CHAPTER SUMMARY

8.1 Introduction

Although organic halogen compounds are rarely found in nature, they do have a variety of commercial applications including use as insecticides, herbicides, dry-cleaning agents and degreasers, aerosol propellants and refrigerants, and important polymers.

8.2 Structure, Nomenclature, and Physical Properties

A. Structure and Properties

Alkyl halides are organic halogen compounds in which one or more hydrogens of a hydrocarbon have been replaced with a halogen. These compounds can be classified as primary, secondary, or tertiary depending on whether there are one, two, or three carbons respectively connected to the carbon bearing the halogen. In aryI halides the halogen is directly attached to a benzene or other aromatic hydrocarbon ring and in benzylic halides, the halogen is on a carbon directly
attached to a benzene ring. If the halogen is directly attached to a carbon-
carbon double bond, it is termed \textit{vinyl}, and if it is attached to a carbon
directly attached to the double bond it is \textit{allylic}.

Alkyl halides are generally \textit{water insoluble} and have a \textit{greater
density} than water. Their \textit{boiling points increase with molecular
weight}; alkyl iodides have higher boiling points than the corresponding
alkyl bromides which boil at higher temperatures than the chlorides.

\textbf{B. IUPAC Nomenclature}

IUPAC \textit{nomenclature} involves using the prefixes fluoro, chloro,
bromo, and iodo to designate halogen in a molecule.

\textbf{C. Common Nomenclature}

A “salt-type” nomenclature is frequently used with alkyl halides in
which the alkyl group’s name precedes the name of the halide. In
addition, halogen derivatives of methane have familiar non-systematic
names.

\textbf{8.3 Preparations of Organic Halogen Compounds}

\textbf{A. Free-Radical Halogenation of Alkanes}
\textbf{B. Addition to Alkenes and Alkynes}
\textbf{C. Electrophilic Aromatic Substitution}
\textbf{D. Conversion of Alcohols to Alkyl Halides}

\textbf{CONNECTIONS 8.1 Drug Design}

\textbf{8.4 Nucleophilic Substitution}

\textbf{A. General Reaction}

A characteristic reaction of alkyl halides is \textit{nucleophilic
substitution}. In this reaction, a \textit{nucleophile (Lewis base)} replaces a
halide ion, the \textit{leaving group}. Chloride, bromide, and iodide are
effective leaving groups; common negative nucleophiles include \( \text{OH}^- \), \( \text{SH}^- \), \( \text{NH}_2^- \), and their derivatives, as well as cyanide and acetylide ions.

**B. Nucleophilic Substitution with Neutral Nucleophiles**
Neutral nucleophiles include water, alcohols, and amines. These substances replace a leaving group such as halide ion; the product is a cationic salt that can be neutralized in some cases.

**C. Introduction to Nucleophilic Substitution Reaction Mechanisms**
There are two general nucleophilic substitution reaction mechanisms: (1) a one step process in which the nucleophile enters at the same time the leaving group exits \( (S_N^2) \) and (2) a two step process in which the leaving group departs and then the nucleophile enters \( (S_N^1) \).

**D. The \( S_N^2 \) Mechanism**
The \( S_N^2 \) mechanism is a one step process involving both the alkyl halide and nucleophile simultaneously. The nucleophile enters as the halide leaves, attacking the carbon from the side opposite to that from which the halide departs. The reaction is **bimolecular**; this means the reaction rate depends on the concentrations of both the alkyl halide and the nucleophile. The reaction involving optically active halides occurs with **inversion of configuration**.

**E. The \( S_N^1 \) Mechanism**
The \( S_N^1 \) mechanism is a two step process. In the first step the negative halide ion departs leaving a **carbocation intermediate**. In the second step the carbocation is neutralized by the nucleophile. \( S_N^1 \) reactions commonly occur in neutral or acid conditions with neutral nucleophiles. The reaction rate is dependent on the slow step, carbocation formation from the alkyl halide, and is termed **unimolecular**. Reaction of an optically active alkyl halide by \( S_N^1 \) results in the formation of a pair of enantiomers, an **optically inactive racemic mixture**, since the intermediate carbocation can be attacked from either side by the nucleophile.
F. Factors Influencing the Reaction Mechanism: 
\( S_N2 \) versus \( S_N1 \)

Several factors influence whether a reaction will occur by an \( S_N1 \) or \( S_N2 \) mechanism: **carbocation stability, steric effects, strength of nucleophile, and the solvent.** **Tertiary halides** tend to react by the \( S_N1 \) process because they can form the relatively stable tertiary carbocations and because the presence of three large alkyl groups sterically discourages attack by the nucleophile on the carbon-halogen bond. The \( S_N2 \) reaction is favored for **primary halides** because it does not involve a carbocation intermediate (primary carbocations are unstable) and because primary halides do not offer as much steric hindrance to attack by a nucleophile as do the more bulky tertiary halides. **Strong nucleophiles** favor the \( S_N2 \) mechanism and **polar solvents** promote \( S_N1 \) reactions.

G. \( S_N1 \) and \( S_N2 \): A Summary

1. **Reaction:** Both \( S_N1 \) and \( S_N2 \) reactions are simple substitution in which a nucleophile replaces a leaving group.
2. **Mechanism:** An \( S_N2 \) reaction proceeds by a one-step mechanism involving a five-centered transition state. An \( S_N1 \) reaction is a two-step process with a carbocation intermediate.
3. **Reaction Rates:** \( S_N2 \) reactions are bimolecular; the reaction rate depends on the concentrations of both the alkyl halide and the nucleophile. \( S_N1 \) reactions are unimolecular; the rate depends on the slowest of the two steps, the one in which the carbocation intermediate is formed.
4. **Stereochemistry:** \( S_N2 \) reactions involving optically active halides produce optically active products but with inversion of configuration of the chiral carbon atom bearing the halogen; attack by the nucleophile occurs on the opposite side from that the halide is leaving. \( S_N1 \) reactions proceed by a carbocation intermediate that can be attacked by the nucleophile from either side; a racemic mixture results.
5. **Structure and Reactivity:** \( S_N1 \) reactions are favored by bulky alkyl halides that form stable carbocations. Just the opposite is true for \( S_N2 \) reactions. Consequently, \( 3^0 \) halides usually react by an \( S_N1 \) mechanism, \( 1^0 \) by an \( S_N2 \), and \( 2^0 \) by either depending on specific factors.
6. **Nucleophiles**: Strong nucleophiles favor S<sub>N</sub>2 reactions.

7. **Solvent**: Polar solvents with unshared electron pairs such as water and alcohols favor S<sub>N</sub>1 reactions.

### 8.5 Elimination Reactions of Alkyl Halides

Alkyl halides undergo **dehydrohalogenation** reactions in which **elimination** of a hydrogen and halogen from adjacent carbons produces a double bond.

**A. The E<sub>2</sub> and E<sub>1</sub> Mechanisms**

The elimination reaction mechanisms are analogous to those of nucleophilic substitution.

**B. Comparison of E<sub>2</sub> and E<sub>1</sub> Reactions**

The **E<sub>2</sub>** mechanism is a concerted one-step process in which a nucleophile abstracts a hydrogen ion from one carbon while the halide is leaving from an adjacent one. The **E<sub>1</sub>** mechanism is two-steps and involves a **carbocation intermediate** formed upon departure of the halide ion in the first step. **E<sub>2</sub>** reactions are **bimolecular** and the reaction rate depends on the concentrations of both the alkyl halide and nucleophile. **E<sub>1</sub>** reaction rates depend on the slowest step, formation of the carbocation, and are influenced only by the concentration of the alkyl halide; the reaction is **unimolecular**. **E<sub>2</sub>** reactions involve **anti elimination** and produce a specific alkene, either cis or trans. **E<sub>1</sub>** reactions involve an intermediate carbocation and thus give products of both **syn and anti elimination**.

### 8.6 Substitution versus Elimination

**Nucleophilic substitution and elimination** are competitive processes. Which prevails depends on a variety of factors. One important consideration is the stability of the alkene that would result from elimination. Since tertiary halides form the more stable highly substituted alkenes, they are more likely to react by elimination than primary halides.
8.1 **Nomenclature**
(a) 2-chloropentane; (b) 1,4-dibromo-2-butene; (c) p-difluorobenzene;
(d) 1,1,1-trichloro-2,2-difluoroethane

8.2 **Nomenclature**
(a) CBr_4; b) CH_2Br_2; (c) CHI_3; (d) CH_2=CHBr;
(e) O_2N—CH_2Cl; f) CH_3CHCH_3

8.3 **Nucleophilic Substitution**
CH_3I + reagents in a-i ——> 
(a) CH_3OH; (b) CH_3OCH_2CH_2CH_3; (c) CH_3SH; (d) CH_3SCH_3;
(e) CH_3NH_2;
(f) CH_3NHCH_2CH_3; g) CH_3N(CH_3)_2; h) CH_3CN; i) CH_3C=CCH_3

8.4 **Nucleophilic Substitution**
(a) CH_3CH_2CH_2Br + NaCN ———> CH_3CH_2CH_2CN + NaBr
(b) CH_3CH_2CH_2CH_2Cl + NaOH ———> CH_3CH_2CH_2CH_2OH + NaCl
(c) CH_3I + NaSCH_3 ———> CH_3SCH_3 + NaI

8.5 **Nucleophilic Substitution**
(a) CH_3CHCH_2CH_3 (b) CH_3CHCH_2CH_3 (c) CH_3CHCH_2CH_3

8.6 **SN2 Mechanism**
8.7 Reaction Rates

(a) 3x  (b) 4x  (c) 6x

8.8 Reaction Rate Equations

\[
\text{Rate} = k \text{ (bromomethane) (NaOH)} \quad \text{Rate} = K \text{ (2-chloropentane) (NaSCH}_3\text{)}
\]

8.9 $S_N^2$ Mechanism with Stereochemistry

![S_N^2 Mechanism Diagram]

Pure enantiomer; optically active.

Transition state showing nucleophile attacking from opposite side of leaving bromide

Pure enantiomer; optically active; inverted mirror image configuration

8.10-8.11 Inversion of Configuration

(a) $S \xrightarrow{\text{CH(C}_3\text{)}_2} R \text{ CH(C}_3\text{)}_2$

\[
\text{H}_3C\xrightarrow{\text{C}}\text{I} + \text{NaOH} \rightarrow \text{HO} \xleftarrow{\text{C}}\text{CH}_3
\]

(b) $S \xrightarrow{\text{CH}_2\text{CH}_3} R \text{ CH}_2\text{CH}_3$

\[
\text{Br} \xrightarrow{\text{C}}\text{H} + \text{NaOCH}_3 \rightarrow \text{H} \xleftarrow{\text{C}}\text{OCH}_3
\]

8.12 Nucleophilic Substitution

\[
\text{CH}_3\xrightarrow{\text{Cl}}\text{CH}_2\text{CH}_2\text{CH}_3 + \text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{CH}_3\xrightarrow{\text{OCH}_2\text{CH}_3}\text{CH}_2\text{CH}_2\text{CH}_3 + \text{HCl}
\]
8.13 $S_N 1$ Mechanism

$\text{CH}_3 \text{CCH}_2\text{CH}_3 \text{Cl} \rightarrow \text{CH}_3 \text{CCH}_2\text{CH}_3 ^+ \text{Cl}^-$ → $\text{CH}_3 \text{CCH}_2\text{CH}_3 \text{CH}_3\text{OH}$

8.14 Reaction Rate Equation
Rate = $k$ (2-chloro-2-methylbutane)

8.15 Reaction Rates
(a) no effect  (b) 2x  (c) 4x  (d) 3x

8.16 $S_N 1$ and $S_N 2$ Reaction Mechanisms
(a) $S_N 1$

Pure enantiomer; optically active.

Nucleophile attacks planar carbocation equally from either side

Both inversion and retention of configuration occur equally. A pair of enantiomers is the result. This is an optically inactive racemic mixture.
(b) \( \text{S}_2\text{N} \) Mechanism

\[ \text{CH}_3\text{CH}_2\text{O} \rightleftharpoons \text{CH}_3\text{CH}_2\text{Cl} \]

Pure enantiomer; optically active.

Pure enantiomer; inversion of configuration

8.17 - 8.18 Racemization in \( \text{S}_1\text{N} \) Reactions

(a) \( \text{R} \) \( \text{CH} (\text{CH}_3)_2 \)

\[ \text{CH}_3 \text{C} \rightleftharpoons \text{I} + \text{H}_2\text{O} \rightarrow \text{CH}_3 \text{C} \rightleftharpoons \text{OH} \]

(b) \( \text{R} \) \( \text{CH}_2\text{CH}_3 \)

\[ \text{Br} \rightleftharpoons \text{H} + \text{CH}_3\text{OH} \rightarrow \text{CH}_3 \text{O} \rightleftharpoons \text{H} \]

8.19 \( \text{S}_1\text{N} \) Mechanism and Carbocation Stability

Tertiary carbocations are quite stable so tertiary halides tend to react by \( \text{S}_1\text{N} \) mechanisms since the mechanism involves carbocation intermediates. Primary carbocations are unstable and primary halides react by the \( \text{S}_2\text{N} \) mechanism in which there is no carbocation intermediate.
8.20 Steric Effects and SN2 Mechanisms
The primary bromide, 1-bromobutane, is less crowded around the reacting carbon and thus more accessible to the incoming nucleophile. The SN2 mechanism is likely to proceed faster in this case than with the more crowded secondary bromide.

8.21 Strength of Nucleophile
(a) CH₃O⁻ because it is negative; (b) NH₂⁻ because nitrogen is less electronegative than oxygen; (c) CH₃NH₂ because nitrogen is less electronegative than oxygen; (d) SH because it is negative and S is less electronegative than O; (e) CH₃CH₂SH because sulfur is less electronegative than oxygen.

8.22 Predicting Mechanisms
(a) SN2: the reactants are a primary halide and a strong, negative nucleophile.
(b) SN1: the reactants are a tertiary halide and a neutral nucleophile.

8.23 E₁ and E₂ Mechanisms

8.24 Rates of Elimination Reactions
(a) double the reaction rate for both; (b) doubles the rate of E₂ but has no influence on E₁. (c) quadruples the rate of E₂ and doubles that of E₁; (d) increases E₂ 12 times and E₁ three times.

8.25 Rates of Substitution Reactions
The answers are the same as those in problem 8.24.
8.26 Anti Elimination and $E_2$ Reactions

(a) Interchanging two groups on a chiral carbon produces the mirror image. Thus one interchange on the 3R carbon converts it to 3S.

$$\begin{align*}
3S, 4R
\end{align*}$$

(b) Interchanging two groups on the other carbon gives the mirror image configuration.

$$\begin{align*}
3S, 4S
\end{align*}$$

(c) from 3R, 4S

$$\begin{align*}
3R, 4S
\end{align*}$$

8.27 Syn and Anti Elimination

The $E_2$ reaction proceeds exclusively via anti elimination whereas the $E_1$ reaction is capable of both. Rotate the carbon-carbon bond to position for syn and anti elimination. Eliminate the H and Br as highlighted and then look down the axis from the front to back carbon and imagine a double bond has formed. Translate this into the products shown.
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**8.28 Williamson Synthesis**

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{Br} + \text{CH}_3\text{CHONa} & \rightarrow \text{CH}_3\text{CHOCH}_2\text{CH}_3 + \text{NaBr}
\end{align*}
\]

**8.29 IUPAC Nomenclature:** Section 8.2B

(a) 3-bromopentane;   (b) chloroethane;   (c) 1-iodopropane;
(d) 4,4-dimethyl-1,1,1-tribromopentane;
(e) 2,4,6-trichloroheptane;   (f) trans (or E) 5-bromo-6-methyl-2-heptene;
(g) 5-iodo-2-hexyne;   (h) meta bromochlorobenzene;

**8.30 Nomenclature:** Section 8.2B

a) CHCl₃  
 b) CH₂=CH—CH₂  
 c) CH₂—CH₂  
 d) CCl₄

\[
\begin{align*}
e) & \quad \text{Cl}\text{C}=&\text{C}\text{Cl} \\
f) & \quad \text{Cl}\text{C}=&\text{Cl}
\end{align*}
\]

**8.31 Common Nomenclature:** Section 8.2C

(a) CH₃Br ;   (b) CH₂Cl₂ ;   (c) CHBr₃ ;   (d) CF₄ ;   (e) CH₂=CHCH₂I ;
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8.32 Nucleophilic Substitution: Section 8.4A

a) CH₃CHCH₃  
   b) CH₃CN  
   c) CH₃CH₂SH

   d) CH₃CH₂CH₂NHCH₃  
   e) CH₃CH₂CN  
   f) CH₃CH₂CH₂SCH₃

   g) CH₂CH₂C≡CCH₃  
   h) CH₃NH₂

8.33 Nucleophilic Substitution: Section 8.4B

   a) CH₃CH₂CH₂CH₃  
   b) CH₃CH₂NCH₃  
   c) CH₃CH₂CH₂OCH₃

8.34 Williamson Synthesis of Ethers: Sections 8.4A and 8.6

The halogen can be Cl, Br, or I.

(a) CH₃CH₂CH₂ONa + CH₃CH₂Cl → CH₃CH₂CH₂OCH₂CH₃ + NaCl

(b) CH₃CHONa + CH₃CH₂Cl → CH₃CHOCH₂CH₃ + NaCl

8.35 Nucleophilic Substitution in Preparing Alkynes: Sections 5.8 and 8.4A

The halogen can be Cl, Br, or I.

a) HC≡CH  + NaNH₂ → HC≡CNa  + CH₃CH₂Br → HC≡CCH₂CH₃
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8.36 Nucleophilic Substitution: Section 8.4A

a) \( \text{CH}_2=\text{CHCH}_2\text{Br} + \text{NaSH} \rightarrow \text{CH}_2=\text{CHCH}_2\text{SH} + \text{NaBr} \)

b) \( \text{CH}_2=\text{CHCH}_2\text{SCH}_2\text{CH}=\text{CH}_2 \rightarrow \text{CH}_2=\text{CHCH}_2\text{SCH}_2\text{CH}+\text{NaBr} \)

c) \( \text{CH}_2=\text{C} \rightarrow \text{NaNH}_2 \rightarrow \text{CH}_2=\text{CNa} \rightarrow \text{CH}_2=\text{CCH}_2\text{CH}_3 \)

8.37 Synthesis: Section 8.4A

a) \( \text{CH}_3(\text{CH}_2)_8\text{Cl} + \text{NaNH}_2 \rightarrow \text{CH}_3(\text{CH}_2)_8\text{NH}_2 + \text{NaCl} \)

b) \( \text{CH}_3\text{CH}_2\text{Cl} + \text{NaSCH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{SCH}_3 + \text{NaCl} \)

c) \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} + \text{NaOH} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} + \text{NaBr} \)

8.38 \( S_N1 \) and \( S_N2 \) Mechanisms: Section 8.4G

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>( S_N1 )</th>
<th>( S_N2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate Expression</td>
<td>( \text{Rate} = k(\text{RX}) )</td>
<td>( \text{Rate} = k(\text{RX})(\text{Nu}) )</td>
</tr>
<tr>
<td>Reaction Intermediate</td>
<td>Carbocation (two steps)</td>
<td>None (one step)</td>
</tr>
<tr>
<td>Stereochemistry</td>
<td>Racemization: inversion and retention.</td>
<td>Inversion of configuration</td>
</tr>
<tr>
<td>Relative Reaction Rates of Alkyl Halides</td>
<td>( 3^\circ &gt; 2^\circ &gt; 1^\circ )</td>
<td>( 1^\circ &gt; 2^\circ &gt; 3^\circ )</td>
</tr>
<tr>
<td>Effect of Increasing Nucleophile Concentration</td>
<td>None, reaction rate is independent of the nucleophile</td>
<td>Reaction rate is increased</td>
</tr>
<tr>
<td>Effect of Increasing Alkyl Halide Concentration</td>
<td>Reaction rate is increased</td>
<td>Reaction rate is increased</td>
</tr>
</tbody>
</table>
Effect of Polar Solvent | Increases rate of reaction and likelihood of $S_N^1$ | Decreases rate and likelihood of $S_N^2$
---|---|---
Effect of Non-Polar Solvent | Decreases rate and likelihood of $S_N^1$ | Increases rate and likelihood of $S_N^2$
Effect of Bulky Groups at Reaction Center | Favors $S_N^1$ as crowding decreased in carbocation | Disfavors $S_N^2$ as transition state is more crowded (pentavalent)
Strength of the Nucleophile | Disfavors $S_N^1$ | Favors $S_N^2$

8.39 Nucleophilic Substitution Mechanisms: Section 8.4G

8.40 Elimination Reactions: Sections 4.5 and 8.5

(a) CH$_3$CH=CH$_2$ (b) CH$_3$CH=CHCH$_2$CH$_3$ (c) CH$_3$CH=CHCH$_2$CH$_3$
8.41 Elimination Reaction Mechanisms:  Section 8.5

STEP 1: Bromide departs and is solvated by the aqueous ethanol solvent. A carbocation intermediate results.

STEP 2: Hydroxide abstracts the hydrogen ion to complete the elimination. The carbocation is neutralized, the double bond forms.

This is a concerted one-step mechanism in which bonds are breaking and new bonds forming all at once.

8.42 S_N1 and S_N2 Stereochemistry:  Section 8.4 D.2 and E.2

a) Br\textsuperscript{-} + CH\textsubscript{3}SH $\rightarrow$ CH\textsubscript{3}S\textsuperscript{+} + CH\textsubscript{3}SH

b) CH\textsubscript{3}Cl + NaNH\textsubscript{2} $\rightarrow$ H\textsubscript{2}N$\textsuperscript{+}$ + CH\textsubscript{3}
8.43 \textbf{S}N\textsubscript{1} and \textbf{S}N\textsubscript{2} \textbf{Stereochemistry}: Sections 8.4D.1 and E.1
\S_N2 reactions proceed with inversion of configuration. Since both starting materials were optically active, the products are also optically active.

8.44 \textbf{E}1 and \textbf{E}2 \textbf{Stereochemistry}: Section 8.5

8.45 \textbf{E}1 and \textbf{E}2 \textbf{Stereochemistry}: Section 8.5
First draw the compound without stereochemistry. Then we will convert it to a Newman projection with the 2R, 3S configuration. This is most easily done by drawing an eclipsed Newman projection and putting the two low priority groups down and placing the others to conform to the stated configuration. Finally, rotate the Newmans to syn and anti elimination and draw the products.

\textbf{E}2: anti elimination only
\textbf{E}1: both syn and anti eliminations are possible
Another configuration that will produce the cis isomer.

Two configurations that will produce the trans isomer.
8.46  $E_1$ and $E_2$ Stereochemistry:  Sections 4.5B and 8.5

$E_2$ reactions proceed by anti elimination. The only anti possibility is shown and it does not give the most stable product (Saytzeff).

$E_1$ reactions proceed by syn or anti elimination. The syn shown gives the most stable alkene (Saytzeff).

8.47  Nucleophilic Substitution Reactions:  Section 8.4D.2

This first reaction is an $S_n$2 reaction as a result of the strong nucleophile. $S_n$2 reactions proceed with inversion of configuration so the product will be trans 1-ethoxy-2-methylcyclopentane. The $S_n$1 reaction involves a carbocation intermediate that can be attacked from either side and consequently the cis and trans products are formed.


8.48 E₂ Elimination

(a) The chair shown has two possibilities for anti elimination. The more substituted Saytzeff Rule product predominates as it is more stable.

(b) The chair shown here has only one possibility for anti elimination and that product forms exclusively despite the fact that it is not the most substituted. You may notice that both groups are axial. Actually the diequatorial conformer is more stable and preferred but E₂ elimination occurs only on the small amount that exist at any one time in the diaxial conformation.
8.49 **Nucleophilic Substitution Reactions:** Section 8.4F

These are both primary halides and because they do not form stable carbocations and because they are relatively unhindered sterically, they react by $S_N2$.

The tertiary halide on the left is hindered to attack by a nucleophile but forms a stable carbocation. Consequently it reacts by $S_N1$. The other halide is secondary and can react by either mechanism.

8.50 **Nucleophilic Substitution Reactions:** Section 8.4F

8.51 **Substitution versus Elimination:** Section 8.6

**IV > III > II > I**

III is a tertiary halide and forms a highly substituted alkene. II forms a disubstituted alkene and I forms only a monosubstituted alkene. Elimination is favored when highly substituted stable alkenes are possible.
ACTIVITIES WITH MOLECULAR MODELS

1. Make a model of one of the enantiomers of 2-bromobutane. Make a model of the enantiomer that results from an $S_N2$ reaction in which the bromine is replaced by an OH. Make sure you have inversion of configuration. Look at the original enantiomer and visualize the OH coming in from the rear and displacing the bromine.

2. Now, using the 2-bromobutane enantiomer from exercise 1, make the models of the racemic mixture formed when the bromine is replaced by OH in an $S_N1$ reaction. Visualize the Br leaving first and the water attacking from either side of the carbocation to form the pair of enantiomers.

3. Make molecular models of the $E_2$ reactions described in section 8.5B.2. They may help you in understanding the stereochemistry.

Please see textbook.