

# Virginia Western Community College

## CHM 242

### Organic Chemistry II

#### Prerequisites

CHM 241

#### 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 other functional group organic molecules.
- Understand the relationship between the structure of organic compounds and their physical and chemical properties.
- Synthesize all classes of organic compounds from simpler molecules.
- Predict the products obtained in different organic reactions.
- Understand the mechanistic pathways through which different classes of organic reactions proceed.

#### Topical Description

##### Part 3: Substitution and Elimination Reactions

##### 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

#### Part 4: Identification of Organic Compounds

##### Chapter 14: Mass Spectrometry, Infrared Spectroscopy, and Ultraviolet/Visible Spectroscopy

- 14.1 Mass Spectrometry
- 14.2 The Mass Spectrum / Fragmentation
- 14.3 Using the  $m/z$  of the Molecular Ion to Calculate the Molecular Formula
- 14.4 Isotopes in Mass Spectrometry
- 14.5 High-Resolution Mass Spectrometry Can Reveal Molecular Formulas
- 14.6 The Fragmentation Patterns of Functional Groups
- 14.7 Other Ionization Methods
- 14.8 Gas Chromatography-Mass Spectrometry
- 14.9 Spectroscopy and the Electromagnetic Spectrum
- 14.10 Infrared Spectroscopy
- 14.11 Characteristic Infrared Absorption Bands
- 14.12 The Intensity of Absorption Bands
- 14.13 The Position of Absorption Bands
- 14.14 The Position and Shape of an Absorption Band is Affect by Electron Delocalization, Electron Donation and Withdrawal, and Hydrogen Bonding
- 14.15 Absence of Absorption Bands
- 14.16 Some Vibrations are Infrared Inactive
- 14.17 How to Interpret an Infrared Spectrum
- 14.18 Ultraviolet and Visible Spectroscopy
- 14.19 The Beer-Lambert Law
- 14.20 The Effect of Conjugation on  $\lambda_{\text{max}}$
- 14.21 The Visible Spectrum and Color
- 14.22 Some Uses of UV/Vis Spectroscopy

##### Chapter 15: NMR Spectroscopy

- 15.1 An Introduction to NMR Spectroscopy
- 15.2 Fourier Transform NMR
- 15.3 Shielding Causes Different Hydrogens to Show Signals at Different Frequencies
- 15.4 The Number of Signals in an  $^1\text{H}$  NMR Spectrum
- 15.5 The Chemical Shift Tells How Far the Signal is from the Reference Signal
- 15.6 The Relative Positions of  $^1\text{H}$  NMR Signals
- 15.7 The Characteristic Values of Chemical Shifts
- 15.8 Diamagnetic Anisotropy
- 15.9 The Integration of NMR Signals Reveals the Relative Number of Protons Causing Each Signal
- 15.10 The Splitting of the Signals is Described by the  $N + 1$  Rule
- 15.11 What Causes Splitting?
- 15.12 More Examples of  $^1\text{H}$  NMR Spectra
- 15.13 Coupling Constants Identify Coupled Protons
- 15.14 Splitting Diagrams Explain the Multiplicity of a Signal

- 15.15 Diastereotopic Hydrogens are Not Chemically Equivalent
- 15.16 The Time Dependence of NMR Spectroscopy
- 15.17 Protons Bonded to Oxygen and Nitrogen
- 15.18 The Use of Deuterium in  $^1\text{H}$  NMR Spectroscopy
- 15.19 The Resolution of  $^1\text{H}$  NMR Spectra
- 15.20  $^{13}\text{C}$  NMR Spectroscopy
- 15.21 DEPT  $^{13}\text{C}$  NMR Spectra
- 15.22 Two-Dimensional NMR Spectroscopy
- 15.23 NMR Used in Medicine is Called Magnetic Resonance Imaging
- 15.24 X-Ray Crystallography

### Part 5: Carbonyl Compounds

#### Chapter 16: Reactions of Carboxylic Acids and Carboxylic Acid Derivatives

- 16.1 The Nomenclature of Carboxylic Acids and Carboxylic Acid Derivatives
- 16.2 The Structures of Carboxylic Acids and Carboxylic Acid Derivatives
- 16.3 The Physical Properties of Carbonyl Compounds
- 16.4 Fatty Acids are Long-Chain Carboxylic Acids
- 16.5 How Carboxylic Acids and Carboxylic Acid Derivatives React
- 16.6 The Relative Reactivities of Carboxylic Acids and Carboxylic Acid Derivatives
- 16.7 The General Mechanism for Nucleophilic Addition-Elimination Reactions
- 16.8 The Reactions of Acyl Chlorides
- 16.9 The Reactions of Esters
- 16.10 Acid-Catalyzed Ester Hydrolysis and Transesterification
- 16.11 Hydroxide-Ion Promoted Ester Hydrolysis
- 16.12 How the Mechanism for Nucleophilic Addition-Elimination was Confirmed
- 16.13 Fats and oils are Triglycerides
- 16.14 Reactions of Carboxylic Acid
- 16.15 Reactions of Amides
- 16.16 Acid Catalyzed Amide Hydrolysis and Alcoholysis
- 16.17 Hydroxide-Ion Promoted Hydrolysis of Amides
- 16.18 The Hydrolysis of an Imide: A Way to Synthesize Primary Amines
- 16.19 Nitriles
- 16.20 Acid Anhydrides
- 16.21 Dicarboxylic Acids
- 16.22 How Chemists Activate Carboxylic Acids
- 16.23 How Cells Activate Carboxylic Acids

#### Chapter 17: Reactions of Aldehydes and Ketones / More Reactions of Carboxylic Acid Derivatives / Reactions of $\alpha,\beta$ -Unsaturated Carbonyl Compounds

- 17.1 The Nomenclature of Aldehydes and Ketones
- 17.2 The Relative Reactivities of Carbonyl Compounds
- 17.3 How Aldehydes and Ketones React
- 17.4 The Reactions of Carbonyl Compounds with Grignard Reagents
- 17.5 The Reactions of Carbonyl Compounds with Acetylide Ions

- 17.6 The Reactions of Carbonyl Compounds with Cyanide Ion
- 17.7 The Reactions of Carbonyl Compounds with Hydride Ion
- 17.8 More About Reduction Reactions
- 17.9 Chemoselective Reactions
- 17.10 The Reactions of Aldehydes and Ketones with Amines
- 17.11 The Reactions of Aldehydes and Ketones with Water
- 17.12 The Reactions of Aldehydes and Ketones with Alcohols
- 17.13 Protecting Groups
- 17.14 The Addition of Sulfur Nucleophiles
- 17.15 The Reactions of Aldehydes and Ketones with Peroxyacid
- 17.16 The Wittig Reaction Forms An Alkene
- 17.17 Designing a Synthesis IV: Disconnections, Synthons, and Synthetic Equivalents
- 17.18 Nucleophilic Addition to  $\alpha,\beta$ -Unsaturated Aldehydes & Ketones
- 17.19 Nucleophilic Addition to  $\alpha,\beta$ -Unsaturated Carboxylic Acid Derivatives

#### Chapter 18: Reactions at the $\alpha$ -Carbon of Carbonyl Compounds

- 18.1 The Acidity of an  $\alpha$ -Hydrogen
- 18.2 Keto-Enol Tautomers
- 18.3 Keto-Enol Interconversion
- 18.4 Halogenation of the  $\alpha$ -Carbon of Aldehydes and Ketones
- 18.5 Halogenation of the  $\alpha$ -Carbon Carboxylic Acids: The Hell-Volhard-Zelinski Reaction
- 18.6 Formation of Enolate Ion
- 18.7 Alkylating the  $\alpha$ -Carbon of Carbonyl Compounds
- 18.8 Alkylating the  $\alpha$ -Carbon Using an Enamine Intermediate
- 18.9 Alkylating the  $\beta$ -Carbon: The Michael Reaction
- 18.10 An Aldol Addition Forms  $\beta$ -Hydroxyaldehydes or  $\beta$ -Hydroxyketones
- 18.11 The Dehydration of Aldol Addition Products Form  $\alpha,\beta$ -Unsaturated Aldehydes and Ketones
- 18.12 The Crossed Aldol Addition
- 18.13 A Claisen Condensation Forms a  $\beta$ -Keto Ester
- 18.14 Other Crossed Condensations
- 18.15 Intramolecular Condensation and Intramolecular Aldol Additions
- 18.16 The Robinson Annulation
- 18.17 Carboxylic Acids with a Carbonyl Group at the 3-Position Can Be Decarboxylated
- 18.18 The Malonic Ester Synthesis: A Way to Synthesize a Carboxylic Acid
- 18.19 The Acetoacetic Ester Synthesis: A Way to Synthesize a Methyl Ketone
- 18.20 Designing A Synthesis V: Making New Carbon-Carbon Bonds
- 18.21 Reactions at the  $\alpha$ -Carbon in Biological Systems
- 18.22 Organizing What We Know About the Reactions of Organic Compounds

Part 6: Aromatic CompoundsChapter 19: Reactions of Benzene and Substituted Benzenes

- 19.1 The Nomenclature of Monosubstituted Benzenes
- 19.2 How Benzene reacts
- 19.3 The General Mechanism for Electrophilic Aromatic Substitution Reactions
- 19.4 The Halogenation of Benzene
- 19.5 The Nitration of Benzene
- 19.6 The Sulfonation of Benzene
- 19.7 The Friedel-Crafts Acylation of Benzene
- 19.8 The Friedel-Crafts Alkylation of Benzene
- 19.9 The Alkylation of Benzene by Acylation-Reduction
- 19.10 Using Coupling Reactions to Alkylate Benzene
- 19.11 It is Important to have More than One Way to Carry Out a Reaction
- 19.12 How Some Substituents on a Benzene Ring Can Be Chemically Changed
- 19.13 The Nomenclature of Disubstituted and Polysubstituted Benzenes
- 19.14 The Effect of Substituents on Reactivity
- 19.15 The Effect of Substituents on Orientation
- 19.16 The Effect of Substituents on  $pK_a$
- 19.17 The Ortho-Para Ratio
- 19.18 Additional Considerations Regarding Substituent Effects
- 19.19 The Synthesis of Monosubstituted and Disubstituted Benzenes
- 19.20 The Synthesis of Trisubstituted Benzenes
- 19.21 The Synthesis of Substituted Benzenes Using Arenediazonium Salts
- 19.22 The Arenediazonium Ion as an Electrophile
- 19.23 The Mechanism for the Reaction of Amines with Nitrous Acid
- 19.24 Nucleophilic Aromatic Substitution: An Addition-Elimination Reaction
- 19.25 The Synthesis of Cyclic Compounds

Chapter 20: More about Amines: Reactions of Heterocyclic Compounds

- 20.1 More About Amine Nomenclature
- 20.2 More About the Acid-Base Properties of Amines
- 20.3 Amines React as Bases and as Nucleophiles
- 20.4 The Synthesis of Amines
- 20.5 Aromatic Five-Membered-Ring Heterocycles
- 20.6 Aromatic Six-Membered-Ring Heterocycles
- 20.7 Some Amine Heterocycles Have Important Roles in Nature
- 20.8 Organizing What We Know About the Reactions of Organic Compounds

Part 8: Bioorganic CompoundsChapter 21: The Organic Chemistry of Carbohydrates

- 21.1 The Classification of Carbohydrates
- 21.2 The D and L Notation
- 21.3 The Configurations of Aldoses
- 21.4 The Configurations of Ketoses
- 21.5 The Reactions of Monosaccharides in Basic Solutions
- 21.6 The Oxidation-Reduction Reactions of Monosaccharides
- 21.7 Lengthening the Chain: The Kiliani-Fischer Synthesis
- 21.8 Shortening the Chain: The Wohl Degradation
- 21.9 The Stereochemistry of Glucose: The Fischer Proof
- 21.10 Monosaccharides Form Cyclic Hemiacetals
- 21.11 Glucose Is the Most Stable Aldohexose
- 21.12 Formation of Glycosides
- 21.13 The Anomeric Effect
- 21.14 Reducing and Nonreducing Sugars
- 21.15 Disaccharides
- 21.16 Polysaccharides
- 21.17 Some Naturally Occurring Products Derived From Carbohydrates
- 21.18 Carbohydrates on Cell Surfaces
- 21.19 Artificial Sweeteners

Chapter 22: The Organic Chemistry of Amino Acids, Peptides, and Proteins

- 22.1 The Nomenclature of Amino Acids
- 22.2 The Configuration of Amino Acids
- 22.3 The Acid-Base Properties of Amino Acids
- 22.4 The Isoelectric Point
- 22.5 Separating Amino Acids
- 22.6 The Resolution of Racemic Mixture of Amino Acids
- 22.8 Peptide Bonds and Disulfide Bonds
- 22.9 Some Interesting Peptides
- 22.10 The Strategy of Peptide Bond Synthesis: N-Protection and C-Activation
- 22.11 Automated Peptide Synthesis
- 22.12 An Introduction to Protein Structure
- 22.13 How to Determine the Primary Structure of a Polypeptide or Protein
- 22.14 Secondary Structure
- 22.15 Tertiary Structure
- 22.16 Quaternary Structure
- 22.17 Protein Denaturation

Chapter 23: Catalysis

- 23.1 Catalysis in Organic Reactions
- 23.2 Acid Catalysis

- 23.3 Base Catalysis
- 23.4 Nucleophilic Catalysis
- 23.5 Metal-Ion Catalysis
- 23.6 Intramolecular Reactions
- 23.7 Intramolecular Catalysis
- 23.8 Catalysis in Biological Reactions

### **Notes to Instructors**

None.