Organic Reactions

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Reaction Mechanism

- How reactions take place
- What bonds break and make as reaction progress
- Drawing curved arrows
- Determining if a reaction can take place
Types of Reactions

• Addition

These two reactants . . .

Ethylene (an alkene) + H—Br → H—C—C—H + Br

Bromoethane (an alkyl halide)

... add to give this product.

• Elimination

This one reactant . . .

Ethanol (an alcohol) → Acid catalyst → Ethylene (an alkene) + H₂O

... gives these two products.

• Substitution

H—C—H + Cl—Cl → Light → H—C—Cl + H—Cl

Methane Chlorine Chloromethane

• Rearrangement

This reactant . . .

CH₃CH₂ H C—C—H → Acid catalyst → H₃C H C—C—H

1-Butene 2-Butene

... gives this isomeric product.
Steps in Reaction Mechanism

• Bond formation or breakage can be symmetrical or unsymmetrical
  • **Symmetrical**- homolytic
  • **Unsymmetrical**- heterolytic

**Symmetrical bond-breaking (radical):**
one bonding electron stays with each product.

\[ \text{A} \cdot \text{B} \rightarrow \text{A} \cdot + \cdot \text{B} \]

**Unsymmetrical bond-breaking (polar):**
two bonding electrons stay with one product.

\[ \text{A} \cdot \text{B} \rightarrow \text{A}^+ + \cdot \text{B}^- \]

**Symmetrical bond-making (radical):**
one bonding electron is donated by each reactant.

\[ \text{A} \cdot + \cdot \text{B} \rightarrow \text{A} : \text{B} \]

**Unsymmetrical bond-making (polar):**
two bonding electrons are donated by one reactant.

\[ \text{A}^+ + \cdot \text{B}^- \rightarrow \text{A} : \text{B} \]
Review - Arrows

- synthesis (yield)
- equilibrium
- resonance
- retrosynthesis (backward)
- transfer of two electrons
- transfer of one electron
Polar Reactions

- Reactions occur at polar bonds.
- The more electronegative element has a negative charge (like a Lewis base)
- The atom bonded to the electronegative atom will have a partially positive charge (Lewis acid)
- Elements such as O, F, N, Cl are more electronegative than carbon
Polarized Reaction

<table>
<thead>
<tr>
<th>The Lewis acid</th>
<th>The Lewis base</th>
</tr>
</thead>
<tbody>
<tr>
<td>• positive center</td>
<td>• negative center</td>
</tr>
<tr>
<td>• electron poor</td>
<td>• electron rich</td>
</tr>
<tr>
<td>• the electrophile</td>
<td>• the nucleophile</td>
</tr>
</tbody>
</table>

This curved arrow shows that electrons move from \( :B^- \) to \( A^+ \).

Electrophile (electron-poor) + Nucleophile (electron-rich) → A–B

The electrons that moved from \( :B^- \) to \( A^+ \) end up here in this new covalent bond.
Arrows in Reaction Mechanism

• Keep a track of movement of electrons with arrows
• Always start from electron rich species (Lewis base)
• Always bring the arrow to electron poor species (Lewis acid)
• The atoms where the arrow starts and ends are the atoms that form a bond or break

Electrons usually flow from one of these nucleophiles.

Negatively charged

Neutral

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Kinetics

- Mechanisms in organic chemistry are explained by kinetics.
- Transition states tell us what species are forming during the reaction.
- Activation energy is the minimum energy required to get to the transition state.
- Order of reaction tells us about the mechanism of the reaction.
Key Words/Concepts

• Reaction Types
  • Addition
  • Elimination
  • Substitution
  • Rearrangement
• Polarity of bond
• Electrophile
• Nucleophile
• Heterolytic cleavage
• Homolytic cleavage
• Reaction mechanisms
• Transition states
• Activation energy