Date Adopted: July 1, 1998
Date Reviewed: December 1, 1999
Date Revised: 1999, 2007, 2011

Alabama Department of Postsecondary Education

Representing Alabama's Public Two-Year College System

Jefferson State Community College

CHM 221
Organic Chemistry I

I. CHM 221 Organic Chemistry I - Prerequisite CHM 112
Credit Hours: 4 Contact Hours: (Lec 3 hrs), (Lab 3 hrs)

II. Course Description

This course is the first in a two-semester sequence. Topics include nomenclature, structure, physical and chemical properties, synthesis, and typical reactions for aliphatic, alicyclic, and aromatic compounds with special emphasis on reaction mechanisms, spectroscopy, and stereochemistry. Laboratory is required and will include the synthesis and confirmation of representative organic compounds with emphasis on basic techniques.

III. Textbook

Organic Chemistry, 8th Edition, McMurry, Brooks/Cole

IV. General Course Competencies

After completing CHM 221, Organic Chemistry I, the student will be able to

A. describe how the structure of a chemical compound affects the physical and chemical properties of a compound.
B. demonstrate an understanding of reactions involving alkanes including nomenclature, stereochemistry, thermodynamics and kinetics.
C. demonstrate an understanding of reactions involving unsaturated compounds including nomenclature, stereochemistry, synthesis and mechanisms.
D. demonstrate an understanding of reactions involving alkyl halides including nomenclature, synthesis, stereochemistry and mechanisms.
E. demonstrate an understanding of the basis and applications of spectroscopic techniques including

mass spectroscopy, infrared spectroscopy, and nuclear magnetic resonance.

F. describe the characteristics structurally, chemically and spectroscopically of conjugated dienes and aromatic compounds.

V. Course Objectives

The student will be required to demonstrate that he has attained each general course competency by performing the objectives listed under each competency.

A. Describe how the structure of a chemical compound affects the physical and chemical properties of a compound.

1. Predict the ground state electronic configuration of atoms.
2. Draw Lewis electron-dot structures of simple compounds.
3. Predict and describe the hybridization of bonds in simple compounds.
4. Predict bond angles and shapes of molecules.
5. Predict the direction of polarity of a chemical bond, and predict the dipole moment of a simple compound.
6. Calculate formal charge for atoms in a molecule.
7. Draw resonance forms of molecules.
8. Predict the relative acid/base strengths of Bronsted acids and bases.
9. Predict the direction of Bronsted acid/base reactions.
10. Calculate: pK_a from K_a, and vice versa;
    pH of a solution of a weak acid.
11. Identify Lewis acids and bases.
12. Draw chemical structures from molecular formulas, and vice versa.

B. Demonstrate an understanding of reactions involving alkanes including nomenclature, stereochemistry, thermodynamics and kinetics.

1. Identify functional groups, and draw molecules containing a given functional group.
2. Draw all isomers of a given molecular formula.
3. Name and draw alkanes, alkyl groups, and cycloalkanes, including cis-trans isomers.
4. Identify carbons and hydrogens as being primary, secondary or tertiary.
5. Draw energy vs. angle of rotation graphs for single bond conformations.
6. Draw Newman projections of bond conformations and predict their relative stability.
7. Understand the geometry of, and predict the stability of, cycloalkanes having fewer than 6 carbons.
8. Draw and name substituted cyclohexanes.
9. Predict the stability of substituted cyclohexanes by estimating steric interactions.
10. Identify reactions as polar, radical, substitution, elimination, addition, or rearrangement reactions.
11. Understand the mechanism of radical reactions.
12. Identify reagents as electrophiles or nucleophiles.
13. Calculate K_{eq} and ΔG^o of reactions, and use bond dissociation energies to calculate ΔH^o of reactions.
14. Draw reaction energy diagrams and label them properly.

C. Demonstrate an understanding of reactions involving unsaturated compounds including nomenclature, stereochemistry, synthesis and mechanisms.

1. Calculate the degree of unsaturation of any compound, including those containing N, O, and

halogens.
2. Name acyclic and cyclic alkenes and alkynes, and draw structures corresponding to names.
3. Assign *E, Z* priorities to groups.
4. Assign cis-trans and *E, Z* designations to double bond.
5. Predict the relative stability of alkene double bonds.
6. Formulate mechanisms of electrophilic addition reactions.
7. Predict the products of reactions involving alkenes and alkynes.
8. Choose the correct alkene or alkyne starting material to yield a given product.
9. Deduce the structure of an alkyne from its molecular formula and products of cleavage.
10. Carry out syntheses involving alkenes and alkynes.

D. Demonstrate an understanding of reactions involving alkyl halides including nomenclature, synthesis, stereochemistry and mechanisms.

1. Calculate the specific rotation of an optically active compound.
2. Locate chirality centers, assign priorities to substituents, and assign R, S designations to chirality centers.
3. Given a stereoisomer, draw its enantiomer and/or disatereomers.
4. Locate the symmetry plane of a meso compound.
5. Manipulate Fischer projections to see if they are identical.
6. Assign R, S designations to Fischer projections.
7. Predict the stereochemistry of reaction products.
8. Draw, name and synthesize alkyl halides.
9. Understand the mechanism of radical halogenation and the stability order of radicals.
10. Prepare Grignard reagents and dialkylcopper reagents and use them in synthesis.
11. Predict the oxidation level of a compound.
12. Formulate the mechanisms of S_N2, S_N1 and elimination reactions.
13. Predict the effects of substrate, nucleophile, leaving group and solvent on substitution and elimination reactions.
14. Predict the products of substitution and elimination reactions.
15. Classify substitution and elimination reactions by type.

E. Demonstrate an understanding of the basis and applications of spectroscopic techniques including mass spectroscopy (MS), infrared spectroscopy (IR) and nuclear magnetic resonance (NMR).

1. Write molecular formulas corresponding to a given molecular ion.
2. Use mass spectra to determine molecular weights and base peaks, to distinguish between hydrocarbons, and to identify selected functional groups by their fragmentation patterns.
3. Calculate the energy of electromagnetic radiation, and convert from wavelength to wavenumber and *vice versa.*
4. Identify functional groups by their infrared absorptions.
5. Use IR and MS to monitor reaction progress.
6. Calculate the relationship between delta value, chemical shift, and spectrometer operating frequency.
7. Identify nonequivalent carbons and hydrogens, and predict the number of signals appearing in the ^{1}H NMR and ^{13}CNMR spectra of compounds.
8. Assign resonances to specify carbons or hydrogens of a given structure.
9. Propose structures for compounds, given their NMR spectra.
10. Predict splitting patterns, using tree diagrams if necessary.
11. Use NMR to distinguish between isomers and to identify reaction products.

F. Describe the characteristics structurally, chemically and spectroscopically of conjugated dienes

and aromatic compounds.

1. Predict the products of electrophilic addition to conjugated molecules.
2. Understand the concept of kinetic *vs.* thermodynamic control of reactions.
3. Recognize diene polymers, and draw a representative segment of a diene polymer.
4. Predict the products of Diels-Alder reactions, and identify compounds that are good dienophiles and good dienes.
5. Calculate the energy required for UV absorption, and use molar absorptivity to calculate concentration.
6. Predict if and where a compound absorbs in the ultraviolet region.
7. Name and draw substituted benzenes.
8. Draw resonance structures and molecular orbital diagrams for benzene and other cyclic conjugated molecules.
9. Use Huckel's rule to predict aromaticity.
10. Draw orbital pictures of cyclic conjugated molecules.
11. Use NMR and IR and UV data to deduce the structures of aromatic compounds.
12. Predict the products of electrophilic aromatic substitution reactions.
13. Formulate the mechanisms of electrophilic aromatic substitution reactions.
14. Understand the activating and directing affects of substituents on aromatic rings, and use inductive and resonance arguments to predict orientation and reactivity.
15. Predict the products of other reactions of aromatic compounds.
16. Synthesize substituted benzenes.

Organic Chemistry Laboratory

General Objectives

The student will be able to perform basic laboratory operations necessary for success in an organic laboratory.

A. Follow the given format in writing laboratory reports.
B. Use the Handbook of Chemistry and Physics to obtain the information required in writing laboratory reports.
C. Calculate the theoretical yield and the percent yield for experiments where such calculations are appropriate.
D. Bend glass tubing, bore corks and rubber stoppers, use the Mel-Temp or Fisher-Johns apparatus to determine melting points, use a polarimeter, pack a distilling column, construct a safety bottle, and use a rotary evaporator. In addition, properly pack a capillary melting point tube, use a separatory funnel and set up a distillation apparatus.

General Course Objectives

The student will be able to answer the following questions related to the performance of each of the specific laboratories performed during the course.

A. Melting points of pure substances and mixtures
    1. Given weight of the components of several mixtures and the melting points of each mixture, the student will be able to calculate mole fractions of each component in the mixture and prepare a graph of melting point versus mole fraction.
B. Crystallization
    1. Describe the types of impurities generally encountered in purification of solids by recrystallization.
    2. Describe the factors to be considered in the selection of a suitable solvent for use in a recrystallization.
    3. Explain the reasons for use of decolorizating carbon and celite in recrystallizations.
C. Extraction

1. What is a distribution coefficient?
2. What factors must be considered in selection of a solvent for extraction uses?
3. Compare the efficiency of single versus multiple extractions.
4. Describe the effect of salts on solubility.

D. Simple distillation
1. Distinguish between a boiling point and a boiling temperature.
2. What is a minimum boiling azeotrope? A maximum boiling azeotrope?
3. What is the effect on the boiling point of soluble (nonvolatile) and insoluble impurities?

E. Fractional distillation
1. Given the necessary data, show how the number of theoretical plates in a packed column can be calculated.
2. What is meant by the "temperature gradient" of the column?

F. Optical activity: hydrolysis of sucrose
1. From experimental data, calculate the concentration of sucrose in a sample.
2. From experimental data, calculate the expected rotation for 100% inversion of sucrose.
3. From experimental data, calculate the percent inversion of sucrose.

G. Dehydration of an alkene

H. Preparation of alkyl halide
1. Explain why such milder conditions are necessary to prepare n-butyl chloride than to prepare the n-butyl bromide.
2. Discuss reactivity versus selectivity in halogenation reactions.

I. Preparation of ethanol by fermentation
1. Describe the reagents used, evidence of positive reaction, and interpretation of positive reactions for the following tests: iodoform, Lucas, and chromic anhydride (oxidation).
2. Describe the preparation of alcohol derivatives such as p-nitrobenzoates, 3.5 dinitrobenzoates and 1-naphtyl carbamates.

J. Substitution reaction of aromatic compounds
1. Halogenation
2. Nitration
3. Sulfonation
4. Friedel Crafts alkylation
5. Friedel Crafts acylation

K. Study of conjugated dienes by UV-VIS spectroscopy

VI. Class Activities

A. Lecture
1. Lecture
2. Discussion
3. Problem solving

B. Laboratory
1. Demonstrations
2. Problem solving
3. Experimentation

VII. Criteria For Evaluation

The student will have demonstrated attainment of the general course competencies if he accumulates a total of 70 percent of the points possible from the following criteria:

A. Participation in laboratory and class activities
B. Laboratory Reports/Class Homework
C. Written examinations
D. Final examinations

VIII. Attendance

Students are expected to attend all classes for which they are registered. Students who are unable to attend class regularly, regardless of the reason or circumstance, should withdraw from that class before poor attendance interferes with the student's ability to achieve the objectives required in the course. Withdrawal from class can affect eligibility for federal financial aid.

IX. Statement on Discrimination/Harassment

The College and the Alabama State Board of Education are committed to providing both employment and educational environments free of harassment or discrimination related to an individual's race, color, gender, religion, national origin, age, or disability. Such harassment is a violation of State Board of Education policy. Any practice or behavior that constitutes harassment or discrimination will not be tolerated.

X. Americans with Disabilities

The Rehabilitation Act of 1973 (Section 504) and the Americans with Disabilities Act of 1990 state that qualified students with disabilities who meet the essential functions and academic requirements are entitled to reasonable accommodations. It is the student's responsibility to provide appropriate disability documentation to the College. The ADA Accommodations office is located in FSC 300 (205-856-7731).