
5

Organic Chemistry

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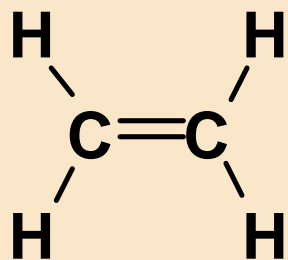
Alkenes I

Chapter 5

5-2

5 Unsaturated Hydrocarbons

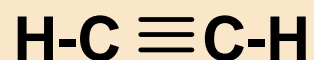
- u **Unsaturated hydrocarbon:** contains one or more carbon-carbon double or triple bonds
- u **Alkene:** contains a carbon-carbon double bond and has the general formula C_nH_{2n} (Ch 5-6)



**Ethylene
(an alkene)**

5 Unsaturated Hydrocarbons

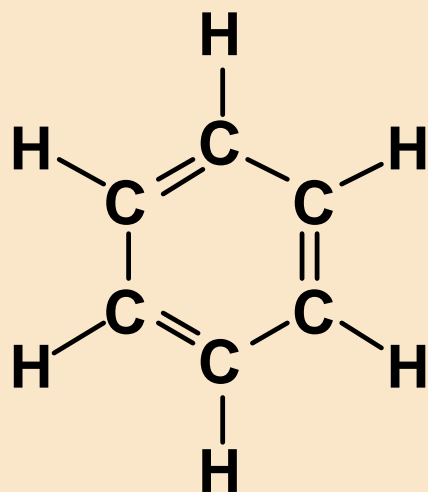
- u **Alkyne**: contains a carbon-carbon triple bond and has the general formula C_nH_{2n-2} (Ch 10)



Acetylene
(an alkyne)

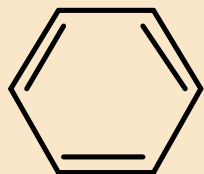
5 Unsaturated Hydrocarbons

- u **Arenes:** benzene and its derivatives (Ch 19-20)

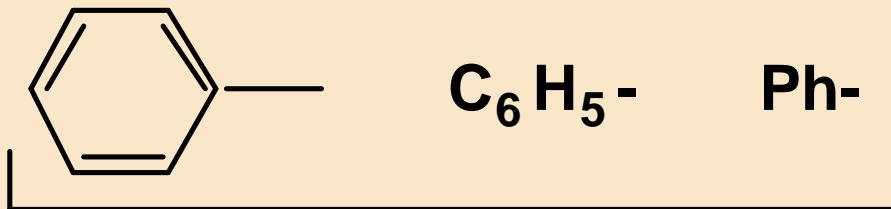


5 Benzene & Phenyl Group

- u We do not study benzene and its derivatives until Chapters 19 & 20
- u But, we show structural formulas of compounds containing the phenyl group before that time
- u The phenyl group is not reactive under any of the conditions we describe in Ch 6-19



Benzene



Alternative representations
for the phenyl group

5 Structure of Alkenes

- u The two carbon atoms of a double bond and the four atoms attached to them lie in a plane, with bond angles of approximately 120°

- u According to the MO model, a double bond consists of
 - one sigma bond formed by overlap of sp^2 hybrid orbitals
 - one pi bond formed by overlap of parallel 2p orbitals

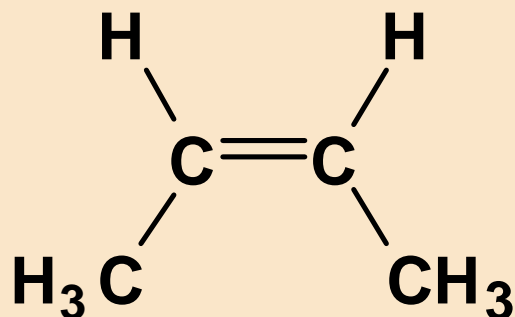
5 Structure of Alkenes

- u Length of C-C bonds: single > double > triple
- u Strength of C-C bonds: triple > double > single

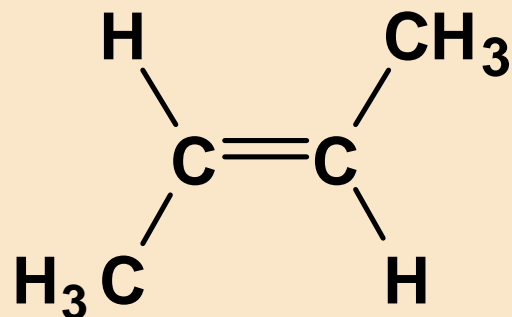
Molecule	C-C Orbital Overlap	Å	kcal/mol
ethane	sp^3-sp^3	1.54	90
ethylene	$sp^2-sp^2, 2p-2p$	1.34	172
acetylene	$sp-sp, two\ 2p-2p$	1.21	230

5 *Cis-Trans* Isomerism

- u Because of restricted rotation about a C-C double bond, groups on adjacent carbons are either *cis* or *trans* to each other



cis-2-Butene
mp -139°C, bp 4°C



trans-2-Butene
mp -106°C, bp 1°C

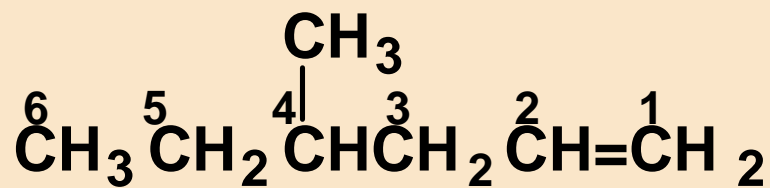
5 Structure of Alkenes

- u ***trans* alkenes are more stable than *cis* alkenes because of nonbonded interactions**

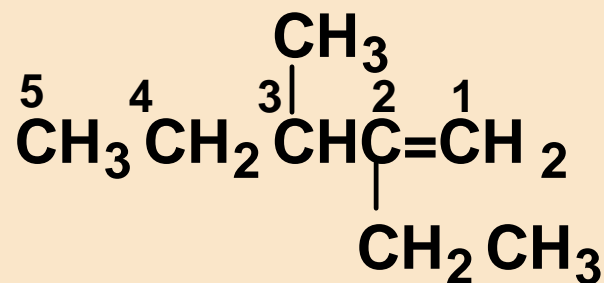
5 IUPAC Nomenclature

- u Use the infix **-en-** to show the presence of a C-C double bond
- u Number the parent chain to give the 1st carbon of the double bond the lower number
- u Follow IUPAC rules for numbering and naming substituents
- u For a cycloalkene, the double bond must be numbered 1,2

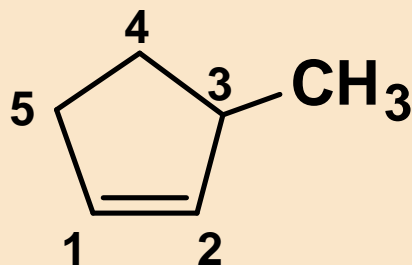
5 IUPAC Nomenclature



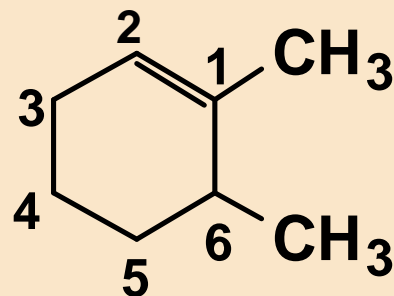
4-Methyl-1-hexene



2-Ethyl-3-methyl-1-pentene

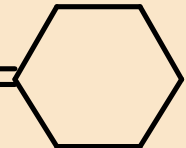


3-Methylcyclo-
pentene



1,6-Dimethylcyclo-
hexene

5 Alkenyl Groups

Alkenyl Group	Common Name	Example
$\text{CH}_2 =$	methylene	$\text{CH}_2 =$  methylenecyclohexane
$\text{CH}_2 = \text{CH}-$	vinyl	$\text{CH}_2 = \text{CHCl}$ vinyl chloride
$\text{CH}_2 = \text{CHCH}_2 -$	allyl	$\text{CH}_2 = \text{CHCH}_2 \text{Cl}$ allyl chloride

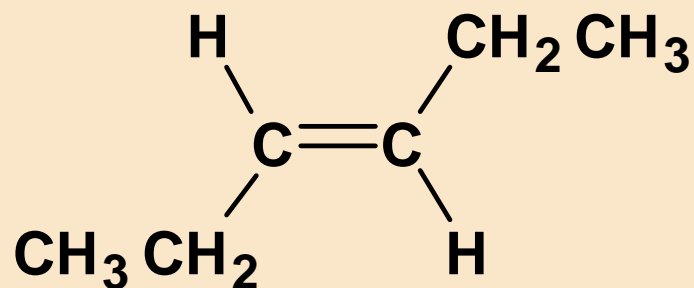
5 Common Names

- u Despite the precision and universal acceptance of IUPAC nomenclature, some alkenes, particularly low-molecular-weight ones, are known almost exclusively by their common names

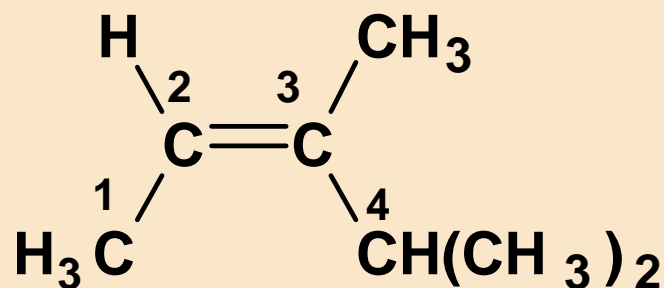
	$\text{CH}_2=\text{CH}_2$	$\text{CH}_3\text{CH}=\text{CH}_2$	$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3\text{C}=\text{CH}_2 \end{array}$
IUPAC:	Ethene	Propene	2-Methylpropene
Common:	Ethylene	Propylene	Isobutylene

5 Configuration

- u **The *cis-trans* system:** configuration is determined by the orientation of atoms of the main chain



trans-3-Hexene

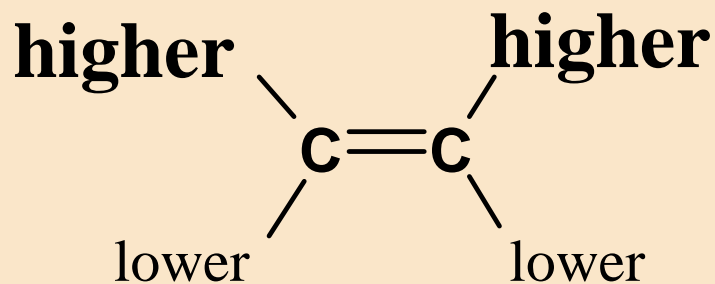


cis-3,4-Dimethyl-2-pentene

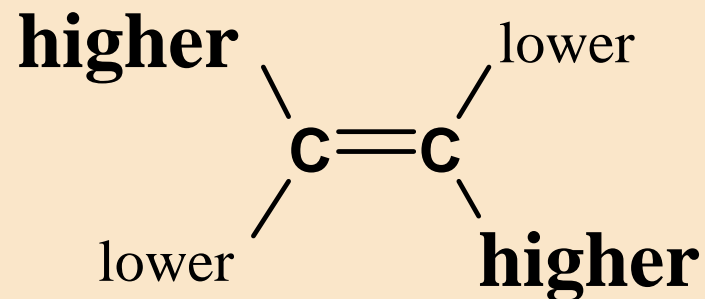
5 Configuration - E,Z

- u The E,Z uses priority rules (Chapter 4)
- u If groups of higher priority are on the same side, configuration is Z (German, zusammen)
- u If groups of higher priority are on opposite sides, configuration is E (German, entgegen)

5 Configuration - E,Z



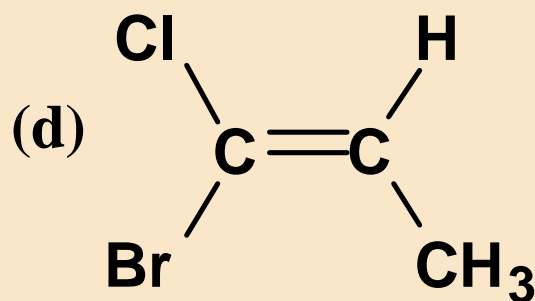
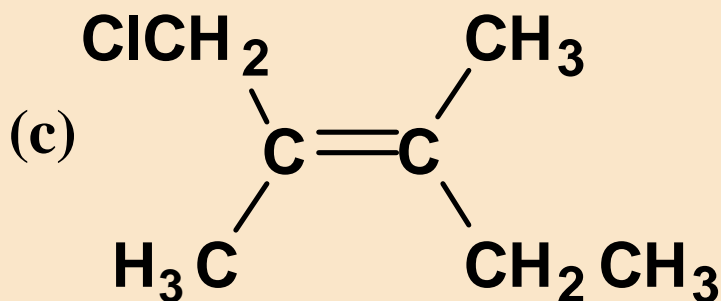
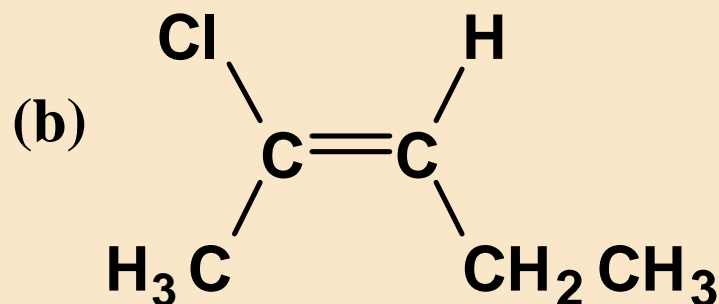
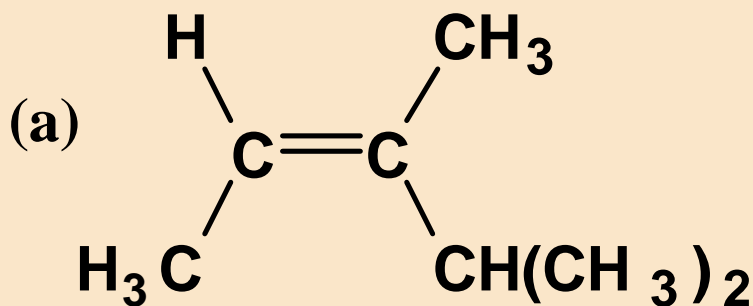
Z (zusammen)



E (entgegen)

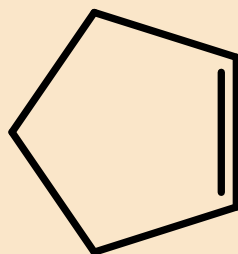
5 Configuration - E,Z

u **Example:** name each alkene and specify its configuration by the E,Z system



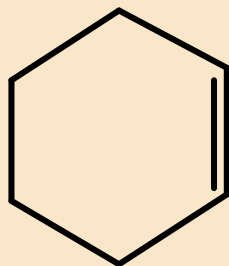
5 *Cis-Trans* Isomerism in Cycloalkenes

- u Configuration of the double bond in cyclopropene through cycloheptene must be **cis**
- u Cyclopentene is planar



5 *Cis-Trans* Isomerism in Cycloalkenes

u Cyclohexene is slightly puckered



5 *Cis-Trans* Isomerism in Cycloalkenes

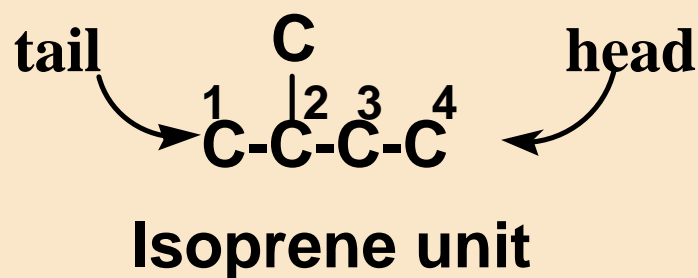
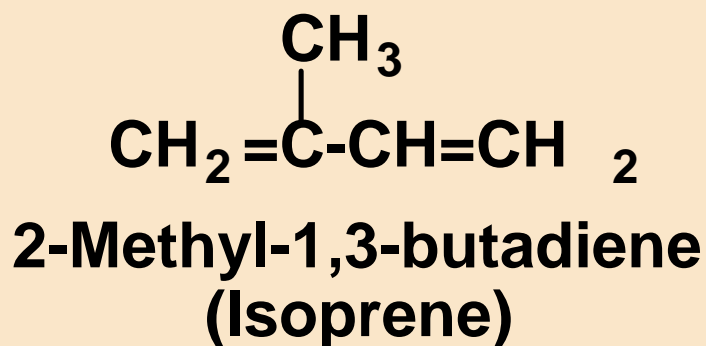
- u ***trans*-Cyclooctene is the smallest *trans*-cycloalkene stable at 25°C**
 - the *cis* isomer is 9.1 kcal/mol more stable than the *trans* isomer.

5 Physical Properties

- u Alkenes are nonpolar compounds
- u The only attractive forces between their molecules are dispersion forces
- u The physical properties of alkenes are similar to those of alkanes

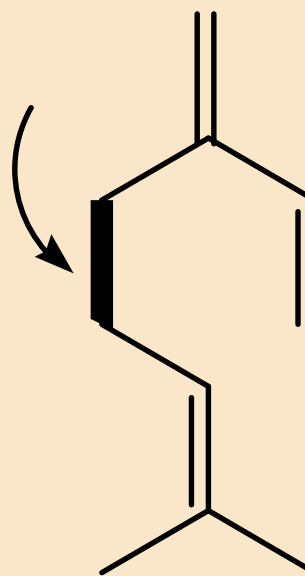
5 Terpenes

- u **Terpene:** a compound whose carbon skeleton can be divided into two or more units identical with the carbon skeleton of isoprene



5 Terpenes

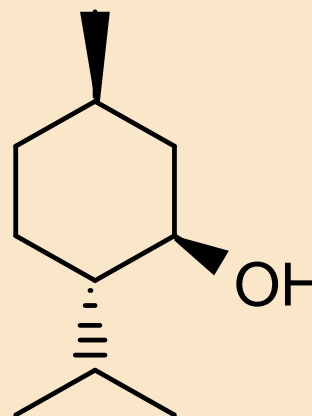
- u **Myrcene, $C_{10}H_{16}$, a component of bayberry wax and oils of bay and verbena**



Myrcene

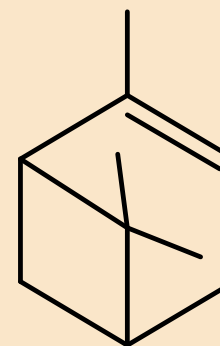
5 Terpenes

u Menthol, from peppermint



5 Terpenes

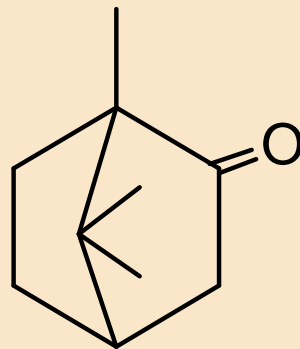
u α -Pinene, from turpentine, shown first without hydrogens, then with them



α -Pinene

5 Terpenes

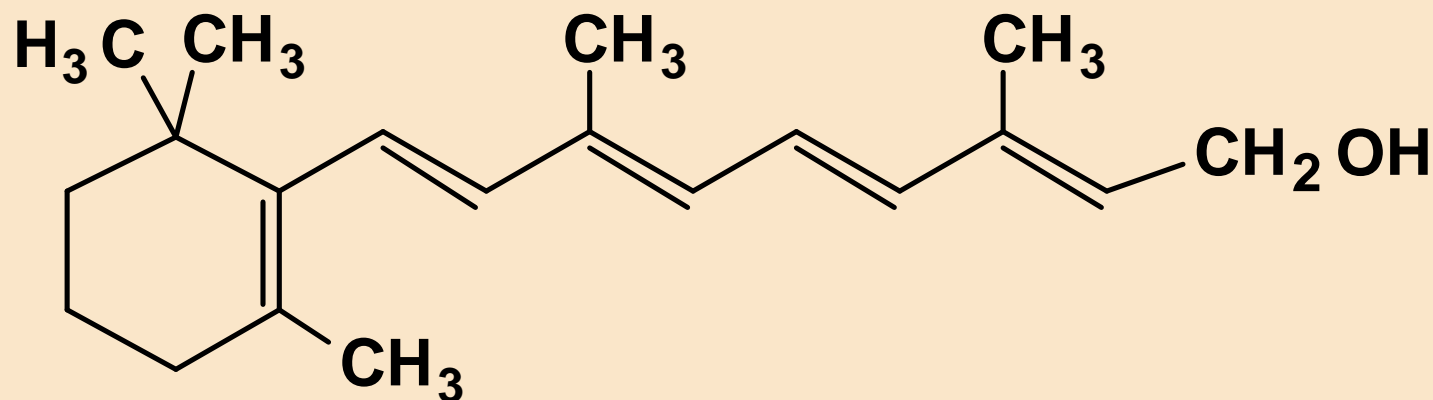
u Camphor, from the camphor tree



Camphor

5 Vitamin A (Retinol)

- u How many stereoisomers are possible for this triterpene alcohol?



5

Alkenes I

End Chapter 5

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