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. Lectures 3 hours per week.

Semester Credits: 3 **Lecture Hours: 3**

Required Materials

Textbook:
Organic Chemistry. Bruice. 8th edition. Pearson Publishing. ISBN: 9780134042282

General Course Purpose

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 Objectives

Upon completing the course, the student will be able to:

Structure and Bonding, Polar Bonds and Their Consequences, Organic Compounds: Alkanes and Cycloalkanes, Stereochemistry of Alkanes and Cycloalkanes

- Predict and explain patterns in structure, geometry, bonding, hybridization, formal charge, stability, acidity, basicity, and polarity of organic molecules.
- Describe the trends in solubility, melting points, boiling points and other physical properties of organic molecules based on intermolecular forces and presence of specific functional groups.
- Classify organic molecules by their functional groups and provide correct IUPAC names for alkanes, alkenes, alkynes, alkyl halides, and other optional functional groups, including cyclic molecules and stereochemistry. Draw Lewis condensed and line structures.
- Classify molecules as structural isomers, resonance structures, conformers, chiral or achiral, identify chiral carbons as (R) or (S), and describe stereoisomers and optical activity.

Alkenes and Alkynes: Structure, Reactivity, Reactions, and Synthesis, Alkyl Halides, Reactions of Alkyl Halides: Nucleophilic Substitutions and Eliminations, Structure Determination: Infrared Spectroscopy and Nuclear Magnetic Resonance Spectroscopy

- Explain and draw detailed mechanism, and predict the products of alkane free radical halogenation.

- Explain and draw detailed mechanism, and predict the products of the alkyl halide S_N2, S_N1, E2, E1 reactions. Describe the reagents and solvent properties that promote each mechanism.
- Explain electrophilic addition of alkenes and alkynes, which may include oxymercuration, halogenation, hydration, reduction, hydroboration, epoxidation and other addition reactions. Predict the structure of the intermediates and products, including stereoisomers(cis, trans, E, and Z).
- Use retrosynthetic analysis to design efficient syntheses involving alkanes, alkenes, alkyl halides, and/or alcohols as starting materials, intermediates or final products.
- Predict the structure of organic molecules by calculating degrees of unsaturation and/or interpretation of infrared spectra, mass spectrometry, and NMR for appropriate families.
- Predict the products of the reduction of alkenes and oxidation of alcohols.

Major Topics to be Included

Structure and Bonding
Polar Bonds and Their Consequences
Organic Compounds: Alkanes and Cycloalkanes
Stereochemistry of Alkanes and Cycloalkanes
Alkenes and Alkynes: Structure, Reactivity, Reactions, and Synthesis
Alkyl Halides
Reactions of Alkyl Halides: Nucleophilic Substitutions and Eliminations
Structure Determination: Infrared Spectroscopy and Nuclear Magnetic Resonance Spectroscopy

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 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 Alkyl Groups
- 3.2 The Nomenclature of Alkanes
- 3.3 The Nomenclature of Cycloalkanes
- 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 Noncovalent Interactions
- 3.10 The Solubility of Organic Compounds
- 3.11 Rotation Occurs about Carbon-Carbon Single Bonds
- 3.12 Some Cycloalkanes Have Angle Strain
- 3.13 Conformers of Cyclohexane
- 3.14 Conformers of Monosubstituted Cyclohexanes
- 3.15 Conformers of Disubstituted Cyclohexanes
- 3.16 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 Using the E,Z System to Distinguish Isomers
- 4.3 A Chiral Object has a NonSuperimposable Mirror Image
- 4.4 An Asymmetric Center is a Cause of Chirality in a Molecule
- 4.5 Isomers with One Asymmetric Center
- 4.6 Asymmetric Centers and Stereocenters
- 4.7 How to Draw Enantiomers
- 4.8 Naming Enantiomers by the R, S System
- 4.9 Chiral Compounds are Optically Active
- 4.10 How Specific Rotation is Measured
- 4.11 Enantiomeric Excess
- 4.12 Compounds with more than one Asymmetric Center
- 4.13 Stereoisomers of Cyclic Compounds

- 4.14 Meso Compounds have one Asymmetric Center but are Optically Inactive
- 4.15 How to name Isomers with more than one Asymmetric Center
- 4.16 Nitrogen and Phosphorus Atoms can be Asymmetric Centers
- 4.17 Receptors
- 4.18 How Enantiomers Can be Separated

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 Structure of Alkenes
- 5.4 How an Organic Compound Reacts Depends on Its FunctionalGroup
- 5.5 How Alkenes React / Curved Arrows Show the Flow of Electrons
- 5.6 Thermodynamics: How Much Product is Formed?
- 5.7 Increasing the Amount of Product Formed in a Reaction
- 5.8 Calculating ΔH^{o} Values
- 5.9 Using ΔH^{o} Values to Determine the Relative Stabilities of Alkenes
- 5.10 Kinetics: How Fast is the Product Formed?
- 5.11 The Rate of a Chemical Reaction
- 5.12 A Reaction Coordinate Diagram Describes the Energy Changes That Take Place During a Reaction
- 5.13 Catalysis
- 5.14 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 The Addition of Borane to an Alkene: Hydroboration-Oxidation
- 6.9 The Addition of a Halogen to an Alkene
- 6.10 The Addition of a Peroxyacid to an Alkene
- 6.11 The Addition of Ozone to an Alkene: Ozonolysis
- 6.12 Regioselective, Stereoselective, and Stereospecific Reactions
- 6.13 The Stereochemistry of Electrophilic Addition Reactions
- 6.14 The Stereochemistry of Enzyme-Catalyzed Reactions
- 6.15 Enantiomers Can Be Distinguished by Biological Molecules
- 6.16 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 Structure of Alkynes
- 7.4 The Physical Properties of Unsaturated Hydrocarbons

- 7.5 Reactivity of Alkynes
- 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 pKa, and the Products of a Reaction*Aromaticity and Electronic Effects: An Introduction to the Reactions of Benzene

- 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 Delocalized Electrons Increase Stability
- 8.8 A Molecular Orbital Description of Stability
- 8.9 Delocalized Electrons Affect pK_a Values
- 8.10 Electronic Effects
- 8.11 Delocalized Electrons Can Affect the Product of a Reaction
- 8.12 Reactions of Dienes
- 8.13 Thermodynamic Versus Kinetic Control
- 8.14 The Diels-Alder Reaction Is a 1,4-Addition Reaction
- 8.15 Retrosynthetic Analysis of Diels-Alder Reaction
- 8.16 Benzene is an Aromatic Compound
- 8.17 The Two Criteria for Aromaticity
- 8.18 Applying the Criteria for Aromaticity
- 8.19 A Molecular Orbital Description of Aromaticity
- 8.20 Aromatic Heterocylic Compounds
- 8.21 How Benzene Reacts

Part 3: Substitution and Elimination Reactions

Chapter 9: Substitution and Elimination Reactions of Alkyl Halides

- 9.1 The S_N2 Reaction
- 9.2 Factors That Affect S_N2 Reactions
- 9.3 The S_N1 Reaction
- 9.4 Factors That Affect S_N1 Reactions
- 9.5 Competition Between S_N2 and S_N1 Reactions
- 9.6 Elimination Reactions
- 9.7 The E2 Reaction
- 9.8 The E1 Reaction
- 9.9 Competition between E2 and E1 Reactions

- 9.10 E2 and E1 Reactions Are Stereoselective
- 9.11 Elimination from Substituted Cyclohexanes
- 9.12 Predicting the Products of the Reaction of an Alkyl Halide with a Nuceleophile/Base
- 9.13 Benzylic Halides, Allylic Halides, Vinylic Halides, and Aryl Halides
- 9.14 Solvent Effects
- 9.15 Substitution and Elimination Reactions in Synthesis
- 9.16 Intermolecular Versus Intramolecular Reactions
- 9.17 Designing a Synthesis II: Approaching the Problem

Chapter 12: Radicals / Reactions of Alkanes

- 12.1 Alkanes are Unreactive Compounds
- 12.2 The Chlorination and Bromination of Alkanes
- 12.3 Radical Stability Depends on the Number of Alkyl Groups Attached to the Carbon with the Unpaired Electron
- 12.4 The Distribution of Products Depends on Probability and Reactivity
- 12.5 The Reactivity – Selectivity Principle
- 12.6 Formation of Explosive Peroxides
- 12.7 The Addition of Radicals to an Alkene
- 12.8 The Stereochemistry of Radical Substitution and Radical Addition Reactions
- 12.9 Radical Substitution of Allylic and Benzylic Hydrogens
- 12.10 Designing a Synthesis III: More Practice with MultistepSynthesis
- 12.11 Radical Reactions in Biological Systems
- 12.12 Radicals and Stratospheric Ozone

ADA Statement

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Title IX Statement

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Notes to Instructors

None.