I. Introduction
   A. Unsaturated hydrocarbons contain one or more double or triple bond.
   B. There are three different classes of unsaturated hydrocarbons:
      1. Alkenes contain one or more double bonds.
      2. Alkynes contain one or more triple bond.
      3. Aromatics contain rings with special arrangements of repeating double and single bonds.
         a. We will focus on those that contain six carbon rings.

   Figure 11-7: Classification of Hydrocarbons

   4. Examples:

      \[
      \begin{align*}
      C &= C \\
      H &= H \\
      \end{align*}
      \]
      \[
      \begin{align*}
      H &= C &= C = H \\
      H &= H \\
      \end{align*}
      \]

      ethylene   acetylene   benzene
      an akene    an alkyne    an aromatic

II. Nomenclature of Alkenes
   A. IUPAC Rules
      1. Name the longest chain that contains the double bond to determine the root name.
         a. Use the ending \textit{–ene}.
      2. Number the longest chain of carbon atoms so that the carbon atoms joined by the double bond have numbers as low as possible.
      3. Locate the double bond by the lower-numbered carbon atom bound by the double bond.
      4. Locate and name attached groups.
      5. Combine the names for the attached groups.
      6. Combine the names for the attached groups and the longest chain into a name.

   B. If a molecule has more than one double bond, use the prefix \textit{di-}, \textit{tri-}, \textit{tetra-},… before the \textit{–ene} ending to indicate there numbers, and place their location numbers in front of the root name
1. Fore example:

\[
\begin{align*}
\text{CH}_3 & \\
\text{CH}_3\text{CH}_2\text{CH}=\text{C}=\text{C}=\text{C}=\text{C}=\text{C}=\text{C}=\text{CH}_3 & \\
\text{4-methyl-2,4-heptadiene}
\end{align*}
\]

## III. Geometry of Alkenes

A. **Cis – trans isomers**

1. Unlike single bonds, there is no free rotation about double bonds.
2. This leads to the possibility of structural isomers.
3. *cis-trans* isomers are different molecules with different properties

### Table 12.1 – Physical properties of *cis*-2-butene and *trans*-2-butene

## IV. Properties of Alkenes

A. **Physical properties**

### Table 12.2 – Physical properties of some alkenes

1. Are similar to alkanes
   a. Nonpolar, interact with one another through dispersion (vander Waals) interactions.
   b. Alkenes are gases when they have fewer than 4 carbons.
   c. Are not soluble in water.

B. **Chemical properties**

1. The presence of the double bond makes alkenes more reactive than alkanes.
   a. For this reason the double bond is thought of as a function group.

2. In particular, they readily undergo addition reactions
   a. Addition of halogens, *halogenation*
   b. Addition of hydrogen, *hydrogenation*
   c. Addition of hydrogen halides
      i. *Markovnikov’s Rule* – The hydrogen becomes attached to the carbon that already has more hydrogens, “The rich get richer”
   d. Addition of water
      i. Catalyzed with sulfuric acid, H\_2SO\_4.
      ii. Important step in glycolysis involves addition of water

V. **Alkynes**

A. Involves a triple bond
   1. *sp* hybridization.

B. Chemical and physical properties are like the alkenes.

C. Are chemically reactive.

D. Are not common in biological systems.
VI. Aromatic Compounds and the Benzene Structure
   A. Aromatic classification was originally based on the odors that this group of molecules produced.
   B. Not all aromatic molecules, however, have aromas.
   C. Aromatic molecules contain rings of carbon where carbons are $sp^2$ hybridized.
   D. We will focus primarily on derivatives of the aromatic compound, benzene.
   E. Benzene
      1. Is a six carbon ring that can be represented as having alternating double and single bonds
         a. All carbons are $sp^2$ hybridized.
      2. Unlike alkenes, though, these double bonds are very stable.
         a. Chemically, aromatic compounds are more like alkanes.
      3. Kekulé structure
         a. The $\pi$-bond is distributed over the entire molecule.

VII. Nomenclature of Benzene Derivatives
   A. Naming of Benzene derivative
      1. IUPAC
         a. Ethylbenze
         b. Nitrobenzene
         c. Bromobenzene
         d. Chlorobenzene
      2. Common names for some derivatives
         a. Toluene
         b. Phenol
         c. Aniline
         d. Benzoic acid
      3. When benzene is a group it is called a phenyl group.
      4. Multiple substituents
         a. ortho
         b. meta
         c. para

VIII. Properties and uses of Aromatic Compounds

  Table 12.4 – Some Important Aromatic Compounds