Organic Reaction Mechanisms

Organic Reactions and Mechanisms

1. **Substitution Reactions:**
   - **Nucleophilic Substitution (S_n1 and S_n2):**
     - **S_n1 Mechanism:**
       - Two-step process.
       - Formation of a carbocation intermediate.
       - Rate-determining step depends only on the concentration of the substrate.
       - Example: Hydrolysis of tertiary alkyl halides.
     - **S_n2 Mechanism:**
       - One-step process.
       - Backside attack by the nucleophile.
       - Inversion of configuration (Walden inversion).
       - Rate depends on both substrate and nucleophile concentrations.
       - Example: Hydrolysis of primary alkyl halides.
   - **Electrophilic Substitution (Aromatic):**
     - Typically occurs in aromatic compounds.
     - Example: Nitration, Sulfonation, Halogenation, Friedel-Crafts Alkylation, and Acylation.
     - Mechanism involves the formation of a sigma complex followed by deprotonation.
2. **Addition Reactions:**
   - **Electrophilic Addition:**
     - Occurs in alkenes and alkynes.
     - Example: Addition of hydrogen halides (HCl, HBr) to alkenes.
     - Mechanism involves the formation of a carbocation intermediate.
     - Markovnikov's rule applies.
   - **Nucleophilic Addition:**
     - Occurs typically in carbonyl compounds (aldehydes and ketones).
     - Example: Addition of cyanide ion (CN^-) to aldehydes.
     - The nucleophile attacks the carbonyl carbon, forming an alkoxide intermediate.
3. **Elimination Reactions:**
   - **E1 Mechanism (Unimolecular Elimination):**
     - Two-step process.
     - Formation of a carbocation intermediate.
     - Rate depends on the concentration of the substrate.
     - Often competes with S_n1 reactions.
   - **E2 Mechanism (Bimolecular Elimination):**
     - One-step process.
     - The base abstracts a proton while the leaving group leaves.
     - Rate depends on both substrate and base concentrations.
     - Often competes with S_n2 reactions.
     - Example: Dehydrohalogenation of alkyl halides.
4. **Rearrangement Reactions:**

- **Carbocation Rearrangement:**
  - Occurs during reactions like S_n1 or E1.
  - Example: 1,2-hydride or 1,2-methyl shift leading to a more stable carbocation.
- **Beckmann Rearrangement:**
  - Conversion of oximes to amides.
  - Involves migration of a group adjacent to the oxime.

5. **Oxidation-Reduction Reactions:**
   - **Oxidation:**
     - Increase in oxidation state (loss of electrons).
     - Example: Oxidation of alcohols to aldehydes/ketones using PCC.
   - **Reduction:**
     - Decrease in oxidation state (gain of electrons).
     - Example: Reduction of ketones to alcohols using $LiAlH_4$.
6. **Pericyclic Reactions:**
   - **Cycloaddition:**
     - Example: Diels-Alder reaction.
     - A concerted reaction that forms a cyclic product from a diene and a dienophile.
   - **Sigmatropic Rearrangements:**
     - Shifts in σ-bonds with concurrent π-bond rearrangements.
     - Example: Claisen rearrangement.
7. **Radical Reactions:**
   - **Halogenation of Alkanes:**
     - Example: Chlorination of methane.
     - Involves initiation, propagation, and termination steps.