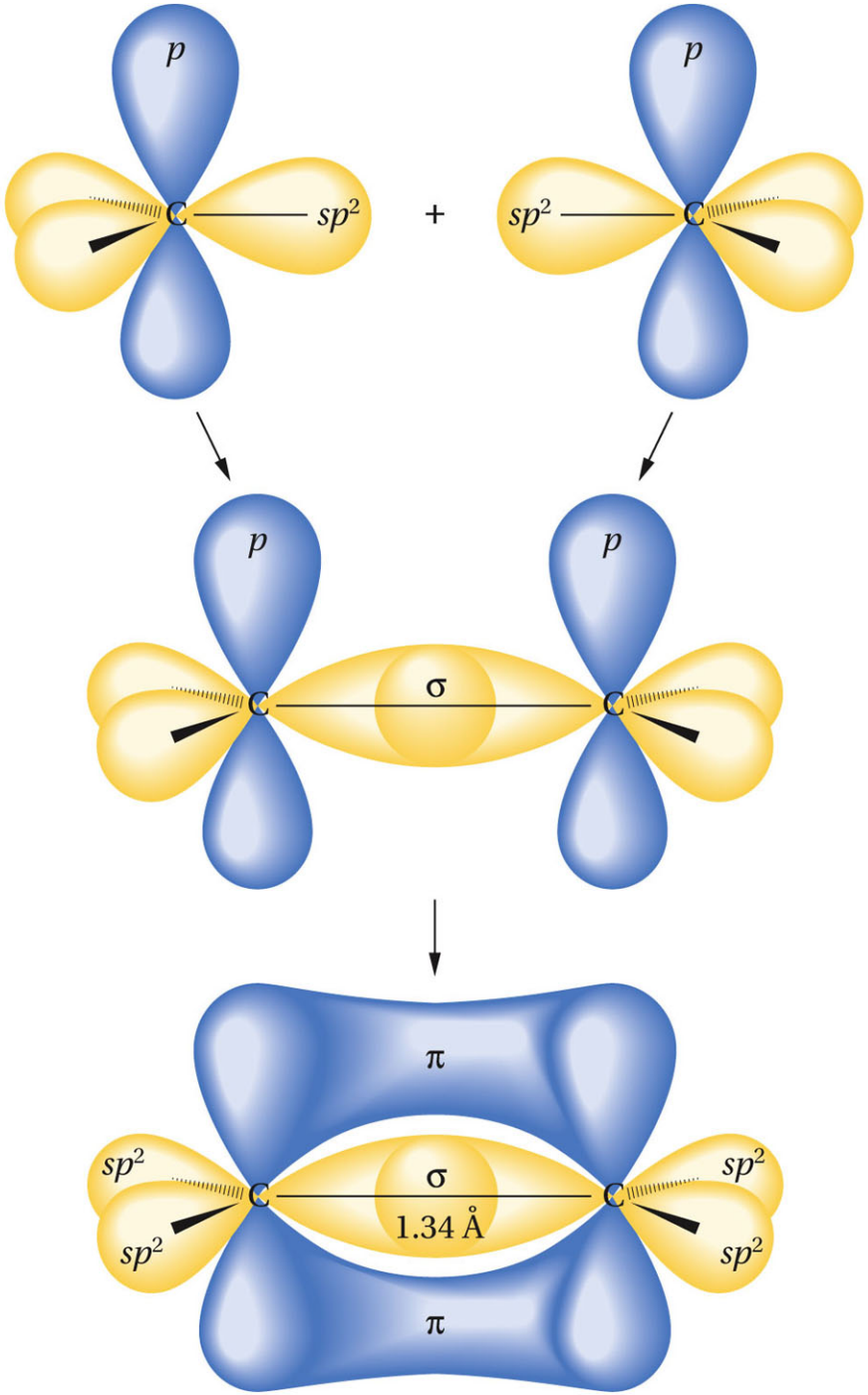
side view



side view with
the sp^2 orbitals
represented by lines



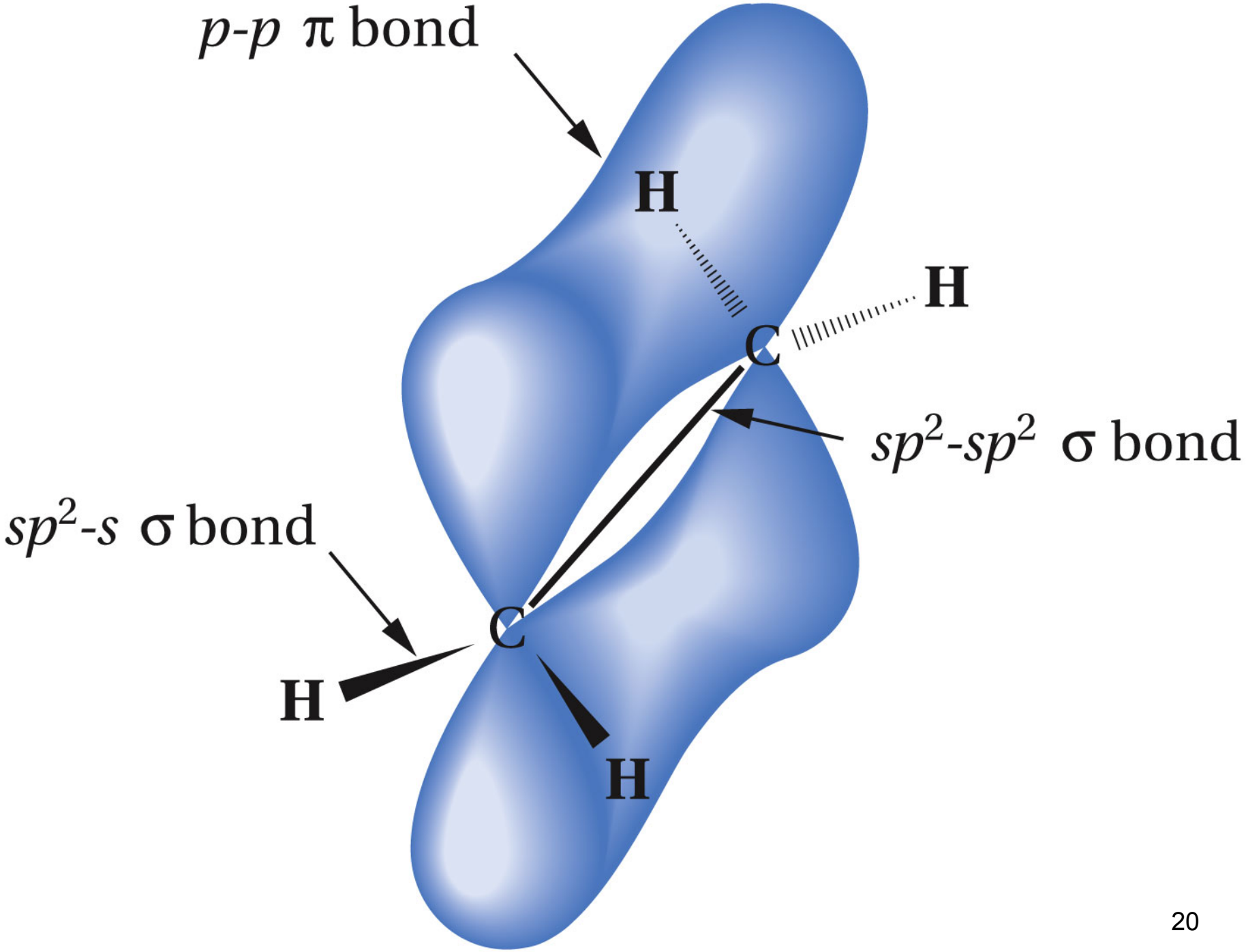
top view

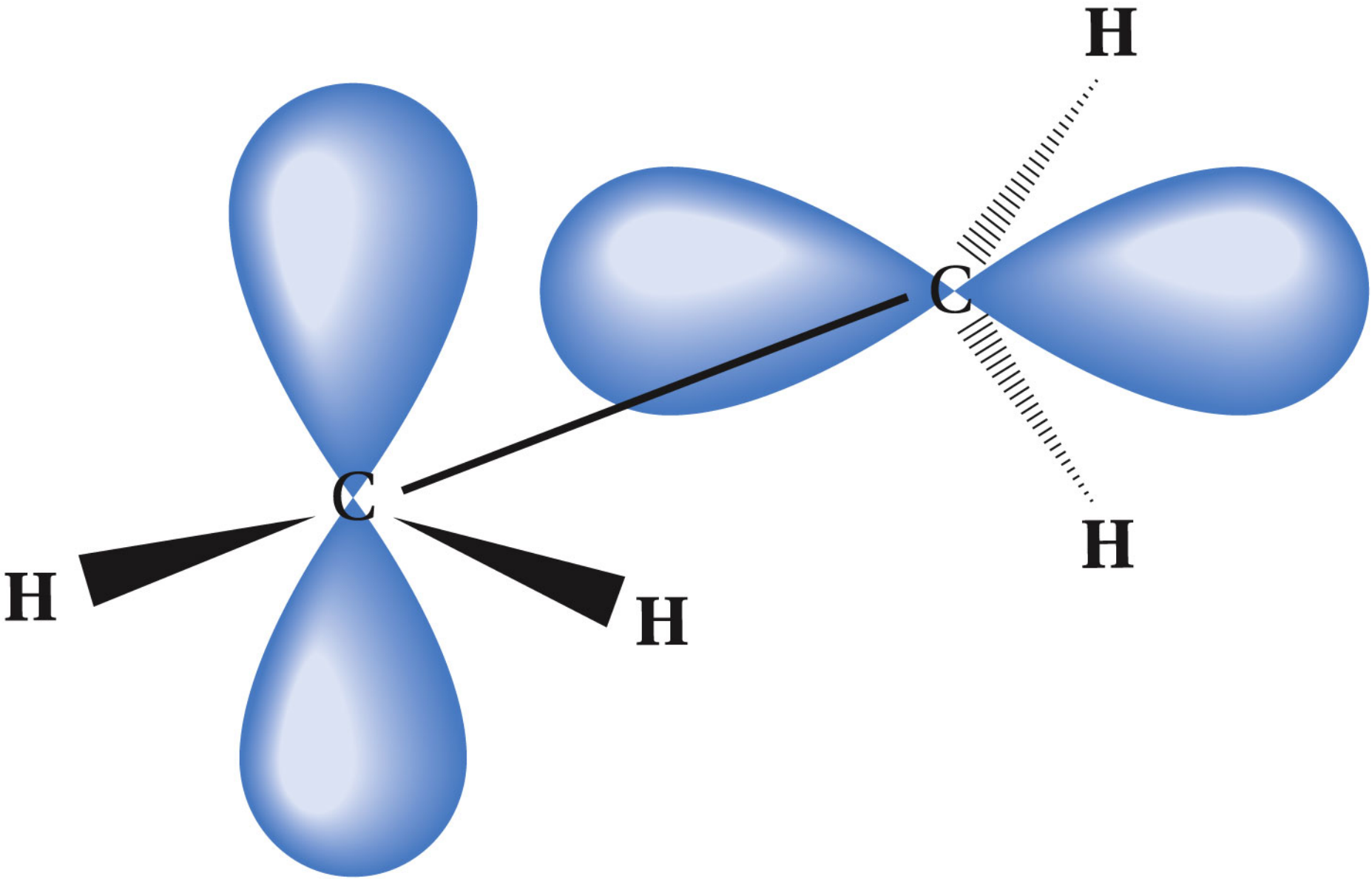


two sp^2-hybridized carbons with p orbitals parallel

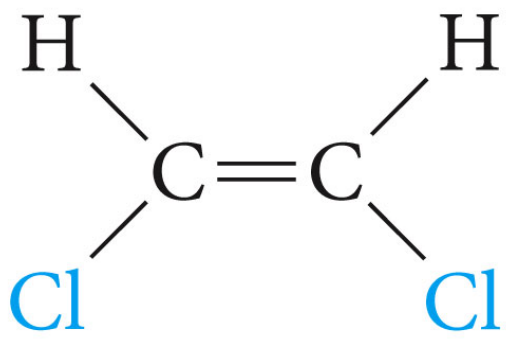
the σ bond is formed by two electrons in overlapping sp^2 orbitals

the π bond is formed by two electrons in overlapping parallel p orbitals


p-p π bond
H
H
C
sp²-sp² σ bond
sp²-s σ bond
C
H
H

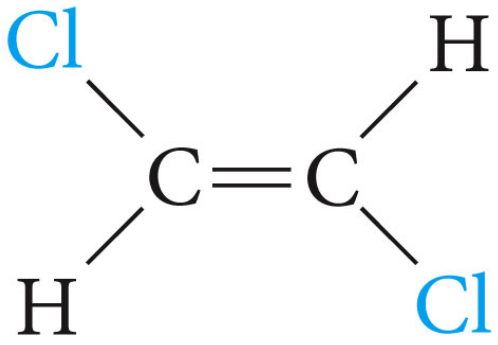

H
C
C
H
H
H

Cis-Trans Isomerism in Alkenes



cis-1,2-dichloroethene

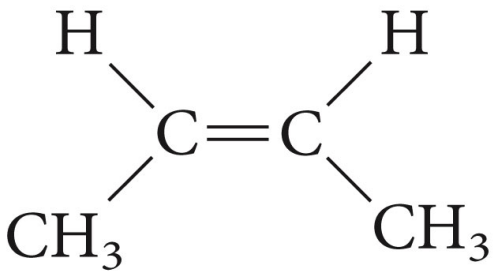
bp 60°C, mp −80°C



trans-1,2-dichloroethene

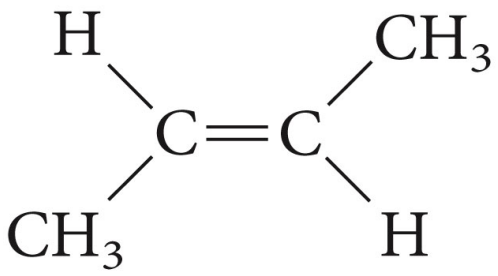
bp 47°C, mp −50°C

Are cis-trans isomers possible for 1-butene and 2-butene?



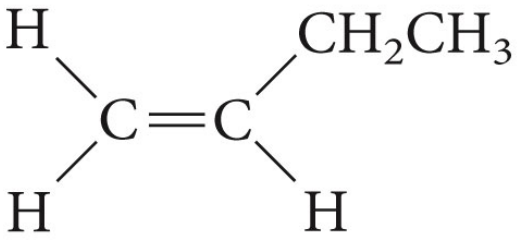
cis-2-butene

bp 3.7°C, mp −139°C



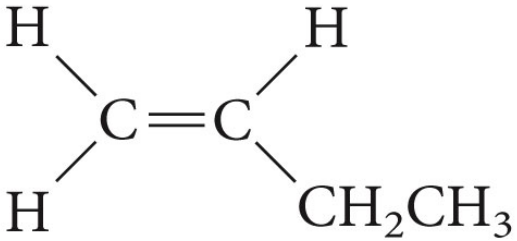
trans-2-butene

bp 0.3°C, mp −106°C



1-butene

is identical to



1-butene

Geometric isomers of alkenes can be interconverted if sufficient energy is supplied to break the pi bond and allow rotation about the remaining sigma bond.