

Virginia Western Community College

CHM 241

Organic Chemistry I

Prerequisites

CHM 112 or equivalent with a grade of C or better.

Course Description

Introduces fundamental chemistry of carbon compounds, including structures, physical properties, syntheses, and typical reactions. Emphasizes reaction mechanisms. Intended for chemistry majors as well as science, chemical engineering, and pre-professional health students.

Semester Credits: 3

Lecture Hours: 3

Required Materials

Textbook:

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

Goal of Course

The general purpose of this course is to prepare the student for advanced study in organic chemistry through development of: skills in synthetic organic problem solving and in critical thinking, an understanding of the methods of organic chemistry, understanding of the general concepts and principles of organic chemistry.

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
- Formal charge

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
- Stability of conjugate base

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

- Draw Lewis, condensed, and line structures.

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 Reactions

Chapter 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 13: Radicals / Reactions of Alkanes

- 13.1 Alkanes are Unreactive Compounds
- 13.2 The Chlorination and Bromination of Alkanes
- 13.3 Radical Stability Depends on the Number of Alkyl Groups Attached to the Carbon with the Unpaired Electron
- 13.4 The Distribution of Products Depends on Probability and Reactivity
- 13.5 The Reactivity – Selectivity Principle
- 13.6 Formation of Explosive Peroxides
- 13.7 The Addition of Radicals to an Alkene
- 13.8 The Stereochemistry of Radical Substitution and Radical Addition Reactions
- 13.9 Radical Substitution of Benzylic and Allylic Hydrogens
- 13.10 Designing a Synthesis III: More Practice with Multistep Synthesis
- 13.11 Radical Reactions Occur in Biological Systems
- 13.12 Radicals and Stratospheric Ozone

Notes to Instructors

None.