5.5
Physical Properties of Alkenes
Dipole moments

What is direction of dipole moment?
Does a methyl group donate electrons to the double bond, or does it withdraw them?

\[
\mu = 0 \text{ D}
\]

\[
\mu = 0.3 \text{ D}
\]
Chlorine is electronegative and attracts electrons.

Dipole moments

\[ \mu = 1.4 \text{ D} \]

\[ \mu = 0 \text{ D} \]

\[ \mu = 0.3 \text{ D} \]
Dipole moment of 1-chloropropene is equal to the sum of the dipole moments of vinyl chloride and propene.

\[ \mu = 1.4 \text{ D} \]

\[ \mu = 1.7 \text{ D} \]

\[ \mu = 0.3 \text{ D} \]
Therefore, a methyl group donates electrons to the double bond.
Alkyl groups stabilize sp$^2$ hybridized carbon by releasing electrons.

$\text{R-C}^+\quad$ is more stable than $\text{H-C}^+$

$\text{R-C}^\cdot\quad$ is more stable than $\text{H-C}^\cdot$
Alkyl groups stabilize sp² hybridized carbon by releasing electrons.

- $R-C^+$ is more stable than $H-C^+$
- $R-C^-$ is more stable than $H-C^-$
- $R-C$ is more stable than $H-C$
5.6
Relative Stabilities of Alkenes
Double bonds are classified according to the number of carbons attached to them.

monosubstituted

R
\[
\begin{array}{c}
\text{C} \\
\text{R} \\
\text{H} \\
\text{H} \\
\text{H}
\end{array}
\]

disubstituted

R
\[
\begin{array}{c}
\text{C} \\
\text{R} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{R'}
\end{array}
\]

disubstituted

R
\[
\begin{array}{c}
\text{C} \\
\text{R} \\
\text{H} \\
\text{H} \\
\text{R'}
\end{array}
\]

R
\[
\begin{array}{c}
\text{C} \\
\text{R} \\
\text{H} \\
\text{H} \\
\text{R'}
\end{array}
\]
Double bonds are classified according to the number of carbons attached to them.

- **Trisubstituted**: $\text{R'R''}$
- **Tetrasubstituted**: $\text{R'R'''}$
Substituent Effects on Alkene Stability

Electronic

disubstituted alkenes are more stable than monosubstituted alkenes

Steric

trans alkenes are more stable than cis alkenes
Figure 5.4 Heats of combustion of \( \text{C}_4\text{H}_8 \) isomers.

\[
\text{C}_4\text{H}_8 + 6\text{O}_2 \rightarrow 4\text{CO}_2 + 8\text{H}_2\text{O}
\]

- 2717 kJ/mol
- 2710 kJ/mol
- 2707 kJ/mol
- 2700 kJ/mol
Electronic

alkyl groups stabilize double bonds more than H

more highly substituted double bonds are more stable than less highly substituted ones.
Problem 5.8

Give the structure or make a molecular model of the most stable C$_6$H$_{12}$ alkene.
Give the structure or make a molecular model of the most stable $\text{C}_6\text{H}_{12}$ alkene.

\[
\begin{align*}
\text{H}_3\text{C} & \quad \text{CH}_3 \\
\text{C} & \quad \text{C} \\
\text{H}_3\text{C} & \quad \text{CH}_3
\end{align*}
\]
Steric effects

*trans* alkenes are more stable than *cis* alkenes

*cis* alkenes are destabilized by van der Waals strain
van der Waals strain due to crowding of cis-methyl groups

*Figure 5.5*

* cis and trans-2-Butene

* cis-2-butene

* trans-2-butene*
van der Waals strain due to crowding of cis-methyl groups

Figure 5.5

cis and trans-2-Butene

cis-2-butene

trans-2-butene
Steric effect causes a large difference in stability between cis and trans-(CH₃)₃CCH=CHC(CH₃)₃

cis is 44 kJ/mol less stable than trans
5.7
Cycloalkenes
Cyclopropene and cyclobutene have angle strain.

Larger cycloalkenes, such as cyclopentene and cyclohexene, can incorporate a double bond into the ring with little or no angle strain.
Stereoisomeric cycloalkenes

cis-cyclooctene and trans-cyclooctene are stereoisomers

cis-cyclooctene is 39 kJ/ mol more stable than trans-cyclooctene
cis-cyclooctene and trans-cyclooctene are stereoisomers.

* cis-cyclooctene is 39 kJ/ mol more stable than trans-cyclooctene.*

---

**Stereoisomeric cycloalkenes**

- **cis-cyclooctene**
- **trans-cyclooctene**
**Stereoisomeric cycloalkenes**

*trans*-cyclooctene is smallest *trans*-cycloalkene that is stable at room temperature

* cis* stereoisomer is more stable than *trans* through \( C_{11} \) cycloalkenes

* cis* and *trans*-cyclododecene are approximately equal in stability
Stereoisomeric cycloalkenes

*trans*-cyclooctene is smallest *trans*-cycloalkene that is stable at room temperature

* cis* stereoisomer is more stable than *trans* through C₁₁ cycloalkenes

* cis* and *trans*-cyclododecene are approximately equal in stability
**Stereoisomeric cycloalkenes**

*trans*-cyclooctene is smallest *trans*-cycloalkene that is stable at room temperature

* cis* stereoisomer is more stable than *trans* through C$_{11}$ cycloalkenes

* cis* and *trans*-cyclododecene are approximately equal in stability

When there are more than 12 carbons in the ring, *trans*-cycloalkenes are more stable than *cis*. The ring is large enough so the cycloalkene behaves much like a noncyclic one.