Lecture Contact Hours: 48-54; Outside-of-Class Hours: 96-108
Laboratory Contact Hours: 96-108; Outside-of-Class Hours: 0;
Total Student Learning Hours: 240-270

CUYAMACA COLLEGE
COURSE OUTLINE OF RECORD

Chemistry 231 – Organic Chemistry I

3 hours lecture, 3 units
6 hours laboratory, 2 units
Total units: 5

Catalog Description
First of a two semester organic chemistry sequence. Includes nomenclature of organic compounds, stereochemistry, reaction mechanisms, and the study of representative reactions for certain classes of organic compounds. The relationship of structure to properties, reactivity, and mechanism or reaction will be emphasized. This course is intended for biology, chemistry and pre-medical majors needing either one or two semesters of organic chemistry.

Prerequisite
"C" grade or higher or "Pass" in CHEM 142 or equivalent

Entrance Skills
Without the following skills, competencies and/or knowledge, students entering this course will be highly unlikely to succeed:
1) Understand the concept of vapor pressure.
2) Understand the concepts of enthalpy, entropy, and free energy and their application to chemical reactions and elementary molecular processes.
3) Understand the concept of bond energy.
4) Use bond energies to estimate enthalpies of reaction.
5) Understand the factors that affect the rate of a chemical reaction.
6) Understand the mathematical definition of reaction rate.
7) Understand the concepts of a rate law, a reaction order, and a rate constant. Calculate a reaction order from tabular data or rate vs. concentration.
8) Understand the concept of activation energy.
9) Understand the concepts of an elementary step and a reaction mechanism. Write the rate law for an elementary step.
10) Understand the concept of a rate determining step. Given the elementary steps in a reaction mechanism and their relative rates, be able to write the expected rate law for a reaction.
11) Understand the concepts of equilibrium and the equilibrium constant as they apply to chemical reactions.
12) Understand the relationship between the equilibrium constant and the free energy change for a reaction both qualitatively and quantitatively.
13) Understand the concepts of oxidation and reduction. Identify chemical reactions that are oxidation-reduction.

Course Content
1) Classes, properties and reactivity of organic compounds
2) Synthesis, isolation, purification and characterization of carbon compounds in the laboratory – using both traditional and modern instrumental techniques
3) Draw the structures of all the possible constitutional isomers corresponding to a given molecular formula
4) Nomenclature of organic functional groups and organic compounds

5) Conformational analysis of aliphatic hydrocarbons and cyclohexane derivatives
6) Stereochemistry of saturated, unsaturated, and cyclic hydrocarbons
7) Nucleophilic substitution, elimination and radical reactions and their mechanisms

Course Objectives

Students will be able to:

1) Distinguish among the numerous classes of organic compounds and predict their properties and reactivity.
2) Deduce the structures of the constitutional isomers corresponding to a given molecular formula.
3) Write a systematic name for an organic compound given its structure and vice-versa.
4) Deduce the principal conformations of open chain molecules and cyclohexane derivatives and determine their relative potential energies.
5) Deduce the structures of the stereoisomers possible for molecules with stereogenic centers.
6) Predict the operative mechanisms and the structures of the products in nucleophilic substitution, elimination, electrophilic addition, nucleophilic addition, radical substitution and addition, oxidation, and reduction reactions.
7) Design the synthesis and identify intermediates for an organic compound requiring multiple reaction steps.
8) In the laboratory, determine physical properties of melting point, boiling point and refractive index of organic compounds.
9) In the laboratory, perform simple qualitative tests for detection of the different types of functional groups on compounds.
10) In the laboratory, separate compounds using modern chromatographic instrumentation including HPLC and GC.
11) In the laboratory, characterize compounds based on modern spectrometric data including FTIR, NMR and GC/MS.
12) Determine the structure of molecules from their FTIR and NMR spectra.
13) In the laboratory, use GC/MS data to further characterize the nature of product and by-products of synthesis reactions.
14) Synthesize, isolate, purify and characterize both solid and liquid organic compounds using methods described in course objectives 8 through 13, above.
15) Analyze and evaluate observations acquired in the laboratory by applying the theoretical principles being studied.

Method of Evaluation

A grading system will be established by the instructor and implemented uniformly. Grades will be based on demonstrated proficiency in subject matter determined by multiple measurements for evaluation, one of which must be essay exams, skills demonstration or, where appropriate, the symbol system.

1) Exams that measure students' ability to explain and apply the basic concepts of organic chemistry. General question types are short essay and problem solving. Specific question types include:
   a. Classification of organic compounds.
   b. Prediction of physical and chemical properties.
   c. Deduction of structures from molecular formulas, infrared spectra, and nuclear magnetic resonance spectra.
   d. Translation of structure to name and vice-versa.
   e. Prediction of reaction mechanisms and products.
   f. Synthesis of molecules.
2) Laboratory activities that evaluate students' ability to observe the properties of a wide range of organic compounds, to apply competent observational skills, to demonstrate proper collection and recording of data, to assemble and utilize complex glassware setups for synthesis and purification, and to operate modern laboratory instruments.
3) Written laboratory reports that measure students' ability to interpret and analyze both qualitative and quantitative data.

Special Materials Required of Student
Scientific calculator, laboratory notebook, safety glasses, lab apron

Minimum Instructional Facilities
1) Lecture room with demonstration bench equipped with gas, air, vacuum, water, sink
2) Laboratory equipped with same utilities as lecture room, each student station having gas, air, vacuum, water, sink and fume hoods
3) Student lockers stocked with organic glassware kit in addition to standard laboratory glassware
4) Essential laboratory equipment: standard taper glassware kits, electronic top-loading balances, melting point apparatuses, hot plates, and vortexers
5) Refractometer and polarimeter are highly desirable for product characterization. Two instruments which tremendously increase the quality of the course are a gas chromatograph and infrared spectrometer
6) Variety of organic chemicals and solvents as well as thin layer chromatography supplies

Method of Instruction
1) Lectures are designed to explain basic concepts. As much as possible, concepts are introduced by presentation of data. Analysis and explanations of data are elicited from students by frequent and persistent questions. Demonstrations of chemical properties and reactivity are utilized where practical, either live or as video clips. Molecular models are used extensively to convey structures of molecules. Applications to the real world are incorporated as much as possible.
2) In the laboratory, short lectures are used to introduce the theory and design of the experiment, to demonstrate laboratory techniques and to review safety precautions. Individual instruction in lab technique is provided throughout the lab period.
3) Laboratories correlate with lectures and are designed to allow students to make observations of chemical phenomena. Students work individually for most experiments. Lab reports require students to explain their laboratory observations employing the concepts discussed in class.
4) The textbook is required reading and is essential to successful solution of homework problems, performance of laboratory experiments, and performance on exams.
5) Students are strongly encouraged to form study groups and to seek help through peer tutoring and instructor office hours.

Out-of-Class Assignments
1) Reading and homework problems
2) Formal lab reports
3) Specialized project involving selected topics in chemistry, as required; this project may require the use of research on the internet, at the library, or other resources

Texts and References
1) Required (representative examples):
   a. Solomons, et al. *Organic Chemistry*. 13th edition. Wiley, 2022.
   b. Anness and Villareal. *Chemistry 231 Supplementary Labs*. Cuyamaca College, 2024.
2) Supplemental: None

Exit Skills
Students having successfully completed this course exit with the following skills, competencies and/or knowledge:
1) Draw the structures of all the possible constitutional isomers corresponding to a given molecular formula.
2) Write systematic names for carbon based compounds.
3) Draw the primary conformations of open chain and cyclohexane derivatives and determine their relative potential energies.
4) Identify chiral molecules and draw the structures of the stereoisomers possible.

5) Predict the mechanism that will be operative as well as the structures of the products in nucleophilic substitution, elimination, electrophilic addition, nucleophilic addition, oxidation, and reduction reactions.
6) Write mechanisms for radical reactions as well as predict the structures and relative distribution of products.
7) Draw the structures of the reactants needed and intermediates formed in multistep syntheses.
8) Determine micro melting and boiling points of substances as well as perform simple qualitative tests for detecting the different classes of functional groups.
9) Synthesize and purify compounds including the purification techniques of refluxing, steam distillation, simple distillation, fractional distillation, separation using a separatory funnel, and crystallization.
10) Separate compounds using modern chromatographic instrumentation including HPLC and GC.
11) Determine the structure of molecules from spectrometric data including FTIR, NMR and GC/MS.

Student Learning Outcomes

Upon successful completion of this course, students will be able to:

1) Distinguish among the various families of organic compounds and draw their constitutional isomers from a given molecular formula.
2) Write the IUPAC name for an organic compound given its structure and vice-versa.
3) Perform conformational analysis and determine the relative stabilities of various organic compounds.
4) Identify and categorize chiral molecules, and draw the possible stereoisomers for a particular compound.
5) Predict the products and mechanisms related to nucleophilic substitution, elimination, electrophilic addition, nucleophilic addition, and radical reactions.
6) In the laboratory, identify unknown organic compounds using qualitative tests for functional groups, and analytical techniques such as melting point determination, boiling point determination and IR spectroscopy.
7) In the laboratory, synthesize, isolate, purify and characterize organic compounds.