

## **COURSE OUTLINE** Organic Chemistry I

**Course Description:** CH240. Organic Chemistry I. 5 hours credit. Prerequisite: CH115. Three single lecture/discussion periods and four hours of laboratory periods per week. A study of beginning organic chemistry with emphasis on aliphatic and aromatic compounds.

**Course Relevance:** The impact of chemistry in everyday life is phenomenal. The ability to see chemistry in action on the micro (molecular) and macro scale is necessary to develop a fuller knowledge and understanding of the world around us. Chemistry will enrich the student's appreciation of the world and help him/her better understand the studies of science and the scientific methods.

### **Required Materials:**

Textbook: Solomons, (2000) *Organic Chemistry* (7<sup>th</sup> Ed.) Wiley and Son

Laboratory Notebook purchased from the BCCC Bookstore.

Laboratory Manual: CD-ROM available from instructor.

### **Learning Outcomes:**

The intention is for the student to be able to analyze scientific materials in various forms demonstrating:

1. An understanding of the scientific method
2. An ability to read, communicate and understand scientific materials
3. Knowledge of basic math skills
4. An ability to apply scientific reasoning to real world problems

### **Primary Learning PACT Skill(s) that will be DEVELOPED and/or documented in this course:**

Through the student involvement in this course, he/she will develop his/her ability in the following PACT skill areas:

1. Critical thinking
  - The student will demonstrate scientific reasoning through a variety of mathematical, graphical, experimental, and written assignments.
2. Writing
  - The student will write laboratory reports, which include observations, and analysis of the experiment.
  - The student will write a research paper on an approved topic in chemistry.

Secondary skills (developed but not documented)

- Speaking
- Computer literacy
- Internet use
- Teamwork
- Ethical conduct

### **Major Summative Assessment Task(s):**

These learning outcomes and the primary learning PACT skills will be demonstrated by:

1. Write laboratory reports, including purpose, procedural, observations, and analysis of the experiment using scientific reasoning
2. Writing a research paper upon a topic of the student's choice related to chemistry
3. Final assessment of the course using the ACS standardized exam

### **Course Content:**

- I. Themes - Key recurring concepts that run throughout the course:
  - A. Scientific method
  - B. Scientific reasoning
- II. Issues - Key issues that will be addressed in this course: areas of conflict that must be understood in order to achieve the intended outcome:
  - A. The balance between the conceptual and mathematical models
  - B. The cumulative nature of science and the world
  - C. The cumulative influence of scientific discoveries and the subsequent application of the discoveries
  - D. The balance between "wet" lab chemistry and computer interfacing, collection and analysis of data
- III. Concepts – Key concepts that must be understood to address the issues:
  - A. Mathematics
  - B. Visual/conceptual
  - C. Scientific Methods
  - D. Scientific Reasoning
  - E. Modeling
  - F. Scientific writing
  - G. Scientific principles
  - H. MLA writing format
  - I. Word processing
  - J. Excel spreadsheet
  - K. Graphing
  - L. Characteristics and impact of science in the world around them
- IV. Skills/Competencies - Actions that are essential to achieve the course outcomes:
  - A. Mathematics
  - B. Writing
  - C. Reading
  - D. Speaking
  - E. Computer Literacy
  - F. Computer Spreadsheet/Graphing
  - G. Internet Use
  - H. Teamwork

### **Learning Units**

- I. Lecture
  - A. Structure and Properties
    1. Describe the structural theory of organic chemistry

2. Write Lewis dot structures
  3. Apply the octet rules and the exceptions
  4. Determine formal charges and resonance structures
  5. Apply VSEPR and hybridization to compounds
  6. Draw representation of structural formulas
- B. Representative carbon compounds
1. Identify and draw hydrocarbons: alkanes, alkenes, alkynes and aromatics
  2. Determine polar and nonpolar molecules
  3. Identify functional groups
  4. Describe physical properties and molecular structure
  5. Identify functional groups using the Infrared Spectroscopy
- C. Acid-Base reactions
1. Define an acid, base and describe an acid-base reaction
  2. Describe homolysis and heterolysis
  3. Describe the relative strength of acids and bases
  4. Discuss the effects of solvents on acidity
  5. Demonstrate an understanding of a basic mechanism for an organic reaction
- D. Alkanes and cycloalkanes
1. Describe the molecular structure of alkanes
  2. Name alkanes, alcohols, alkyl halides, alkenes, cycloalkanes, and alkynes using IUPAC nomenclature
  3. State the physical properties of alkanes and cycloalkanes
  4. Discuss and give examples of ring strain, angle strain, and torsional strain
  5. Demonstrate an understanding of trans-cis isomerism
  6. Write chemical reactions of alkanes
  7. Write reactions for the synthesis of alkanes and cycloalkanes
  8. Develop an understanding for retrosynthetic analysis in planning an organic synthesis
- E. Stereochemistry: Chiral Molecules
1. Describe plane-polarized light, polarimeter, optically active or optically inactive, observed rotation, specific rotation, dextrorotatory and levorotatory
  2. Identify chiral, achiral, enantiomers, planes of symmetry, superimposable and nonsuperimposable mirror images and racemic mixtures
  3. Identify asymmetric carbon atoms, chiral centers, R-S convention, priority order and E-Z conventions
  4. Describe the meaning of diastereomers, meso compounds and resolution to lactic acid and tartaric acid
  5. Given the concentration of an optically compound, length of the polarimeter tube, and observed rotation, calculate the specific rotation. Given any three of the four quantities mentioned, calculate the fourth
  6. Given the structural formula, draw it in 3-D and locate any plane of symmetry
  7. Given the structure of a compound, state if any chiral centers are present

- Given the structure or name of a compound, state whether it is capable of optical activity
- State the rules for establishing priority orders of groups in the R-S convention
- Given a chiral center in a molecule, assign the R or S configuration to it
- Draw the 3-D formula of a molecule with a particular configuration, R or S
- Given a structure with more than one chiral center, tell how many stereoisomers are possible and draw the structure of each
- State whether or not a particular structure can exist as a meso form
- Given a structure with two or more identical chiral centers, draw the structure of the meso form
- Given a pair of stereoisomers, classify them as configurational or conformation, chiral or achiral, and enantiomers or diastereomers

F. Ionic Reactions: S<sub>N</sub> and E<sub>1</sub> reactions of alkyl halides

- Define nucleophilic substitution reaction, substrate and leaving group
- Write examples of nucleophilic substitution reactions
- Write S<sub>N</sub>2 mechanism, inversion of configuration, S<sub>N</sub>1 mechanism, racemization, rate-determining step, E<sub>2</sub> and E<sub>1</sub> mechanisms
- Given the name of an alkyl halide of a polyhalogen compound, write its structural formula
- Given the structural formula of an alkyl halide, write the correct name for it
- Write the reactions for the preparation of alkyl halides
- Write the reactions of alkyl halides
- Given the structure of an alkyl halide and a nucleophile, write the equations that illustrate the formation of both the substitution and elimination products, and be able to predict with path is likely to be favored
- State the stereochemical outcome of S<sub>N</sub>1 and S<sub>N</sub>2 substitutions and of E<sub>1</sub> and E<sub>2</sub> eliminations
- Given an alkyl halide with a particular stereochemistry, a nucleophile, and reactions conditions, predict the stereochemistry of the product of nucleophilic substitution
- Combine nucleophilic substitutions with previously studied reactions to devise a multi-step synthesis of a given product

G. Alkenes and Alkynes: addition reactions

- Write (E) and (Z) conformations of alkene diastereomers
- Write reactions for the synthesis of alkenes by dehydrohalogenation
- State the properties of a carbocation reaction
- Write reactions for the synthesis of alkynes through replacements of the terminal hydrogen, hydrogenation of alkenes
- Discuss various reaction of alkynes
- Discuss all mechanisms for the above in detail

H. Alkenes and Alkynes: addition reactions

- Draw the mechanisms and understand the stereochemistry for the following reactions

2. Write reactions and mechanisms for the addition of hydrogen halides, sulfuric acid, addition of bromine and chlorine and the hydration reaction
3. Write reactions for the oxidation of alkenes and alkynes

#### I. NMR and MS

1. Explain the electromagnetic spectrum
2. Discuss and interpret in detail NMR, including spin, shielding and deshielding of protons, chemical shifts of equivalent and nonequivalent protons and signal splitting
3. Interpret carbon-13 NMR spectroscopy
4. Discuss and interpret in detail the mass spectrometer, determination of molecular formulas, molecular weights, and fragmentations
5. Discuss and interpret in detail GC/MS analysis

#### J. Free Radical Reactions

1. Explain a homolytic bond
2. Write the mechanism for the halogenation of alkanes
3. Write the mechanism for the anti-Markovnikov addition of a hydrogen halide
4. Describe other important radical reactions

#### K. Alcohols

1. Describe oxymercuration-demercuration
2. Describe hydroboration-oxidation
3. Describe the reaction for epoxides
4. Describe antihydroxylation of alkenes via epoxides

#### L. Aromatics

1. Define a Kekulé structure, benzene resonance hybrid, resonance or stabilization energy
2. Define ortho, meta, para, phenyl group, benzyl group, benzene, toluene, and arenes
3. Describe electrophilic substitution halogenation, nitration, sulfonation, alkylation, and Friedel-Crafts reactions
4. Name and write structures for aromatic compounds, especially monosubstituted and disubstituted benzenes and toluenes
5. Given the reactants, write the structures of the main organic products of the common electrophilic aromatic substitution reactions
6. Write the steps in the mechanism for an electrophilic aromatic substitution reaction
7. Draw the structures of the main contributors to the benzenonium ion resonance hybrid
8. Draw the structures of the main contributors to substituted benzenonium ions, and tell whether the substituent stabilizes or destabilizes the ion
9. State which groups are ortho, meta, or para directing, and explain why each group directs the way it does

10. Given two successive electrophilic aromatic substitution reaction, write the structure of the product, with substituents in the correct locations on the ring
11. Given a disubstituted or trisubstituted benzene, deduce the correct sequence in which to carry out electrophilic substitutions to give the product with the desired orientation
12. Apply Huckel rule to tell whether or not a particular cyclic unsaturated compound is aromatic

## II. Laboratory

- A. Working in the laboratory in accordance with good laboratory practices
  1. Dress in an appropriate manner as to promote safety in the laboratory, wearing a lab coat and goggles when anyone is working with chemicals in the laboratory
  2. Follow written directions accurately
  3. Work safely and effectively, using equipment and chemicals carefully and correctly
  4. Demonstrate use of required safety and common laboratory techniques
  5. Dispose of waste products in a proper manner
- B. Gather and record qualitative and quantitative data accurately
  1. Acquire data using balances and volumetric glassware
  2. Make and record visual observations
  3. Use computers, when appropriate, as data acquisition tools
  4. List or describe experimental assumptions made and any deviations from the written experimental procedures
- C. Handle and evaluate data in logical, productive, and meaningful ways
  1. Create notebooks and laboratory reports that are clear, understandable, and accurately represent the data collected
  2. Display computer data in a spreadsheet or graphically, as appropriate
  3. Correlate observations with chemical or physical processes
  4. Carry out suitable calculations with quantitative data, recognizing when data and calculations are within a reasonable range
  5. Use observations of experimental data to present relevant conclusions pertaining to the experimental procedure
- D. Correlate laboratory work with principal topics in Organic I lecture

### **Learning Activities:**

Independent and collaborative learning activities will be assigned within and outside the classroom and laboratory to achieve the intended course outcomes. Classroom discussion, lecture, and textbook reading assignments will also contribute to the learning process.

### **Grade Determination:**

Grade determination may include tests, projects, quizzes, homework, written assignments and laboratory experiments. Other methods may be used at the discretion of the instructor.