

CHEM 12A: ORGANIC CHEMISTRY

Foothill College Course Outline of Record

Heading	Value
Effective Term:	Summer 2023
Units:	4
Hours:	4 lecture per week (48 total per quarter)
Prerequisite:	CHEM 1C.
Advisory:	Concurrent enrollment in CHEM 12AL recommended, as CHEM 12A and 12AL are required for progression to CHEM 12B.
Degree & Credit Status:	Degree-Applicable Credit Course
Foothill GE:	Non-GE
Transferable:	CSU/UC
Grade Type:	Letter Grade (Request for Pass/No Pass)
Repeatability:	Not Repeatable

Student Learning Outcomes

- Apply an understanding of functional group reactivity to predict the product of an organic reaction.
- Understand how various structural features of an organic compound may influence its reactivity
- Evaluate the current state of equity and inclusion in science and in science education
- Evaluate the stereochemistry of an organic compound

Description

This course is the first of a three quarter course describing the chemistry of organic (carbon containing) compounds. Emphasis on structure-reactivity relationships and mechanisms of functional group transformations. For science majors and students pursuing professional careers in dentistry, medicine, pharmacy, or veterinary medicine. Generally not appropriate for nursing majors (see CHEM 30B).

Course Objectives

The student will be able to:

- Apply current theories of bonding to an understanding of molecular structure and reactivity.
- Distinguish between the roles that kinetics and thermodynamics play in the outcome of a chemical reaction.
- Evaluate the stereochemistry of an organic compound and relate its importance to selectivity in the reactions of bioactive molecules.
- Name, draw and interpret three-dimensional representations of organic molecules.
- Recognize the relationship between structure and reactivity through a study of functional groups in organic molecules.

Course Content

- Apply current theories of bonding to an understanding of molecular structure and reactivity

- Atomic orbitals and hybridization: shapes and relative energies of atomic orbitals
- Molecular orbitals: sigma and pi bonding and antibonding orbitals
- Molecular orbital energy diagrams: identifying HOMO and LUMO
- Drawing Lewis structures including resonance and formal charges
- Recognizing resonance stabilized molecules and ranking the relative contributions of resonance forms
- Distinguish between the roles that kinetics and thermodynamics play in the outcome of a chemical reaction
 - The concept of mechanisms in organic chemistry: curved arrow formalism and reaction energy diagrams
 - Predicting rate laws from a known mechanism and utilizing rate information to confirm or refute a proposed mechanism
 - Hammond's postulate applied to free radical and SN1 reactions
 - Solvent effects on reaction rate
 - Distinguishing between kinetic versus thermodynamic control in a reaction
- Understand the concept of chirality in organic compounds and its importance in chemical systems
 - Identification of stereocenters, chiral and meso compounds
 - Distinguishing between stereoisomers, conformers and constitutional isomers
 - Assessing the stereochemical relationship between organic molecules: enantiomers and diastereomers
 - Optical activity of chiral molecules, enantiomeric excess and optical purity
 - Interpreting stereochemical designations (R,S versus +,-)
 - Predicting the stereochemical outcome of a chemical reaction from an interpretation of its mechanism: inversion vs retention in SN1, SN2, E vs Z selectivity in E1 and E2 reactions
- Regio- and stereo-selectivity in alkene addition reactions
- Name, draw and interpret three-dimensional representations of organic molecules
 - Nomenclature of alkanes, alkyl halides and alkenes
 - IUPAC rules
 - Common names
 - Assigning absolute configuration to stereocenters: R/S nomenclature
 - Conformations of organic compounds: rotation about carbon-carbon single bonds
 - Conformational energy diagrams
 - Drawing and interpreting Newman projections: eclipsed versus staggered; gauche versus anti conformations
 - Torsional, angle and steric strain
 - The chair conformation of cyclohexane
 - 1) Axial- versus equatorial-substituted cyclohexane
 - 2) Cis/trans isomerism in disubstituted cyclohexane systems
 - 3) Predicting the position of conformational equilibrium in substituted cyclohexane systems
 - Alternative structural representations of organic compounds
- Relate structure to reactivity trends through a study of functional groups in organic molecules
 - Identify Brønsted acids and bases and predict the position of their equilibria in solution
 - Predicting acid strength as a function of anionic conjugate base stability
 - Assess acid-base equilibria qualitatively and quantitatively
 - Recognize electrophiles and nucleophiles and understand their central role in organic reactions
 - Identify functional groups in organic compounds
 - Predict the physical properties (heats of combustion, solubility, bp/mp) of alkanes, alkyl halides and alkenes
 - Reactivity of alkanes

- a. Physical properties of alkanes
- b. Free-radical halogenation of alkanes
 - 1) Mechanism and reaction energy profile
 - 2) Product distribution as a function of statistics and relative selectivity
 - 3) Selectivity and Hammond's postulate
- 6. Reactivity of alkyl halides
 - a. Reactivity of alkyl halides with nucleophiles in SN2, SN1, E2 and E1 reactions
 - b. Predicting the dominant product in a competing reaction environment through assessment of relevant variables
 - 1) The substitution pattern of the alkyl halide (1°, 2° or 3° RX)
 - 2) The nucleophilic strength of the nucleophile (kinetic measure)
 - 3) The base strength of the nucleophile (thermodynamic measure)
 - 4) Solvent polarity and proticity
 - 7. Preparation of alkenes
 - a. From alkyl halides
 - b. From alcohols and alkylsulfonates
 - 8. Reactivity of alkenes: net reaction, mechanism, regio- and stereoselectivity
 - a. Pi molecular orbitals and alkene reactivity
 - b. Hydrogenation: relative ΔH and stability
 - c. Oxymercuration-demercuration
 - d. Addition of hydrogen halides
 - e. Addition of halogens
 - f. Formation of halohydrins
 - g. Anti-Markovnikov syn addition in hydroboration-oxidation
 - h. Addition of peroxydicarboxylic acids
 - i. Sharpless epoxidation: enantioselective reactions (time permitting)
 - j. Vicinal syn-dihydroxylation with osmium tetroxide
 - k. Oxidative cleavage by ozonolysis
 - l. Anti-Markovnikov radical addition of HBr
 - m. Polymerization
 - n. Organometallic couplings (time permitting)
 - 1) The Heck reaction (time permitting)
 - 2) Suzuki coupling (time permitting)
 - 3) Alkene metathesis (time permitting)
 - 9. Multi-step synthesis: overview of strategies and practical limitations as applied to relevant functional group transformations

Lab Content

Not applicable.

Special Facilities and/or Equipment

None.

Method(s) of Evaluation

Methods of Evaluation may include but are not limited to the following:

Multiple quizzes: short answer and/or multiple choice
 2-3 lecture examinations: predominantly short answer
 Final cumulative examination: short answer and multiple choice

Method(s) of Instruction

Methods of Instruction may include but are not limited to the following:

Lecture
 Discussion
 Group work

Representative Text(s) and Other Materials

Klein, D.. Organic Chemistry, 3rd ed.. 2017.

Wade, L.G.. Organic Chemistry, 9th ed.. 2016.

Smith, Janice. Organic Chemistry, 5th ed.. 2016.

Solomons, T.W. Graham. Organic Chemistry, 12th ed.. 2017.

Types and/or Examples of Required Reading, Writing, and Outside of Class Assignments

- A. Short-essay questions that require synthesis and evaluation of concepts in application to real world problems.
- B. Weekly reading assignments from text and/or other peer-reviewed primary or secondary sources that require both comprehension and critical review.
- C. Memorization and organization of content knowledge.

Discipline(s)

Chemistry