CHEM 12B: 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 12A and CHEM 12AL.
Advisory:	Concurrent enrollment in CHEM 12BL recommended, as CHEM 12B and 12BL are required for progression to CHEM 12C.
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

- Effectively write an electronic mechanism accounting for the outcome of a chemical reaction.
- Identify structural features of an organic compound that influence its reactivity
- Determine the stereochemical outcome of a chemical reaction based on its mechanism.
- Understand the role thermodynamics and kinetics plays in the outcome of a chemical reaction.

Description

This course is the continuation of CHEM 12A. Emphasis is on structure-reactivity relationships of organic compounds, mechanisms of functional group transformations, and synthesis of organic target compounds from simple precursors. For chemistry, biological science, and environmental science majors, and for pre-professional students in dentistry, medicine, pharmacy, veterinary medicine, or any other interested students who have mastered the prerequisites.

Course Objectives

The student will be able to:

1. Expand study of functional groups to include the chemical reactivity of alkynes, alcohols and thiols, ethers and thioethers, ketones and aldehydes, dienes, and aromatic compounds.
2. Apply theoretical models that address the structure-reactivity relationships of organic compounds.
3. Gain further proficiency in proposing a detailed mechanism of a chemical transformation in organic chemistry.
4. Design multi-step syntheses of organic target molecules from simple precursors.
5. Elucidate structures of organic molecules from spectroscopic data.
6. Communicate effectively using the language of organic chemistry.
7. Work constructively and collaboratively in groups.

Course Content

1. Expand study of functional groups to include the chemical reactivity of alkynes, alcohols and thiols, ethers and thioethers, dienes, and aromatic compounds
    a. Alkynes
        i. Preparation from dihalides via double elimination
        ii. Reactivity of alkynes
            1. Acidity
            2. Reaction of alkynyl anions with alkyl halides and epoxides
            3. Hydrogenation to alkanes with Pd, Pt, Ni or Rh; to cis alkenes with Lindlar catalyst; to trans alkenes with sodium in liquid ammonia
            4. Formation of Markovnikov ketone via reaction with water under acidic conditions with or without mercury (II) catalyst
            5. Formation of aldehyde or ketone via hydroboration-oxidation
            6. Reaction with molecular halogens to form di- or tetra-halides
            7. Reaction with HX to make geminal dihalides
    b. Alcohols and thiols
        i. Structure and physical properties of alcohols and thiols
        ii. Reactivity of alcohols as weak acids or bases
        iii. Alcohols as electrophiles in reaction with hydrogen halides, PX3, SOCl2, and POCl3
        iv. Conversion to alkylsulfonates for reaction with anionic nucleophiles
        v. Rearrangement of carbocations from alcohols in strong acid
        vi. Hyperconjugation and carbocation stability
        vii. Oxidation of alcohols with Cr(VI): chromic acid versus PCC
        viii. Thiols as Brønsted acids and as nucleophiles
        ix. Formation of alcohols, ethers, and thiols from nucleophilic substitution reactions
    c. Ethers and epoxides
        i. Structure and physical properties of ethers and epoxides
        ii. Reactivity of ethers as electrophiles in reaction with hydrogen halides or other strong acids in water
        iii. Reactivity of epoxides as electrophiles in reaction with nucleophiles
        iv. Under acidic conditions with regioselectivity at more substituted carbon (HX, H3O+, ROH under acidic conditions)
        v. Under basic conditions with regioselectivity at less substituted carbon (Nuc:-, LiAlH4)
    d. Ketones and aldehydes
        i. Relative electrophilicity
        ii. Reaction with nitrogen and oxygen nucleophiles
            1. Imine and enamine formation
            2. Hydrate formation
            3. Hemiacetal and acetal formation
        iii. Reaction with carbon nucleophiles
            1. Wittig reaction
            2. Grignard and organolithium reactions
        iv. Carbonyl reduction and deoxygenation

1. Hydride reducing agents $LiAlH_4$ and $NaBH_4$
2. Clemmenson reduction
3. Wolff-Kishner reduction

e. Dienes and other delocalized pi systems
   i. Relative stability
   ii. Acidity
   iii. Polar addition of HX, H_3O^+ or X_2; regioselectivity dependence on reaction conditions
   iv. The Diels-Alder reaction
   v. Polymerization of conjugated dienes

f. Benzene and aromaticity
   i. Predicting aromaticity, non-aromaticity, and anti-aromaticity
   ii. Frost circles
   iii. Benzylic oxidation

2. Apply theoretical models that address the structure-reactivity relationships of organic compounds
   a. Kinetic vs. thermodynamic control in addition of electrophiles to conjugated dienes
   b. Pi molecular orbitals and molecular orbital energy diagrams of pi systems in conjugated acyclic and cyclic polyenes
   c. Stereo- and regioselectivity in the Diels-Alder reaction: endo vs. exo adducts
   d. Predicting aromaticity and anti-aromaticity from molecular orbital energy diagrams
   e. Apply Hammond's postulate to predict the relative selectivity of a reaction under kinetic control as applied to free-radical reaction and diene addition reactions
3. Gain further proficiency in proposing the detailed mechanism of a chemical transformation in organic chemistry
4. Design multi-step syntheses of organic target molecules from simple precursors
   a. Recognize incompatible functional groups and use protecting group chemistry as appropriate
   b. Assess the advantages and disadvantages of alternative strategies in the synthesis of an organic target compound
   c. Apply knowledge of chemo- and regioselectivity in developing a strategy for multi-step synthesis
5. Elucidate structures of organic molecules from spectroscopic data
   a. Apply knowledge of spectroscopic methods learned in corequisite laboratory course to deduce structural information about an organic compound
      i. 1H and 13C NMR
      ii. IR
   b. UV-Vis spectroscopy
      i. Electronic energy levels and absorption of UV-Vis electromagnetic radiation
      ii. Color and extended conjugation
6. Communicate effectively using the language of organic chemistry
7. Work constructively and collaboratively in groups

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:

Formative assignments and/or quizzes
Written short answer examinations
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. Practice and organization of chemical reactions including drawing reaction mechanisms.

Discipline(s)

Chemistry