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## Course Outline for CHEM 12B

### ORGANIC CHEMISTRY II

Effective: Spring 2016

#### I. CATALOG DESCRIPTION:

CHEM 12B — ORGANIC CHEMISTRY II — 5.00 units

Continuation of Chemistry 12A with an introduction to the chemistry of aromatics, amines, enols and enolate ions, carboxylic acids, aldehydes, ketones and biochemical topics focusing on structure, synthesis and mechanisms of reaction. Laboratory work in basic techniques, synthetic methods, qualitative, spectroscopic, and chromatographic analysis techniques designed for students whose interests require a full year in-depth study of organic chemistry.

3.00 Units Lecture 2.00 Units Lab

#### Prerequisite

CHEM 12A - Organic Chemistry I  
with a minimum grade of C

#### Grading Methods:

Letter Grade

#### Discipline:

	<u>MIN</u>
<b>Lecture Hours:</b>	54.00
<b>Lab Hours:</b>	108.00
<b>Total Hours:</b>	162.00

#### II. NUMBER OF TIMES COURSE MAY BE TAKEN FOR CREDIT: 1

#### III. PREREQUISITE AND/OR ADVISORY SKILLS:

**Before entering the course a student should be able to:**

A. CHEM12A

#### IV. MEASURABLE OBJECTIVES:

**Upon completion of this course, the student should be able to:**

- A. Propose reasonable syntheses for compounds in the classes studied;
- B. Use spectroscopic information and data concerning reactions or physical properties to elucidate structures for compounds in the classes studied;
- C. Draw mechanistic pathways which illustrate how the products are obtained from the reactants;
- D. Evaluate kinetic data as a tool in elucidating the mechanism for a reaction;
- E. Name compounds of the classes studied;
- F. Carry out syntheses in the laboratory, using techniques developed in Chemistry 12A to monitor the progress of the reaction and the purity of the product;
- G. Identify an unknown organic compound in the laboratory by chemical methods;
- H. Utilize enols and enolate ions in proposing sophisticated syntheses;
  - I. Apply knowledge of organic reactions to biological processes;
- J. Perform vacuum distillation;
- K. Write a paper in chemistry journal style describing an experiment;
- L. Present an oral report on a research project (optional);
- M. Dispose of chemical waste properly.

#### V. CONTENT:

- A. Laboratory safety and proper disposal of waste materials
- B. Aromatics
  1. Review of aromaticity
  2. Reactions of benzene
  3. Electrophilic aromatic substitution mechanism, including reactivity and orientation
  4. Synthesis of substituted benzenes
  5. Electrophilic substitution in naphthalene
- C. Arenes and their derivatives
  1. Structure and properties
  2. Nomenclature

- 3. Reactions of alkyl benzenes
- 4. Preparation and reactions of alkenylbenzenes
- D. Aldehydes and ketones
  - 1. Structure and properties
  - 2. Nomenclature
  - 3. Laboratory preparations of aldehydes and ketones
  - 4. Reactions of aldehydes and ketones
  - 5. Detailed analysis of nucleophilic addition
  - 6. Multi-step syntheses of aldehydes, ketones, and related compounds
- E. Carboxylic acids
  - 1. Structure and properties
  - 2. Nomenclature
  - 3. Acidity and relationship to structure
  - 4. Laboratory preparations of carboxylic acids
  - 5. Reactions of carboxylic acids
- F. Functional derivatives of carboxylic acids
  - 1. Nucleophilic acyl substitution reactions, including relative rates
  - 2. Mechanism of nucleophilic acyl substitutions and comparison to alkyl nucleophilic substitution
  - 3. Structure, nomenclature, and laboratory preparations of acid chlorides, acid anhydrides, amides and esters
- G. Enols and enolate ions
  - 1. Aldol condensation
  - 2. Claisen condensation
  - 3. Wittig reactions
  - 4. Malonic ester synthesis of carboxylic acids
  - 5. Acetoacetic ester synthesis of ketones
  - 6. Conjugate addition to  $\alpha$ ,  $\beta$ -unsaturated carbonyls
  - 7. Use of the above reactions in multi-step synthesis
- H. Amines
  - 1. Structure and properties
  - 2. Nomenclature
  - 3. Relationship of structure to base strength
  - 4. Laboratory preparations of amines
  - 5. Reactions of amines
- I. Phenols
  - 1. Structure and properties
  - 2. Nomenclature
  - 3. Relationship of structure to acid strength
  - 4. Laboratory preparations of phenols
  - 5. Reactions of phenols
- J. Aryl Halides
  - 1. Structure and properties
  - 2. Nomenclature
  - 3. Laboratory preparations of aryl halides
  - 4. Reactions of aryl halides
  - 5. Mechanism of nucleophilic aromatic substitution
- K. Heterocyclic compounds
  - 1. Structure and properties of pyrrole, furan, thiophene, and pyridine
  - 2. Electrophilic substitution in heterocyclic compounds
  - 3. Nucleophilic substitution in pyridine
- L. Biomolecules
  - 1. Carbohydrates
    - a. Classifications, Fischer projections and configurations
    - b. Cyclic structures of monosaccharides, hemiacetal formation
    - c. Monosaccharide anomers and mutarotation
    - d. Reactions of monosaccharides (Kiliani-Fischer synthesis)
    - e. Disaccharides and polysaccharides
  - 2. Amino acids and proteins
    - a. Structure and properties of amino acids including isoelectric points
    - b. Peptide bonds
    - c. Peptide sequencing (Edman degradation and C-terminal residue determination techniques)
    - d. Peptide synthesis
    - e. Proteins: structure and denaturation
    - f. Enzymes
  - 3. Lipids
    - a. Structure and properties of waxes, fats, and oils
    - b. Structure and biosynthesis of terpenes and steroids
- M. New laboratory techniques: vacuum distillation, qualitative organic analysis, and multi-step synthesis

## VI. METHODS OF INSTRUCTION:

- A. Computer modeling of molecules, molecular orbitals (HOMO and LUMO), and electrostatic potential energy plots
- B. Computer simulations
- C. Hands-on laboratory work, both individually and in collaboration with others, including direct access to all instrumentation
- D. Collaborative learning
- E. Lecture, informal with student questions encouraged
- F. Problem solving exercises
- G. Individual research projects (at the option of the instructor)

## VII. TYPICAL ASSIGNMENTS:

- A. Read the chapter on ester enolates.
- B. Be prepared to predict the products of Claisen condensation reactions.
- C. Solve all the first thirteen problems at the end of the chapter on ester enolates.
- D. In the laboratory, prepare two compounds by different mechanisms from your assigned alcohol or alkyl halide.
  - 1. Describe your experimental results in two papers written in journal style.

## VIII. EVALUATION:

### A. Methods

- 1. Other:
  - 1. Quizzes and/or tests

2. A minimum of 5 formal written laboratory reports based on departmentally approved experiments and graded on criteria that may include the following
  - a. Description of experimental procedures
  - b. Completeness of data collected
  - c. Quality of data collected
  - d. Computational precision and accuracy
  - e. Accuracy and precision of experimental laboratory results
  - f. Proper use of symbolic notation
  - g. Quality of analysis of scientific principles explored
  - h. Quality of narrative explanations and reasoning
  - i. Representation of data in tables or diagrams
3. Written laboratory notebooks graded on criteria that may include the following
  - a. Description of experimental procedures
  - b. Completeness of data collected
  - c. Quality of data collected
  - d. Computational precision and accuracy
  - e. Accuracy and precision of experimental laboratory results
  - f. Proper use of symbolic notation
  - g. Quality of analysis of scientific principles explored
  - h. Quality of narrative explanations and reasoning
  - i. Representation of data in tables or diagrams
4. Laboratory notebook tests at option of the instructor
5. Other forms of evaluation such as homework sets, worksheets, and computer assignments, and/or writing assignments may be used at the discretion of the instructor

#### B. Frequency

1. Final examination
2. One to five midterm examinations or tests
3. Short quizzes at the option of the instructor
4. Laboratory reports average about one per week with notebooks collected two to five times per semester
5. A minimum of 5 formal written laboratory reports
6. One or two laboratory exams based on notebook at option of instructor

#### IX. TYPICAL TEXTS:

1. Carey, Francis, and Robert Giuliano. *Organic Chemistry*. 9 ed., McGraw-Hill Company, 2014.
2. Solomons, T. W. Graham, Craig Fryhle, and Scott Snyder. *Organic Chemistry*. 11 ed., Wiley Publishing, 2014.
3. McMurry, John. *Organic Chemistry*. 9 ed., Brooks/Cole Publishing Company/Cengage, 2016.
4. Vollhardt, K. Peter, and Neil Schore. *Organic Chemistry: Structure and Function*. 7 ed., W. H. Freeman and Company, 2015.
5. Pavia, Donald, Gary Lampman, George Kriz, and Randall Engel. *Introduction to Organic Laboratory Techniques: A Microscale Approach*. 5 ed., Brooks and Cole/Cengage Learning, 2013.

#### X. OTHER MATERIALS REQUIRED OF STUDENTS:

- A. Molecular model kit
- B. Safety goggles
- C. Scientific calculator
- D. Laboratory notebook, with sewn-in pages