Chapter 6. Alkenes

Alkenes -

Degrees of Unsaturation

ethane

ethylene (or ethene)

“unsaturated”

Because of its double bonds, an alkene has ___________ ____________ than the corresponding alkane.

\[
\text{Example: } C_6H_{10} \\
\text{Compare to the saturated alkane: } \ldots \ldots \text{ Degrees of unsaturation: } \ldots \ldots
\]

Important: Each degree of unsaturation corresponds to _____ ______________ fewer than those of a saturated alkane.

Important: For each degree of unsaturation, a molecule will either have a ___________ or a _____ ________.

Example: Draw the structure of naphthalene. Determine the molecular formula without counting hydrogens.
To determine the degrees of unsaturation, follow these two steps:

1) Determine the formula of the ______________________.
2) Compare that formula to the ______________________ (C\textsubscript{n}H\textsubscript{2n+2})

To get the ______________________ for compounds with elements other than C and H:

1. **Organohalogen compounds**

   \[ C\textsubscript{2}H\textsubscript{5}Br \]

   \[ C\textsubscript{6}H\textsubscript{5}Br\textsubscript{2} \]

2. **Organooxygen compounds**

   acetic acid, \[ C\textsubscript{2}H\textsubscript{4}O\textsubscript{2} \]

   diethylether, \[ C\textsubscript{4}H\textsubscript{10}O \]

3. **Organonitrogen compounds**

   dimethylamine, \[ C\textsubscript{2}H\textsubscript{7}N \]
Examples from previous exams:

1. The molecular formula of diazepam (Valium) is C\textsubscript{16}H\textsubscript{13}N\textsubscript{2}OCl. Calculate the degree of unsaturation in this compound.

2. Calculate the degree of unsaturation in C\textsubscript{10}H\textsubscript{10}Br\textsubscript{2}ClNO\textsubscript{2}.

3. What is the degree of unsaturation in C\textsubscript{9}H\textsubscript{16}Cl\textsubscript{3}NO?
   a) 1
   b) 2
   c) 3
   d) 4
   e) 5

4. What is the degree of unsaturation in C\textsubscript{12}H\textsubscript{16}N\textsubscript{2}O\textsubscript{2}?
   a) 3
   b) 4
   c) 5
   d) 6
   e) 7

5. Calculate the degree of unsaturation in C\textsubscript{7}H\textsubscript{5}N\textsubscript{3}O\textsubscript{6}.
   a) 3
   b) 4
   c) 5
   d) 6
   e) 7

6. A compound of formula C\textsubscript{12}H\textsubscript{15}Br contains two rings. How many molar equivalents of hydrogen does it absorb if all the remaining unsaturations are double bonds?
   a) 2
   b) 3
   c) 4
   d) 5
   e) 6

7. Compound A has the formula C\textsubscript{10}H\textsubscript{14}. On catalytic hydrogenation over palladium, it reacts with 2 molar equivalents of H\textsubscript{2}. How many rings does compound A have?
   a) 0
   b) 1
   c) 2
   d) 3
   e) not enough information to determine

Alkene Nomenclature

1. Find the ____________________________________________________________________________.

2. Number the chain beginning at the end ____________________________.

3. Indicate the position of the double bond by giving the number of the ____________________.

4. If more than one double bond:

5. Be able to name an alkene group as a substituent (called an *alkenyl* group):
Cis-trans Stereoisomers

This type of isomerism results because of ________________________________.

In general, an alkene can exhibit cis-trans stereoisomerism unless

cis-2-butene  trans-2-butene  trans-3,4-dimethyl-3-heptene  2-methyl-2-butene

Question: Which of the following cannot exist as cis and trans isomers?

a) $\text{CH}_3\text{C} \equiv \text{CCH}_3$  
   $\text{Cl} \quad \text{CH}_2\text{CH}_3$  

b) $\text{CH}_3\text{CH}_2\text{CHCl} \equiv \text{CHCH}_3$

c) $(\text{CH}_3)_2\text{C} \equiv \text{CHCH}_3$

d) $\text{Cl} \quad \text{CH}_3\text{CH} \equiv \text{Cl}$
The Cahn-Ingold-Prelog Rules: E,Z Nomenclature of Alkenes

The terms "cis" and "trans" do not always work:

\[
\begin{align*}
&\text{Br} \quad \text{CH}_3 \\
&\text{Cl} \quad \text{H} \\
&\text{Cl} \quad \text{Br} \\
&\text{H}_3\text{C} \quad \text{CH}_2\text{CH}_3
\end{align*}
\]

To determine which group/substituent has the highest priority:

1. The number one priority rule: ____________________  ____________________

2. You must look at ______________ at a time, to the ______________ of difference.
   Remember to count ____________________________.

3. If the two high priority substituents are on the same side, use ____________.
   If they are on opposite sides, use ____________.

Mnemonic:

**Examples from previous exams:**

1. Determine E or Z for each of the following:

   \[
   \begin{align*}
   &\text{H} \quad \text{C} = \text{C} \\
   &\text{H}_3\text{C} \quad \text{CH}_3 \\
   &\text{H} \quad \text{C} = \text{Cl} \\
   &\text{H}_3\text{C} \quad \text{CH}_3 \\
   &\text{H} \quad \text{C} = \text{H} \\
   &\text{H}_3\text{C} \quad \text{HCH}_2\text{CH}_2\text{CH}_3
   \end{align*}
   \]

2. Which of the following does not have a Z configuration?

   a) \[
   \begin{align*}
   &\text{CH}_3\text{O} \quad \text{C} = \text{C} \\
   &\text{CH}_3\text{C} \quad \text{CH}_2\text{CH}_3
   \end{align*}
   \]
   b) \[
   \begin{align*}
   &\text{CH}_3 \quad \text{C} = \text{C} \\
   &\text{CH}_3\text{CH}_2\text{CH}_3
   \end{align*}
   \]
   c) \[
   \begin{align*}
   &\text{CH}_3\text{O} \quad \text{C} = \text{C} \\
   &\text{CH}_3\text{C} \quad \text{CH}_2\text{CH}_3
   \end{align*}
   \]
   d) \[
   \begin{align*}
   &\text{CH}_3 \quad \text{C} = \text{C} \\
   &\text{CH}_3\text{Cl}
   \end{align*}
   \]

3. Assign an E or Z designation to the double bond indicated below.

\[
\begin{align*}
&(\text{CH}_3)_2\text{CHCH}_2 \\
&(\text{CH}_3)_2\text{CH}
\end{align*}
\]
4. Rank the following sets of substituents in order of priority according to the Cahn-Ingold-Prelog sequence rules. Place the highest priority substituent first and place the lowest priority substituent last.

\[
\begin{align*}
&\text{CH}_2\text{CH}_2\text{CH}_3 \\
&\text{CH}_2\text{CCH}_3 \\
&\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \\
&\text{CH}_3\text{CH}_3 \\
\end{align*}
\]

\[
\begin{align*}
&\text{I} \\
&\text{II} \\
&\text{III} \\
&\text{IV} \\
\end{align*}
\]

a) II > III > IV > I
b) II > III > I > IV
c) I > II > IV > III
d) IV > I > II > III
e) III > II > I > IV

5. Consider the compound below. Which term best describes the stereochemistry about the indicated double bond of this molecule?

\[
\begin{align*}
&\text{H}_2\text{C} = \text{CH} \\
&\text{C} = \text{C} \\
&\text{(H}_3\text{C})_3\text{C} \\
&\text{C(CH}_3)_3 \\
\end{align*}
\]

a) E 
 b) Z 
 c) cis 
 d) trans 
 e) none of these terms is appropriate