

Virginia Western Community College

CHM 241

Organic Chemistry I

Prerequisites

CHM 112 or equivalent.

Course Description

Introduces fundamental chemistry of carbon compounds, including structures, physical properties, syntheses, and typical reactions. Emphasizes reaction mechanisms.

Semester Credits: 3

Lecture Hours: 3

Required Materials

Textbook:

Organic Chemistry. Bruice. 7th edition. Pearson Publishing. ISBN: 9780321819031

Course Outcomes

At the completion of this course, the student should be able to:

- Name all hydrocarbons aliphatic and aromatic.
- Understand the relationship between the structure of hydrocarbons and their physical and chemical properties including certain stereochemical concepts.
- Synthesize basic aliphatic and aromatic hydrocarbons from simpler molecules.
- Predict the products obtained in different addition and substitution hydrocarbon reactions and understand the role of the solvent in these reactions.
- Understand the mechanistic pathways through which hydrocarbon reactions proceed.

Topical Description

Part 1: An Introduction to the Study of Organic Chemistry

Chapter 1: Remembering General Chemistry: Electronic Structure and Bonding

- 1.1 The Structure of an Atom
- 1.2 How the Electrons in an Atom are Distributed
- 1.3 Ionic and Covalent Bonds
- 1.4 How the Structure of a Compound is Represented
- 1.5 Atomic Orbitals
- 1.6 An Introduction to Molecular Orbital Theory
- 1.7 How Single Bonds are Formed in Organic Compounds
- 1.8 How a Double Bond is Formed: The Bonds in Ethene
- 1.9 How a Triple Bond is Formed: The Bonds in Ethyne
- 1.10 The Bonds in the Methyl Cation, the Methyl Radical, and the Methyl Anion

- 1.11 The Bonds in Ammonia and in the Ammonium Ion
- 1.12 The Bonds in Water
- 1.13 The Bond in a Hydrogen Halide
- 1.14 Hybridization and Molecular Geometry
- 1.15 Summary: Hybridization, Bond Lengths, Bond Strengths, and Bond Angles
- 1.16 The Dipole Moments of Molecules

Chapter 2: Acids and Bases: Central to Understanding Organic Chemistry

- 2.1 An Introduction to Acids and Bases
- 2.2 pKa and pH
- 2.3 Organic Acids and Bases
- 2.4 How to Predict the Outcome of an Acid-Base Reaction
- 2.5 How to Determine the Position of Equilibrium
- 2.6 How the Structure of an Acid Affects Its pKa Value
- 2.7 How Substituents Affect the Strength of an Acid
- 2.8 An Introduction to Delocalized Electrons
- 2.9 A Summary of the Factors That Determine Acid Strength
- 2.10 How pH Affects the Structure of an Organic Compound
- 2.11 Buffer Solutions
- 2.12 Lewis Acids and Bases

Chapter 3: An Introduction to Organic Compounds: Nomenclature, Physical Properties, and Representation of Structure

- 3.1 How Alkyl Substituents are Named
- 3.2 The Nomenclature of Alkanes
- 3.3 The Nomenclature of Cycloalkanes / Skeletal Structures
- 3.4 The Nomenclature of Alkyl Halides
- 3.5 The Nomenclature of Ethers
- 3.6 The Nomenclature of Alcohols
- 3.7 The Nomenclature of Amines
- 3.8 The Structures of Alkyl Halides, Alcohols, Ethers, and Amines
- 3.9 The Physical Properties of Alkanes, Alkyl halides, Alcohols, Ethers, and Amines
- 3.10 Rotation Occurs about Carbon-Carbon Single Bonds
- 3.11 Some Cycloalkanes Have Angle Strain
- 3.12 Conformers of Cyclohexane
- 3.13 Conformers of Monosubstituted Cyclohexanes
- 3.14 Conformers of Disubstituted Cyclohexanes
- 3.15 Fused Cyclohexane Rings

Part 2: Electrophilic Addition Reactions, Stereochemistry, and Electron Delocalization

Chapter 4: Isomers: The Arrangement of Atoms in Space

- 4.1 Cis-Trans Isomers Result from Restricted Rotation
- 4.2 A Chiral Object has a NonSuperimposable Mirror Image
- 4.3 An Asymmetric Center is a Cause of Chirality in a Molecule
- 4.4 Isomers with One Asymmetric Center

- 4.5 Asymmetric Centers and Stereocenters
- 4.6 How to Draw Enantiomers
- 4.7 Naming Enantiomers by the R, S System
- 4.8 Chiral Compounds are Optically Active
- 4.9 How Specific Rotation is Measured
- 4.10 Enantiomeric Excess
- 4.11 Compounds with more than one Asymmetric Center
- 4.12 Stereoisomers of Cyclic Compounds
- 4.13 Meso Compounds have one Asymmetric Center but are Optically Active
- 4.14 How to name Isomers with more than one Asymmetric Center
- 4.15 How Enantiomers Can be Separated
- 4.16 Nitrogen and Phosphorus Atoms can be Asymmetric Centers

Chapter 5: Alkenes: Structure, Nomenclature, and an Introduction to Reactivity*Thermodynamics and Kinetics

- 5.1 Molecular Formulas and the Degree of Unsaturation
- 5.2 The Nomenclature of Alkenes
- 5.3 The Structures of Alkenes
- 5.4 Naming Alkenes Using the *E,Z* System
- 5.5 How an Organic Compound Reacts Depends on Its Functional Group
- 5.6 How Alkenes React / Curved Arrows Show the Flow of Electrons
- 5.7 Thermodynamics and Kinetics
- 5.8 The Rate of a Chemical Reaction
- 5.9 The Difference between the Rate of a Reaction and the Rate Constant for a Reaction
- 5.10 A Reaction Coordinate Diagram Describes the Energy Changes That Take Place during a Reaction
- 5.11 Catalysis
- 5.12 Catalysis by Enzymes

Chapter 6: The Reactions of Alkenes: The Stereochemistry of Addition Reactions

- 6.1 Addition of a Hydrogen Halide to an Alkene
- 6.2 Carbocation Stability Depends on the Number of Alkyl Groups Attached to Positively Charged Carbon
- 6.3 What Does the Structure of the Transition State Look Like?
- 6.4 Electrophilic Addition Reactions Are Regioselective
- 6.5 The Addition of Water to an Alkene
- 6.6 The Addition of an Alcohol to an Alkene
- 6.7 A Carbocation Will Rearrange If It Can Form a More Stable Carbocation
- 6.8 Oxymercuration-Reduction and Alkoxymercuration-Reduction Are Other Ways to Add Water or an Alcohol to an Alkene
- 6.9 The Addition of Borane to an Alkene: Hydroboration-Oxidation
- 6.10 The Addition of a Halogen to an Alkene
- 6.11 The Addition of a Peroxyacid to an Alkene
- 6.12 The Addition of Ozone to an Alkene: Ozonolysis
- 6.13 The Addition of Hydrogen to an Alkene
- 6.14 The Relative Stabilities of Alkenes
- 6.15 Regioselective, Stereoselective, and Stereospecific Reactions

- 6.16 The Stereochemistry of Electrophilic Addition Reactions of Alkenes
- 6.17 The Stereochemistry of Enzyme-Catalyzed Reactions
- 6.18 Enantiomers Can Be Distinguished by Biological Molecules
- 6.19 Reactions and Synthesis

Chapter 7: The Reactions of Alkynes / An Introduction to Multistep Synthesis

- 7.1 The Nomenclature of Alkynes
- 7.2 How to Name a Compound That Has More than One Functional Group
- 7.3 The Physical Properties of Unsaturated Hydrocarbons
- 7.4 The Structure of Alkynes
- 7.5 Alkynes are Less Reactive than Alkenes
- 7.6 The Addition of Hydrogen Halides and the Addition of Halogens to an Alkyne
- 7.7 The Addition of Water to an Alkyne
- 7.8 The Addition of Borane to an Alkyne: Hydroboration-Oxidation
- 7.9 The Addition of Hydrogen to an Alkyne
- 7.10 A Hydrogen Bonded to an *sp* Carbon Is "Acidic"
- 7.11 Synthesis Using Acetylide Ions
- 7.12 Designing a Synthesis I: An Introduction to Multistep Synthesis

Chapter 8: Delocalized Electrons and Their Effect on Stability, Reactivity, and pK_a, and the Products of a Reaction

- 8.1 Delocalized Electrons Explain Benzene's Structure
- 8.2 The Bonding in Benzene
- 8.3 Resonance Contributors and the Resonance Hybrid
- 8.4 How to Draw Resonance Contributors
- 8.5 The Predicted Stabilities of Resonance Contributors
- 8.6 Delocalization Energy Is the Additional Stability Delocalized Electrons Give to a Compound
- 8.7 Benzene is an Aromatic Compound
- 8.8 The Two Criteria for Aromaticity
- 8.9 Applying the Criteria for Aromaticity
- 8.10 Aromatic Heterocyclic Compounds
- 8.11 Antiaromaticity
- 8.12 A Molecular Orbital Description of Aromaticity and Antiaromaticity
- 8.13 More Examples that Show How Delocalized Electrons Affect Stability
- 8.14 A Molecular Orbital Description of Stability
- 8.15 How Delocalized Electrons Affect pK_a Values
- 8.16 Delocalized Electrons Can Affect the Product of a Reaction
- 8.17 Reactions of Dienes
- 8.18 Thermodynamic Versus Kinetic Control
- 8.19 The Diels-Alder Reaction Is a 1,4-Addition Reaction
- 8.20 Retrosynthetic Analysis of Diels-Alder Reaction
- 8.21 Organizing What We Know About the Reactions of Organic Compounds

Part 3: Substitution and Elimination ReactionsChapter 9: Substitution Reactions of Alkyl Halides

- 9.1 The Mechanism for an S_N2 Reaction
- 9.2 Factors That Affect S_N2 Reactions
- 9.3 The Mechanism for an S_N1 Reaction
- 9.4 Factors That Affect S_N1 Reactions
- 9.5 Benzylic Halides, Allylic Halides, Vinylic Halides, and Aryl Halides
- 9.6 Competition Between S_N2 and S_N1 Reactions
- 9.7 The Role of the Solvent in S_N2 and S_N1 Reactions
- 9.8 Intermolecular Versus Intramolecular Reactions
- 9.9 Methylating Agents Used by Chemists Versus Those Used by Cells

Chapter 10. Elimination Reactions of Alkyl Halides / Competition between Substitution and Elimination

- 10.1 The E2 Reaction
- 10.2 An E2 Reaction Is Regioselective
- 10.3 The E1 Reaction
- 10.4 Benzylic And Allylic Halides
- 10.5 Competition between E2 and E1 Reactions
- 10.6 E2 and E1 Reactions Are Stereoselective
- 10.7 Elimination from Substituted Cyclohexanes
- 10.8 A Kinetic Isotope Effect Can Help Determine a Mechanism
- 10.9 Competition between Substitution and Elimination
- 10.10 Substitution and Elimination Reactions in Synthesis
- 10.11 Designing a Synthesis II: Approaching the Problem

Chapter 11: Reactions of Alcohols, Ethers, Amines Thiols, and Thioethers

- 11.1 Nucleophilic Substitution Reactions of Alcohols: Forming Alkyl Halides
- 11.2 Other Methods Used to Convert Alcohols into Alkyl Halides
- 11.3 Converting an Alcohol into a Sulfonate Ester
- 11.4 Elimination Reactions of Alcohols: Dehydration
- 11.5 Oxidation of Alcohols
- 11.6 Nucleophilic Substitution Reactions of Ethers
- 11.7 Nucleophilic Substitution Reactions of Epoxides
- 11.8 Arene Oxides
- 11.9 Amines Do No Undergo Substitution or Elimination Reactions
- 11.10 Quaternary Ammonium Hydroxides Undergo Elimination Reactions
- 11.11 Thiols, Sulfides and Sulfonium Salts
- 11.12 Organizing What We Know About the Reactions of Organic Compounds

Chapter 12: Organometallic Compounds

- 12.1 Organolithium and Organomagnesium Compounds
- 12.2 The Reaction of Organolithium Compounds and Grignard Reagents with Electrophiles

- 12.3 Transmetallation
- 12.4 Coupling Reactions
- 12.5 Palladium-Catalyzed Coupling Reactions
- 12.6 Alkene Metathesis

Notes to Instructors

None.