CHEM 12A: ORGANIC CHEMISTRY

Foothill College Course Outline of Record

Heading	Value
Effective Term:	Summer 2025
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 theoretical models that incorporate the structure-reactivity relationships of organic compounds to solve problems and rationalize chemical observations.
- Draw and interpret the three-dimensional structure of organic molecules to identify chirality, assign absolute configuration, and evaluate relative conformational energies based on stereoelectronic effects.
- Predict the structure and reactivity of organic acids and bases, alkyl halides, and alkenes.
- Propose the mechanism of a chemical transformation using curved-arrow formalism, consistent with known kinetic data.

Description

This course is the first of a three quarter course describing the chemistry of organic (carbon containing) compounds. The course emphasizes 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:

1. Apply current theories of bonding to an understanding of molecular structure and reactivity.
2. Distinguish between the roles that kinetics and thermodynamics play in the outcome of a chemical reaction.
3. Recognize the importance of chirality in chemical systems and reactions of bioactive molecules, and evaluate the stereochemistry of an organic compound.
4. Name, draw, and interpret three-dimensional representations of organic molecules.
5. Recognize the relationship between structure and reactivity through a study of functional groups in organic molecules.

Course Content

1. Apply current theories of bonding to an understanding of molecular structure and reactivity
    a. Atomic orbitals and hybridization: shapes and relative energies of atomic orbitals
    b. Molecular orbitals: sigma and pi bonding and antibonding orbitals
    c. Molecular orbital energy diagrams: identifying HOMO and LUMO
    d. Drawing Lewis structures including resonance and formal charges
    e. Recognizing resonance stabilized molecules and ranking the relative contributions of resonance forms
2. Distinguish between the roles that kinetics and thermodynamics play in the outcome of a chemical reaction
    a. The concept of mechanisms in organic chemistry: curved arrow formalism and reaction energy diagrams
    b. Predicting rate laws from a known mechanism and utilizing rate information to confirm or refute a proposed mechanism
    c. Hammond's postulate applied to SN1 reactions
    d. Solvent effects on reaction rate
    e. Distinguishing between kinetic versus thermodynamic control in a reaction as applied to elimination reactions
3. Recognize the importance of chirality in chemical systems and reactions of bioactive molecules, and evaluate the stereochemistry of an organic compound
    a. Identification of stereocenters, chiral and meso compounds
    b. Distinguishing between stereoisomers, conformers and constitutional isomers
    c. Assessing the stereochemical relationship between organic molecules: enantiomers and diastereomers
    d. Optical activity of chiral molecules, enantiomeric excess and optical purity
    e. Interpreting stereochemical designations (R,S versus +,-)
    f. 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
    g. Regio- and stereo-selectivity in alkene addition reactions
4. Name, draw and interpret three-dimensional representations of organic molecules
    a. Nomenclature of alkanes, alkyl halides and alkenes
        i. IUPAC rules
        ii. Common names
        iii. Assign absolute configuration to stereocenters: R/S nomenclature
    b. Draw and interpret conformations of organic compounds: rotation about carbon-carbon single bonds
        i. Conformational energy diagrams
        ii. Draw and interpret Newman projections: eclipsed versus staggered; gauche versus anti conformations
        iii. Torsional, angle and steric strain
        iv. 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
        v. Alternative 3-D structural representations of organic compounds
5. Recognize the relationship between structure and reactivity through a study of functional groups in organic molecules
    a. Identify Brønsted acids and bases and predict the position of their equilibria in solution
        i. Predicting acid strength as a function of anionic conjugate base stability
        ii. Assess acid-base equilibria qualitatively and quantitatively
    b. Recognize electrophiles and nucleophiles and understand their central role in organic reactions
    c. Identify functional groups in organic compounds
    d. Predict the physical properties (heats of combustion, solubility, bp/mp) of alkanes, alkyl halides, and alkenes
    e. Reactivity of alkyl halides
        i. Reactivity of alkyl halides with nucleophiles in SN2, SN1, E2, and E1 reactions
        ii. 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
    f. Preparation of alkenes
        i. From alkyl halides
        ii. From alcohols and alkylsulfonates
    g. Reactivity of alkenes: net reaction, mechanism, regio- and stereoselectivity
        i. Pi molecular orbitals and alkene reactivity
        ii. Hydrogenation: relative ΔH and stability
        iii. Oxymercuration-demercuration
        iv. Addition of hydrogen halides
        v. Addition of halogens
        vi. Formation of halohydrins
        vii. Anti-Markovnikov syn addition in hydroboration-oxidation
        viii. Addition of peroxycarboxylic acids
        ix. Sharpless epoxidation: enantioselective reactions (time permitting)
        x. Vicinal syn-dihydroxylation with osmium tetroxide
        xi. Oxidative cleavage by ozonolysis
        xii. Anti-Markovnikov radical addition of HBr
        xiii. Polymerization
    h. 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 involving collaborative discussion and problem solving
Applications that exemplify scientific contributions from diverse scholars

Representative Text(s) and Other Materials

Klein, D.. Organic Chemistry, 4th ed.. 2020.

Wade, L.G.. Organic Chemistry, 9th ed.. 2020.

Smith, Janice. Organic Chemistry, 7th ed.. 2024.

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

1. Short-essay questions that require synthesis and evaluation of concepts in application to real world problems.
2. Weekly reading assignments from text and/or other peer-reviewed primary or secondary sources that require both comprehension and critical review.
3. Memorization and organization of content knowledge.
    a. Solving problems that require analytic reasoning and application of theoretical principles.
    b. Multi-step synthesis of target organic molecules from simple precursors.
    c. Curved-arrow mechanisms delineating detailed sequence of structural changes during a reaction.
4. Prediction of relative rates and equilibria based on structure-reactivity trends.

Discipline(s)

Chemistry