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Science, Engineering, and Math Division

Revised Spring 2023
Implemented Fall 2023

COURSE OUTLINE
Organic Chemistry 1

Course Description
CH 240. Organic Chemistry 1. 5 credit hours. Prerequisite: CH 115 with a C or better. This course will enable the student to study beginning organic chemistry with emphasis on aliphatic and aromatic compounds. The student will participate in three hours of lecture/discussion and four hours of laboratory time per week.

Required Materials
For complete material(s) information, refer to https://bookstore.butlercc.edu

Butler-Assessed Outcomes
The intention is for the student to be able to do the following:
1. Demonstrate scientific methods.
2. Demonstrate knowledge of basic math skills as applied to organic chemistry.
3. Apply scientific reasoning to real world problems in organic chemistry.

Learning PACT Skills that will be developed and documented in this course
Through involvement in this course, the student will develop ability in the following PACT skill area(s):

Communication Skills
- Creation and delivery of messages – Through the completion of lab reports, the student will identify purpose, procedure, observations, and analysis of experiments using scientific reasoning.

Technology Skills
- General computer use - Through the production of electronic-facilitated research, preparation of graphs, and manipulation of data, the student will develop basic computer skills.

Analytical Thinking Skills
- Critical thinking - Through the production of mathematical, graphical, experimental, and written assignments, the student will demonstrate scientific reasoning.

Major Summative Assessment Task(s)
These Butler-assessed Outcome(s) and Learning PACT skill(s) will be demonstrated by the following:
1. Completing a portfolio of laboratory reports using technology (T-skill) and scientific reasoning to identify purpose, procedures, observations, and analysis of the experiment.
2. Writing a research paper on a topic of the student's choice related to organic chemistry (C-skill).
3. Completing a final assessment of the course using the American Chemical Society's national standardized exam for Organic Chemistry I (A-skill).

Skills or Competencies
These actions are essential to achieve the course outcomes:
1. Use basic computer skills.
2. Solve basic mathematical problems related to the sciences.

Learning Units
Lecture

I. Structure and properties
   A. Describe the structural theory of organic chemistry
   B. Write Lewis dot structures
   C. Use the octet rules and the exceptions
   D. Determine formal charges and resonance structures
   E. Apply VSEPRT and hybridization to compounds
   F. Draw representation(s) of structural formulas

II. Representative carbon compounds
   A. Identify and draw hydrocarbons: alkanes, alkenes, alkynes and aromatics
   B. Determine polar and nonpolar molecules
   C. Identify functional groups
   D. Describe physical properties and molecular structure
   E. Identify functional groups using the Infrared Spectroscopy

III. Acid-base reactions
   A. Define an acid and a base and describe an acid-base reaction
   B. Describe hemolysis and heterolysis
   C. Describe the relative strength of acids and bases
   D. Discuss the effects of solvents on acidity
   E. Demonstrate an understanding of a basic mechanism for an organic reaction

IV. Alkanes and cycloalkanes
   A. Describe the molecular structure of alkanes
   B. Name alkanes, alcohols, alkyl halides, alkenes, cycloalkanes, and alkynes using International Union of Pure and Applied Chemistry (IUPAC) nomenclature
   C. State the physical properties of alkanes and cycloalkanes
   D. Discuss and give examples of ring strain, angle strain, and torsional strain
   E. Demonstrate an understanding of trans-cis isomerism
   F. Write chemical reactions of alkanes
   G. Write reactions for the synthesis of alkanes and cycloalkanes
   H. Develop an understanding for retrosynthetic analysis in planning an organic synthesis

V. Stereochemistry: chiral molecules
   A. Describe plane-polarized light, polarimeter, optically active or optically inactive, observed rotation, specific rotation, dextrorotatory and levorotatory
   B. Identify chiral, achiral, enantiomers, planes of symmetry, superimposable and no superimposable mirror images and racemic mixtures

C. Identify asymmetric carbon atoms, chiral centers, R-S convention, priority order and E-Z conventions
D. Describe the meaning of diastereomers, meso compounds and resolution to lactic acid and tartaric acid
E. Calculate specific rotation given the concentration of an optically compound, length of the polarimeter tube, and observed rotation
F. Locate plane of symmetry
G. State if chiral centers are present
H. State if capable of optical activity
I. State the rules for establishing priority orders of groups in the R-S convention
J. Assign the R or S configuration
K. Draw the 3-D formula of a molecule with a particular configuration
L. Identify how many stereoisomers are possible and draw the structure of each
M. State whether a structure can exist as a meso form
N. Draw the structure of the meso form
O. Classify as configurational or conformation, chiral or achiral, and enantiometers of diastereomers

VI. Ionic reactions: SN and El reactions of alkyl halides
A. Define nucleophilic substitution reaction, substrate and leaving group
B. Write examples of nucleophilic substitution reactions
C. Write SN2 mechanism, inversion of configuration, SN1 mechanism, racemization, rate-determining step, E2 and E1 mechanisms
D. Write the structural formula given the name of an alkyl halide of a polyhalogen compound
E. Write the correct name for it given the structural formula of an alkyl halide,
F. Write the reactions for the preparation of alkyl halides
G. Write the reactions of alkyl halides
H. 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
I. State the stereochemical outcome of SN1 and SN2 substitutions and of E1 and E2 eliminations
J. Predict the stereochemistry of the product of nucleophilic substitution
K. Combine nucleophilic substitutions with previously studied reactions to devise a multi-step synthesis of a given product

VII. Alkenes and alkynes: addition reactions synthesis
A. Write conformations of alkene diastereomers
B. Write reactions for the synthesis of alkenes by dehydrohalogenation
C. State the properties of a carbocation reaction
D. Write reactions for the synthesis of alkynes through replacements of the terminal hydrogen, hydrogenation of alkenes
E. Discuss various reaction of alkynes
F. Discuss all mechanisms for the above in detail

VIII. Alkenes and alkynes: addition and oxidation reactions
   A. Draw the mechanisms and understand the stereochemistry
   B. Write reactions and mechanisms for the addition of hydrogen halides, sulfuric acid, addition of bromine and chlorine, and the hydration reaction
   C. Write reactions for the oxidation of alkenes and alkynes

IX. Nuclear magnetic resonance (NMR) and mass spectrometry (MS)
   A. Explain the electromagnetic spectrum
   B. Discuss and interpret in detail NMR, including spin, shielding, and deshielding of protons; chemical shifts of equivalent and nonequivalent protons, and signal splitting
   C. Interpret carbon-13 NMR spectroscopy
   D. Discuss and interpret in detail the mass spectrometer, determination of molecular formulas, molecular weights, and fragmentations
   E. Discuss and interpret in detail gas chromatography mass spectrometry (GC/MS) analysis

X. Free radical reactions
   A. Explain a hemolytic bond
   B. Write the mechanism for the halogenation of alkanes
   C. Write the mechanism for the anti-Markovnikov addition of a hydrogen halide
   D. Describe other important radical reactions

XI. Alcohols
   A. Describe oxymercuration-demercuration
   B. Describe hydroboration-oxidation
   C. Describe the reaction for epoxides
   D. Describe antihydroxylation of alkenes via epoxides

XII. Aromatics
   A. Define a kekule structure, benzene resonance hybrid, resonance or stabilization energy
   B. Define ortho, meta, para, phenyl group, benzyl group, benzene, toluene, and arenas
   C. Describe electrophilic substitution halogenation, nitration, sulfonation, alkylation, and Friedel-Crafts reactions
   D. Name and write structures for aromatic compounds, especially monosubstituted and disubstituted benzenes and toluenes
   E. Write the structures of the main organic products of the common electrophilic aromatic substitutions reactions when given the reactants
   F. Write the steps in the mechanism for an electrophilic aromatic substitution reaction
   G. Draw the structures of the main contributors to the benzenonium ion resonance hybrid
   I. Draw the structures of the main contributors to substituted benzenonium ions, and tell whether the substituent stabilizes or destabilizes the ion

J. State which groups are ortho, meta, or para directing, and explain why each group directs the way it does
K. Write the structure of the product, with substituents in the correct locations on the ring when given two successive electrophilic aromatic substitution reactions
L. Deduce the correct sequence in which to carry out electrophilic substitutions to give the product with the desired orientation when given a disubstituted or trisubstituted benzene
M. Apply Huckel rule to tell whether a cyclic unsaturated compound is aromatic

Laboratory

I. Laboratory practices
   A. 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
   B. Follow written directions accurately
   C. Work safely and effectively, using equipment and chemicals carefully and correctly
   D. Demonstrate use of required safety and common laboratory techniques
   E. Dispose of waste products in a proper manner

II. Qualitative and quantitative data gathering and recording
   A. Acquire data using balances and volumetric glassware
   B. Make and record visual observations
   C. Use computers, when appropriate, as data acquisition tools
   D. List or describe experimental assumptions made and any deviations from the written experimental procedures

III. Data handling and evaluation
   A. Create notebooks and laboratory reports that are clear, understandable, and accurately represent the date collected
   B. Display computer data in a spreadsheet or graphically, as appropriate
   C. Correlate observations with chemical or physical processes
   D. Carry out suitable calculations with quantitative data, recognizing when data and calculates are within a reasonable range
   E. Use observations of experimental data to present relevant conclusions pertaining to the experimental procedure

IV. Correlate laboratory work with principal topics in Organic I lecture

Learning Activities

Learning activities will be assigned to assist the student to achieve the intended learning outcome(s) through lecture, instructor-led class discussion, guest speakers, group activities, drills/skill practice, labs, and other activities at the discretion of the instructor. These activities may be either face-to-face or online.

Grade Determination
The student will be graded on learning activities and assessment tasks. Grade determinants may include the following: daily work, lab reports, research papers, quizzes, chapter or unit tests, comprehensive examinations, projects, presentations, class participation, and other methods of evaluation at the discretion of the instructor.