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Course Outline for CHEM 12A

ORGANIC CHEMISTRY I

Effective: Spring 2016

I. CATALOG DESCRIPTION:
CHEM 12A — ORGANIC CHEMISTRY I — 5.00 units

Hydrocarbons, alkyl halides, alcohols, ethers, and an introduction to aromatic hydrocarbons. Structure, bonding, stereochemistry, conformational analysis, nomenclature, and physical properties in relation to these particular groups of compounds. Emphasis on reactivity and reaction mechanisms. Laboratory work includes microscale, macroscale, spectroscopic, and chromatographic techniques. Chemistry 12A is the first semester in a year long course in organic chemistry designed for students majoring in chemistry and related disciplines.

3.00 Units Lecture 2.00 Units Lab

Prerequisite
CHEM 1B - General College Chemistry II
with a minimum grade of C

Grading Methods:
Letter Grade

Discipline:

	MIN
Lecture Hours:	54.00
Lab Hours:	108.00
Total Hours:	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. CHEM1B

IV. MEASURABLE OBJECTIVES:
Upon completion of this course, the student should be able to:

A. Name hydrocarbons, alkyl halides, alcohols, and ethers using the IUPAC system of nomenclature;
B. Use structure and bonding theories to predict relative and/or relevant physical properties, such as boiling points and acidity, for organic compounds;
C. Identify stereocenters and chiral molecules and determine stereochemical relationships between pairs of compounds;
D. Predict and draw the possible conformations of acyclic and cyclic organic compounds and analyze these conformations for relative stability;
E. Use resonance theory and/or molecular orbital theory to interpret reactivity of organic compounds;
F. Predict the products of reactions involving organic compounds;
G. Suggest feasible methods of synthesis of organic compounds;
H. Analyze and explain mechanisms for elimination and ionic substitution reactions of hydrocarbons, alkyl halides, alcohols and ethers, including the influence of changes in structure and/or solvent;
I. Perform the following laboratory techniques: crystallization, melting point determination, extraction, simple distillation, fractional distillation, boiling point determination, and chromatographic separations;
J. Synthesize, separate, and analyze organic compounds, using microscale and macroscale methods;
K. Explain the theory behind the techniques of crystallization, melting point determination, extraction, distillation, boiling point determination, and chromatographic separations;
L. Operate standard organic laboratory instrumentation, including melting point apparatus, gas chromatograph, refractometer, polarimeter, NMR, UV-Vis spectrophotometer, and Fourier-Transform infrared spectrophotometer;
M. Interpret NMR and IR spectra and use such spectra as tools for structure elucidation;
N. Explain the theory behind NMR, IR, UV and mass spectroscopy;
O. Develop qualitative and quantitative problem solving techniques;
P. Effectively communicate observations and subsequent conclusions by means of written laboratory reports maintained in a bound laboratory notebook;
Q. Utilize library and internet resources for information and in support of laboratory reports;
R. Dispose of chemical wastes properly.

V. CONTENT:

A. Laboratory safety and proper disposal of waste materials
B. Review of general chemistry concepts
    1. Atomic structure and electron configuration
    2. Bonding, hybrid orbitals, and molecular shapes
    3. Molecular structure and relationship to physical properties (boiling point, solubility, etc.)
    4. Acid/base theories
    5. Determination of empirical and molecular formulas from quantitative analysis
C. Overview of organic chemistry
    1. Structure of major functional groups including hydrocarbons, alkyl halides, alcohols, ethers, carbonyl compounds, carboxylic acids and esters, amines and amides
    2. Organic acids and bases
    3. Resonance and inductive effects on acidity/basicity of organic species
D. Organic reactions
    1. Electrophiles and nucleophiles
    2. Substitution reactions
    3. Addition reactions
    4. Detailed analysis of the use of kinetics in elucidating mechanisms
    5. Introduction to synthesis
E. Alkanes
    1. Structure and physical properties
    2. Nomenclature, IUPAC and common names
    3. Reactions of alkanes including free radical halogenation
    4. Conformational analysis of open chain (acyclic) alkanes
    5. Structure of cycloalkanes, including stability and conformational analysis
F. Stereochemistry
    1. Polarimetry and optical activity
    2. Stereocenters and chiral substances
    3. Enantiomers, diastereomers, and racemic mixtures
    4. Specification of configuration, R/S
    5. Synthesis and optical purity
    6. Stereospecific reactions
    7. Alkyl halides
    8. Structure and physical properties
    9. Reactions
    10. Detailed analysis of nucleophilic substitution reactions (SN1 and SN2 mechanisms)
    11. Solvent effects on reaction rates
    12. Carbocations and rearrangements
    13. Alcohols
    14. Structure and physical properties
    15. Nomenclature, IUPAC and common names
    16. Reactions of alcohols
    17. Synthesis of alcohols
    18. Multi-step synthesis
G. Ethers
    1. Structure and physical properties
    2. Nomenclature, IUPAC and common names
    3. Reactions of ethers
    4. Synthesis of ethers
    5. Cyclic ethers and oxiranes(epoxides)
H. Spectroscopy
    1. Infrared spectroscopy and use in identification of chemical compounds
    2. Nuclear magnetic resonance (1H and 13C) spectroscopy and use in elucidating molecular structures
    3. Mass spectroscopy and use in determining molar mass and molecular formulas
    4. Ultraviolet spectroscopy
I. Alkenes
    1. Structure and properties
    2. Nomenclature, IUPAC and common names
    3. Stereoisomerism, including specification of E/Z configuration
    4. Detailed analysis of elimination reactions (E1 and E2)
    5. Stereochemistry of E2 reactions, syn- and anti-elimination
    6. Competition between elimination and substitution
    7. Reactions of alkenes
    8. Detailed analysis of the mechanism of electrophilic addition reactions
    9. Stereochemistry of addition reactions, syn- and anti-addition
    10. Synthesis of alkenes
J. Alkynes
    1. Structure and properties
    2. Nomenclature, IUPAC and common names
    3. Reactions of alkynes, including introduction of tautomerism via hydration
    4. Synthesis of alkynes
    5. Acidity of alkynes
K. Aromaticity
    1. Benzene—structure and resonance
    2. Aromatic character—the Huckel 4n+2 rule
    3. Nomenclature, IUPAC and common names
L. Laboratory techniques
    1. Melting point and boiling point determination
    2. Extraction
    3. Crystallization
    4. Simple distillation
    5. Fractional distillation
    6. Polarimetry
    7. Refractometry
    8. Thin-layer and column chromatography
    9. Vacuum sublimation
    10. Infrared spectroscopy
    11. Nuclear magnetic resonance spectroscopy
    12. Gas chromatography

13. Isolation of organic compounds
14. Synthesis of organic compounds
15. Structure determination
16. Safe handling of organic compounds
17. Use of literature references (the Merck Index, the Aldrich catalog, CRC Handbook of Chemistry and Physics), MSDS, and the Internet to obtain physical properties and determine possible hazards

VI. METHODS OF INSTRUCTION:

A. Lecture, informal with student questions encouraged
B. Problem solving exercises
C. Hands-on laboratory work, both individually and in collaboration with others, including direct access to all instrumentation
D. Computer simulations, especially of reaction mechanisms
E. Computer modeling of molecules, molecular orbitals (HOMO and LUMO), and electron density plots
F. Collaborative learning

VII. TYPICAL ASSIGNMENTS:

A. Read the chapter on stereochemistry in your text

1. Work all the in-chapter problems

2. Work all the end-of-chapter problems

3. Be prepared to describe how to specify the configuration at stereocenters in any specified compounds

B. Synthesize banana oil, otherwise knows as isoamyl acetate.

1. Purify your product by distillation.

2. Obtain the boiling point and refractive index of your product and compare their values with literature values. Cite your literature references.

3. Record the thin-film IR spectrum of your product. Show that the principal peaks are consistent with the expected identity of the product.

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. 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, 2015.
5. Pavia, Donald, Gary Lampman, George Kriz, and Randall Engel. *Introduction to Organic Laboratory Techniques: A Microscale Approach.* 5 ed., Brooks/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