

7: Reactions of Haloalkanes, Alcohols, and Amines. Nucleophilic Substitution

Preview

7.1 Nucleophilic Substitution Reactions of Haloalkanes

Nucleophilic Substitution Mechanisms (7.1A)

The S_N1 Mechanism.

The Meaning of S_N1.

The S_N2 Mechanism.

S_N1 and S_N2 Reactions are Ionic.

Conversion of Haloalkanes to Alcohols (7.1B)

t-Butyl Alcohol ((CH₃)₃C-OH) from t-Butyl Bromide ((CH₃)₃C-Br) (S_N1).

Solvent Stabilizes the Intermediate Ions.

Methanol (CH₃-OH) from Bromomethane (CH₃-Br) (S_N2).

H₂O versus ⁻:OH as a Nucleophile.

7.2 S_N1 versus S_N2 Mechanisms

Steric Sizes of R Groups in R₃C-Br (7.2A)

Relative S_N2 Rates for Different R₃C-Br.

Steric Crowding.

Carbocation Stabilization by R Groups in R₃C-Br (7.2B)

Relative S_N1 Rates for Different R₃C-Br.

Carbocation Stability.

S_N Mechanisms for Simple Haloalkanes (7.2C)

CH₃-Br and (CH₃)₃C-Br.

CH₃CH₂-Br and (CH₃)₂CH-Br.

Alkyl Group Stabilization of Carbocations (7.2D)

Carbocation Geometry and Hybridization.

Hyperconjugation.

Effects of Alkyl Group Substitution at a β-Carbon (7.2E)

S_N1 Mechanisms.

S_N2 Mechanisms.

7.3 Haloalkane Structure and Reactivity

A Comparison of F, Cl, Br, and I as Leaving Groups (7.3A)

Relative S_N Rates for RI, RBr, RCl, and RF.

S_N Rates of R-X and H-X Acidity.

Leaving Group Ability.

Other Nucleophiles, Leaving Groups, and Solvents (7.3B)

The General Substrate R-L.

Preview.

7.4 Stereochemistry of S_N Reactions

Stereochemistry in the S_N2 Reaction (7.4A)

Inversion of Configuration.

The Need for a C-L Stereocenter.

S_N2 Reactions on 2-Chlorobutane.

Stereochemistry in the S_N1 Reaction (7.4B)

Inversion and Retention of Configuration.

Racemic Product.

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7.5 Reaction Rates of S_N Reactions

Reaction Rates (7.5A)

S_N2 Reaction Rates.

S_N1 Reaction Rates.

Activation Energies (7.5B)

Energy Diagram for an S_N1 Reaction.

S_N1 Activation Energies.

Energy Diagram for an S_N2 Reaction.

7.6 Other Nucleophiles

ROH and RO^- as Nucleophiles (7.6A)

ROH Nucleophiles.

RO^- Nucleophiles (Williamson Ether Synthesis).

Limitations of the Williamson Ether Synthesis.

Alkoxide Ion Formation.

Formation of Cyclic Ethers (Epoxides).

R_2NH and R_2N^- as Nucleophiles (7.6B)

Amine Nucleophiles R_2NH .

The Amine Products React Further.

Two Different R Groups on N.

3° Amine ($R_3N:$) Nucleophiles.

Amide Nucleophiles R_2N^- .

S_N1 Mechanisms and Amine Nucleophiles.

RSH and RS^- as Nucleophiles (7.6C)

H_2S and HS^- .

RSH and RS^- .

Halide Ion Nucleophiles (X^-) (7.6D)

Formation of Fluoroalkanes.

Formation of Iodoalkanes.

The Nucleophiles N_3^- and $^-C\equiv N$ (7.6E)

Cyanide Ion.

Azide Ion.

7.7 Leaving Groups

The OH Group in Alcohols (R-OH) (7.7A)

R-OH is a Poor Substrate for S_N Reactions.

$R-OH_2^+$ is a Good Substrate for S_N Reactions.

Haloalkanes from Protonated Alcohols.

The OR Group in Ethers (R-OR) (7.7B)

Haloalkanes from Cleavage of Ethers.

Ring Opening of Cyclic Ethers (7.7C)

Epoxide Ring Opening.

Acid Catalysis.

Epoxide Ring Opening by Halide Ions.

A Summary of Leaving Groups (7.7D)

Some "Good" Leaving Groups.

Some "Poor" Leaving Groups.

Leaving Group Ability and K_a Values for H-L.

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7.8 Nucleophilicity and Reaction Solvent

The Halide Ions (7.8A)

Solvent Dependence of Nucleophilicity.

Origin of Solvent Effect.

Solvation Changes during an S_N2 Reaction.

Solvation by Hydroxylic Solvents.

Polar Aprotic Solvents (7.8B)

Some Examples of Polar Aprotic Solvents.

Nucleophilic Substitution Mechanisms in Polar Aprotic Solvents.

Nucleophilicities of Other Nucleophiles (7.8C)

Nucleophiles and their Conjugate Bases.

Nucleophiles in the Same Row of the Periodic Table.

Nucleophiles in the Same Column of the Periodic Table.

Comparative Nucleophilicities in S_N2 versus S_N1 Reactions.

7.9 Carbon Nucleophiles

Organometallic Compounds give C Nucleophiles (7.9A)

Organomagnesium and Organolithium Compounds.

Carbon Polarity in Organometallic Compounds.

C-C Bond Formation Using Organometallic Compounds (7.9B)

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Alkyl Group Coupling.

Reactions with Epoxides.

Positive, Negative and Neutral Carbon Atoms (7.9C)

7.10 Nucleophilic Hydrogen

The Polarity of H in Various Compounds (7.10A)

Metal Hydrides are Sources of Nucleophilic H (7.10B)

Appendix: Nucleophiles and Leaving Groups

Chapter Review