Virginia Western Community College
CHM 242
Organic Chemistry II

Prerequisites

CHM 241 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. Lecture 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 Outcomes

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

Benzene, Alcohols and Phenols, Aldehydes and Ketones

- Describe and apply the rules of IUPAC nomenclature for alcohols, aldehydes, ketones, carboxylic acids, derivatives of carboxylic acids, arenes, and amines, including stereochemical assignments.
- Explain trends in physical properties for organic functional groups, such as intermolecular forces, acidity, solubility in water and organic solvents, melting points and boiling points.
- Interpret spectrum from instrumentation such as IR, NMR, UV-Vis and MS to determine the structure of appropriate families.

Carbonyl Condensation Reactions, Carbonyl Alpha Substitution Reactions

- Explain molecular stability and with concepts of resonance, conjugation, and by showing stepwise reaction mechanisms with Lewis structures and curved arrows that demonstrate electron flow.
- Draw the reaction mechanisms of carbonyl group compounds, including condensation reactions, keto-enol tautomerism, and nucleophilic addition reactions with carbon, nitrogen, oxygen or hydrogen nucleophiles.

Carboxylic Acid Derivatives and Nucleophilic Acyl Substitution Reactions, Ketones and Aldehydes

- Illustrate the use of carbon nucleophile reagents, such as organometallic Grignard reagent, phosphonium ylide Wittig reagent and carbon electrophile reagents like carbenes and organometallic-complexed carbenoids.

- Predict product structures and demonstrate mechanisms of oxidation and reduction reactions of alcohols, aldehydes, ketones, and carboxylic acids using reagents such as chromic acid, organic hydrides, catalytic reduction, and reactions such as Clemmensen and Wolf-Kishner reduction.
- Describe the synthetic pathways to prepare carboxylic acids and their derivatives and the stepwise mechanisms of typical reactions for these compounds.
- Describe alpha carbon chemistry of enolate formation and reactivity, including the formations of beta-hydroxy carbonyl compounds and beta-unsaturated compounds.

Conjugated Dienes, Benzene and Aromaticity, Chemistry of Benzene: Electrophilic Aromatic Substitution, Amines

- Describe mechanisms for stabilization of conjugated compounds such as pericyclic reactions and Diels-Alder reaction and for products associated with the electrophilic addition of conjugated dienes, such as Michael addition.
- Predict the stability of aromatic compounds by using molecular orbital theory and the Huckel 4n+2 rule; explain reaction mechanisms for aromatic compounds including aromatic substitution reactions directed by activating and deactivating effects of substituents.
- Describe the chemistry of amines, including synthesis and common reactions.

Major Topics to be Included

Benzene
Alcohols and Phenols
Aldehydes and Ketones
Carbonyl Condensation Reactions
Carbonyl Alpha Substitution Reactions
Carboxylic Acid Derivatives and Nucleophilic Acyl Substitution Reactions
Ketones and Aldehydes
Conjugated Dienes
Benzene and Aromaticity
Chemistry of Benzene: Electrophilic Aromatic Substitution
Amines

Topical Description

Part 4: Identification of Organic Compounds

Chapter 13: Mass Spectrometry, Infrared Spectroscopy, and Ultraviolet/Visible Spectroscopy

- 13.1 Mass Spectrometry
- 13.2 The Mass Spectrum / Fragmentation
- 13.3 Using the *m/z* of the Molecular Ion to Calculate the Molecular Formula
- 13.4 Isotopes in Mass Spectrometry
- 13.5 High-Resolution Mass Spectrometry Can Reveal Molecular Formulas
- 13.6 The Fragmentation Patterns of Functional Groups
- 13.7 Other Ionization Methods
- 13.8 Gas Chromatography-Mass Spectrometry
- 13.9 Spectroscopy and the Electromagnetic Spectrum
- 13.10 Infrared Spectroscopy
- 13.11 Characteristic Infrared Absorption Bands
- 13.12 The Intensity of Absorption Bands
- 13.13 The Position of Absorption Bands

- 13.14 The Position and Shape of an Absorption Band is Affect by Electron Delocalization, Electron Donation and Withdrawal, and Hydrogen Bonding
- 13.15 C—H Absorption Bands
- 13.16 The Absence of Absorption Bands
- 13.17 Some Vibrations are Infrared Inactive
- 13.18 How to Interpret an Infrared Spectrum
- 13.19 Ultraviolet and Visible Spectroscopy
- 13.20 The Beer-Lambert Law
- 13.21 The Effect of Conjugation on λ_{max}
- 13.22 The Visible Spectrum and Color
- 13.23 Some Uses of UV/Vis Spectroscopy

Chapter 14: NMR Spectroscopy

- 14.1 An Introduction to NMR Spectroscopy
- 14.2 Fourier Transform NMR
- 14.3 Shielding Causes Different Hydrogens to Show Signals at Different Frequencies
- 14.4 The Number of Signals in an ^{1}H NMR Spectrum
- 14.5 The Chemical Shift Tells How Far the Signal is from the Reference Signal
- 14.6 The Relative Positions of ^{1}H NMR Signals
- 14.7 The Characteristic Values of Chemical Shifts
- 14.8 Diamagnetic Anisotropy
- 14.9 The Integration of NMR Signals Reveals the Relative Number of Protons Causing Each Signal
- 14.10 The Splitting of the Signals is Described by the $N + 1$ Rule
- 14.11 What Causes Splitting?
- 14.12 More Examples of ^{1}H NMR Spectra
- 14.13 Coupling Constants Identify Coupled Protons
- 14.14 Splitting Diagrams Explain the Multiplicity of a Signal
- 14.15 Enantiotopic and Diastereotopic Hydrogens
- 14.16 The Time Dependence of NMR Spectroscopy
- 14.17 Protons Bonded to Oxygen and Nitrogen
- 14.18 The Use of Deuterium in ^{1}H NMR Spectroscopy
- 14.19 The Resolution of ^{1}H NMR Spectra
- 14.20 ^{13}C NMR Spectroscopy
- 14.21 DEPT ^{13}C NMR Spectra
- 14.22 Two-Dimensional NMR Spectroscopy
- 14.23 NMR Used in Medicine is Called Magnetic ResonanceImaging
- 14.24 X-Ray Crystallography

Chapter 10: Reactions of Alcohols, Ethers, Amines Thiols, and Thioethers

- 10.1 Nucleophilic Substitution Reactions of Alcohols: Forming Alkyl Halides
- 10.2 Other Methods Used to Convert Alcohols into Alkyl Halides
- 10.3 Converting an Alcohol into a Sulfonate Ester
- 10.4 Elimination Reactions of Alcohols: Dehydration
- 10.5 Oxidation of Alcohols
- 10.6 Nucleophilic Substitution Reactions of Ethers
- 10.7 Nucleophilic Substitution Reactions of Epoxides
- 10.8 Arene Oxides
- 10.9 Amines Do No Undergo Substitution or Elimination Reactions
- 10.10 Quaternary Ammonium Hydroxides Undergo Elimination Reactions
- 10.11 Thiols, Sulfides and Sulfonium Ions
- 10.12 Methylating Agents Used by Chemistry versus Those Used by Cells
- 10.12 Organizing What We Know About the Reactions of Organic Compounds (Group II)

Chapter 11: Organometallic Compounds

- 11.1 Organolithium and Organomagnesium Compounds
- 11.2 Transmetallation
- 11.3 Organocuprates
- 11.4 Palladium-Catalyzed Coupling Reactions
- 11.5 Alkene Metathesis

Part 5: Carbonyl Compounds

Chapter 15: Reactions of Carboxylic Acids and Carboxylic Acid Derivatives

- 15.1 The Nomenclature of Carboxylic Acids and Carboxylic Acid Derivatives
- 15.2 The Structures of Carboxylic Acids and Carboxylic Acid Derivatives
- 15.3 The Physical Properties of Carbonyl Compounds
- 15.4 How Carboxylic Acids and Carboxylic Acid Derivatives React
- 15.5 The Relative Reactivities of Carboxylic Acids and Carboxylic Acid Derivatives
- 15.6 Reactions of Acyl Chlorides
- 15.7 Reactions of Esters
- 15.8 Acid-Catalyzed Ester Hydrolysis and Transesterification
- 15.9 Hydroxide-Ion Promoted Ester Hydrolysis
- 15.10 Reactions of Carboxylic Acid
- 15.11 Reactions of Amides
- 15.12 Acid Catalyzed Amide Hydrolysis and Alcoholysis
- 15.13 Hydroxide-Ion Promoted Hydrolysis of Amides
- 15.14 The Hydrolysis of an Imide: A Way to Synthesize Primary Amines
- 15.15 Nitriles
- 15.16 Acid Anhydrides
- 15.17 Dicarboxylic Acids
- 15.18 How Chemists Activate Carboxylic Acids

- 15.19 How Cells Activate Carboxylic Acids

Chapter 16: Reactions of Aldehydes and Ketones / More Reactions of Carboxylic Acid Derivatives / Reactions of α,β-Unsaturated Carbonyl Compounds

- 16.1 The Nomenclature of Aldehydes and Ketones
- 16.2 The Relative Reactivities of Carbonyl Compounds
- 16.3 How Aldehydes and Ketones React
- 16.4 Reactions of Carbonyl Compounds with Carbon Nucleophiles
- 16.5 The Reactions of Carbonyl Compounds with Hydride Ion
- 16.6 More About Reduction Reactions
- 16.7 Chemoselective Reactions
- 16.8 The Reactions of Aldehydes and Ketones with Nitrogen Nucleophiles
- 16.9 The Reactions of Aldehydes and Ketones with Oxygen Nucleophiles
- 16.10 Protecting Groups
- 16.11 Reactions of Aldehydes and Ketones with Sulfur Nucleophiles
- 16.12 The Reactions of Aldehydes and Ketones with Peroxyacid
- 16.13 The Wittig Reaction Forms an Alkene
- 16.14 Designing a Synthesis IV: Disconnections, Synthons, and Synthetic Equivalents
- 16.15 Nucleophilic Addition to α,β-Unsaturated Aldehydes &Ketones
- 16.16 Nucleophilic Addition to α,β-Unsaturated Carboxylic Acid Derivatives
- 16.17 Conjugate Addition Reactions in Biological Systems

Chapter 17: Reactions at the α-Carbon of Carbonyl Compounds

- 17.1 The Acidity of an α-Hydrogen
- 17.2 Keto-Enol Tautomers
- 17.3 Keto-Enol Interconversion
- 17.4 Halogenation of the α-Carbon of Aldehydes and Ketones
- 17.5 Halogenation of the α-Carbon Carboxylic Acids
- 17.6 Formation of Enolate Ion
- 17.7 Alkylating the α−Carbon
- 17.8 Alkylating and Acylating the α-Carbon Via an Enamine Intermediate
- 17.9 Alkylating the β-Carbon
- 17.10 An Aldol Addition Forms β-Hydroxyaldehydes or β-Hydroxyketones
- 17.11 The Dehydration of Aldol Addition Products Forms α,β-Unsaturated Aldedydes and Ketones
- 17.12 A Crossed Aldol Addition
- 17.13 A Claisen Condensation Forms a β-Keto Ester
- 17.14 Other Crossed Condensations
- 17.15 Intramolecular Condensation and Intramolecular Aldol Additions
- 17.16 The Robinson Annulation
- 17.17 CO_2 Can be Removed from a Carboxylic Acid that has a Carbonyl Group at the 3-Position
- 17.18 The Malonic Ester Synthesis: A Way to Synthesize a Carboxylic Acid
- 17.19 The Acetoacetic Ester Synthesis: A Way to Synthesize a Methyl Ketone
- 17.20 Designing A Synthesis V: Making New Carbon-Carbon Bonds

- 17.21 Reactions at the α-Carbon in Living Systems
- 17.22 Organizing What We Know About the Reactions of Organic Compounds (Group III)

Part 6: Aromatic Compounds

Chapter 18: Reactions of Benzene and Substituted Benzenes

- 18.1 The Nomenclature of Monosubstituted Benzenes
- 18.2 The General Mechanism for Electrophilic Aromatic Substitution Reactions
- 18.3 Halogenation of Benzene
- 18.4 Nitration of Benzene
- 18.5 Sulfonation of Benzene
- 18.6 Friedel-Crafts Acylation of Benzene
- 18.7 Friedel-Crafts Alkylation of Benzene
- 18.8 Alkylation of Benzene by Acylation-Reduction
- 18.9 Using Coupling Reactions to Alkylate Benzene
- 18.10 How Some Substituents on a Benzene Ring Can Be Chemically Changed
- 18.11 The Nomenclature of Disubstituted and Polysubstituted Benzenes
- 18.12 The Effect of Substituents on Reactivity
- 18.13 The Effect of Substituents on Orientation
- 18.14 The Ortho-Para Ratio
- 18.15 Additional Considerations Regarding Substituent Effects
- 18.16 Designing A Synthesis VI: The Synthesis of Monosubstituted and Disubstituted Benzenes
- 18.17 The Synthesis of Trisubstituted Benzenes
- 18.18 The Synthesis of Substituted Benzenes Using Arenediazonium Salts
- 18.19 Azobenzenes
- 18.20 The Mechanism for the Formation of a Diazonium Ion
- 18.21 Nucleophilic Aromatic Substitution
- 18.22 Designing A Synthesis VII: The Synthesis of Cyclic Compounds

Chapter 19: More about Amines: Reactions of Heterocyclic Compounds

- 19.1 More About Nomenclature
- 19.2 More About the Acid-Base Properties of Amines
- 19.3 Amines React as Bases and as Nucleophiles
- 19.4 Synthesis of Amines
- 19.5 Aromatic Five-Membered-Ring Heterocycles
- 19.6 Aromatic Six-Membered-Ring Heterocycles
- 19.7 Some Heterocyclic Amines Have Important Roles in Nature
- 19.8 Organizing What We Know About the Reactions of Organic Compounds (Group IV)

Part 7: Bioorganic Compounds

Chapter 21: The Organic Chemistry of Carbohydrates (Optional)

Chapter 21: The Organic Chemistry of Amino Acids, Peptides, and Proteins (optional)

- 21.1 The Nomenclature of Amino Acids
- 21.2 The Configuration of Amino Acids
- 21.3 Acid-Base Properties of Amino Acids
- 21.4 The Isoelectric Point
- 21.5 Separating Amino Acids
- 21.6 Synthesis of Amino Acids
- 21.7 Resolution of Racemic Mixture of Amino Acids
- 21.8 Peptide Bonds and Disulfide Bonds
- 21.9 Some Interesting Peptides
- 21.10 The Strategy of Peptide Bond Synthesis: N-Protection and C-Activation
- 21.11 Automated Peptide Synthesis
- 21.12 An Introduction to Protein Structure
- 21.13 How to Determine the Primary Structure of a Polypeptide or Protein
- 21.14 Secondary Structure
- 21.15 Tertiary Structure
- 21.16 Quaternary Structure
- 21.17 Protein Denaturation

Chapter 23: Catalysis (optional)

Notes to Instructors

None.

ADA Statement (PDF)
Title IX Statement (PDF)