SECTION 5 – STRUCTURE AND REACTIVITY OF ALKENES

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- Alkenes ("olefins") = hydrocarbons with one or more double-bonds (d.b.'s).

\[ C=C \rightarrow 1 \sigma \text{-bond and 1 } \pi \text{-bond} \]
\[ \rightarrow \text{double-bonds are shorter and stronger than single-bonds} \]

\[ \text{lengths:} \]
\[ \text{d.b.} = 1.33 \text{Å} \]
\[ \text{s.b.} = 1.54 \text{Å} \]
\[ (1 \text{Å} = 1 \times 10^{-10} \text{m}) \]

- Strength of a \( C=C \) d.b. \( \Rightarrow \) 145-150 kcal/mol
  (\( \sigma \) and \( \pi \) combined) \( \leq \) 80-85 kcal/mol (C-C \( \sigma \)-bond).

\[ \text{Stereoisomerism:} \]
\[ \text{trans} \]
\[ \text{cis} \]

\[ \text{the energy-barrier (E_a) is too high at room temp. to rotate 1 end by 180°.} \]

\[ \text{Nomenclature of Alkenes.} \]

\[ \text{name of principal (main) chains or rings contain "-ene" endings.} \]

\[ \text{ex: } H_2C=CH_2 \quad \text{IUPAC} \quad \text{COMMON NAME} \]
\[ \text{ethene} \quad \text{ethylene} \]

\[ \text{ex: } H_2C=CH-CH_3 \quad \text{propene} \quad \text{propylene} \]
**6 Rules for Naming Alkenes.**

1. Chains numbered from an end such that the d.b. gets the lowest locator number, specifying the first carbon of the d.b.
   
   **ex:** \( \text{CH}_2=\text{CH}-\text{CH}_2-\text{CH}_3 \rightarrow 1\text{-butene} \)
   
   **ex:** \( \text{CH}_3-\text{CH}=\text{CH}-\text{CH}_3 \rightarrow 2\text{-butene} \)

2. If 2 or more d.b.'s are present, number the main chain so that the d.b.'s get the lowest #’s overall.

   * endings (suffixes) \( \Rightarrow -\text{diene}, -\text{triene}, \) and \(-\text{tetraene} \)

   **ex:** \( 1,3,7\text{-octatriene} \)
   
   (NOT: \( 1,5,7\text{-octatriene} \))

   **ex:** \( 1,3\text{-cyclopentadiene} \)

- **1st priority**: principal (main) chain is the one with the most d.b.'s. It's not simply the longest chain!

- **Tiebreaker**: if 2 or more chains have the same # of d.b.'s, choose the longest chain.

**Example:**

\[
\begin{array}{c}
\text{Ex:} \\
\begin{array}{c}
\text{branch} \\
\end{array}
\end{array}
\]

\[\Rightarrow 2\text{-propyl-1,5-hexadiene}\]

**Example:**

\[
\begin{array}{c}
\text{Ex:} \\
\end{array}
\]

\[\Rightarrow 3\text{-ethylcyclopentene}\]

**Notes:** no need to specify "1" for the alkene location, it's implied.

4. Alkenal Substituents (Branches).

- "alkenes as branches"
- change "-ene" ending to "-enyl" ending

a) number the branch from its point of attachment to the main chain.

b) specify branch #’s with a locator #.

* examples on the next page...
-CH = CH₂  |  IUPAC: ethenyl  |  COMMON NAME: vinyl  
CH₂-CH = CH₂  |  -2-propenyl  |  allyl  
CH = CH-CH₃  |  -1-propenyl  |  (none)  

\[ \text{ex:} \quad \begin{array}{c}
5 \quad \begin{array}{c}
4 \quad 1 \quad 3 \quad 2 \quad 3' \quad 2' \quad 4'
\end{array}
\end{array} \quad \rightarrow \quad 3-(1\text{-butenyl})\text{cyclopentene} \]

\[ \text{ex:} \quad \begin{array}{c}
5 \quad \begin{array}{c}
6 \quad 3 \quad 4 \quad 2 \quad 5'
\end{array}
\end{array} \quad \rightarrow \quad \begin{array}{c}
1-(2\text{-propenyl})-1,4\text{-cyclohexadiene}
\end{array}\quad \text{or} \quad \begin{array}{c}
1\text{-allyl}-1,4\text{-cyclohexadiene}
\end{array} \]

5. Stereoisomerism = possible if and only if each of the d.b. C's has 2 different things attached.

\[ \begin{array}{c}
\text{CH₃} \quad \text{CH₂CH₃}
\end{array} \quad \begin{array}{c}
\text{C=CH₂CH₃}
\end{array} \quad \begin{array}{c}
\text{CH₃} \quad \text{C=CH₂CH₃}
\end{array} \quad \begin{array}{c}
\text{C=CH₂CH₃}
\end{array} \quad \begin{array}{c}
\text{CH₃} \quad \text{C=CH₂CH₃}
\end{array} \]

\[ \text{cis-2-pentene} \quad \text{trans-2-pentene} \]

\[ \text{cis} = "\text{similar groups" on the same side.} \]
\[ \text{trans} = "\text{similar groups" on the opposite side.} \]

*note:  \[ \begin{array}{c}
\text{H} \quad \text{CH₃}
\end{array} \quad \rightarrow \quad \text{cis/trans unclear here, so see rule 6 on the next page...} \]
Priority System within Nomenclature.

- assign high and low priorities to groups or atoms attached to each double-bond (d.b.).

\[ \text{high } C = C \text{ high} \Rightarrow \text{Z-configuration (together)} \]

\[ \text{low } C = C \text{ low} \Rightarrow \text{E-configuration (opposite)} \]

* unimportant, but: \[ Z = \text{Zusammen} \Rightarrow \text{German words} \]

- highest priority substituents \( \Rightarrow \) atom with the highest atomic #

1st tiebreaker \( \Rightarrow \) list atoms attached to the atoms in (1) above in order of decreasing atomic #, and compare until first point of difference

2nd tiebreaker \( \Rightarrow \) move to first atom of the list and repeat.

\[ \text{ex: } C \text{ higher priority than } H \]

\[ \text{ex: } C \text{ (C,C,H) } \Rightarrow \text{this branch has highest priority} \]

\[ \text{zipped together on the next page...} \]
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