

CHEM 12B: ORGANIC CHEMISTRY

Foothill College Course Outline of Record

Heading	Value
Effective Term:	Summer 2021
Units:	4
Hours:	4 lecture per week (48 total per quarter)
Prerequisite:	CHEM 12A and CHEM 12AL.
Advisory:	Concurrent enrollment in CHEM 12BL or 13BH recommended, as CHEM 12B and 12BL/13BH 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, 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:

- Expand study of functional groups to include the chemical reactivity of alkynes, alcohols and thiols, ethers and thioethers, dienes, and aromatic compounds.
- Apply theoretical models that address the structure-reactivity relationships of organic compounds.
- Gain further proficiency in proposing a detailed mechanism of a chemical transformation in organic chemistry.
- Design multi-step syntheses of organic target molecules from simple precursors.
- Interpret spectroscopic data to elucidate structural information about an organic compound.
- Communicate effectively using the language of organic chemistry.

G. Work constructively and collaboratively in groups.

Course Content

- Expand study of functional groups to include the chemical reactivity of alkynes, alcohols and thiols, ethers and thioethers, dienes, and aromatic compounds
 - Alkynes
 - Preparation from dihalides via double elimination
 - Reactivity of alkynes
 - Acidity
 - Reaction of alkynyl anions with alkyl halides and epoxides
 - Hydrogenation to alkanes with Pd, Pt, Ni or Rh; to cis alkenes with Lindlar catalyst; to trans alkenes with sodium in liquid ammonia
 - Formation of Markovnikov ketone via reaction with water with acid or mercury (II) catalyst
 - Formation of aldehyde or ketone via hydroboration-oxidation
 - Reaction with molecular halogens to form di- or tetra-halides
 - Reaction with HX to make geminal dihalides
 - Alcohols and thiols
 - Structure and physical properties of alcohols and thiols
 - Reactivity of alcohols as weak acids or bases
 - Alcohols as electrophiles in reaction with hydrogen halides, PX_3 , $SOCl_2$, $POCl_3$ and sulfonyl chloride
 - Conversion to alkylsulfonates for reaction with anionic nucleophiles
 - Rearrangement of carbocations from alcohols in strong acid
 - Hyperconjugation and carbocation stability
 - Oxidation of alcohols with Cr(VI): chromic acid versus PCC
 - Thiols as Brønsted acids and as nucleophiles
 - Formation of alcohols, ethers and thiols from nucleophilic substitution reactions
 - Ethers and epoxides
 - Structure and physical properties of ethers and epoxides
 - Reactivity of ethers as electrophiles in reaction with hydrogen halides or other strong acids in water
 - Reactivity of epoxides as electrophiles in reaction with nucleophiles
 - Under acidic conditions with regioselectivity at more substituted carbon (HX, H_3O^+)
 - Under basic conditions with regioselectivity at less substituted carbon (Nuc⁻, $LiAlH_4$)
 - Dienes and other delocalized pi systems
 - Relative stability
 - Acidity
 - Polar addition of HX, H_3O^+ or X_2 ; regioselectivity dependence on reaction conditions
 - The Diels-Alder reaction
 - Polymerization of conjugated dienes
 - Benzene and aromaticity
 - Predicting aromaticity, non-aromaticity and anti-aromaticity
 - Electrophilic aromatic substitution
 - Nitration
 - Sulfonation
 - Halogenation
 - Friedel-Crafts alkylation and acylation
 - Nucleophilic aromatic substitution
 - Synthesis of poly-substituted aromatics
 - Oxidation of benzylic carbon
 - Strategic multistep synthesis
- Apply theoretical models that address the structure-reactivity relationships of organic compounds
 - Kinetic vs. thermodynamic control in addition of electrophiles to conjugated dienes

2. Pi molecular orbitals and molecular orbital energy diagrams of pi systems in conjugated acyclic and cyclic polyenes
 3. Stereo- and regioselectivity in the Diels-Alder reaction: endo vs. exo adducts
 4. Predicting aromaticity and anti-aromaticity from molecular orbital energy diagrams
 5. Relative reactivity and directing effects of aromatic substituents in electrophilic aromatic substitution
 6. Computational chemistry of substituted benzene
 7. Apply Hammond's postulate to predict the relative selectivity of a reaction under kinetic control
- C. Gain further proficiency in proposing the detailed mechanism of a chemical transformation in organic chemistry
1. Propose the mechanism of a reaction sequence from knowledge of individual reaction mechanisms
- D. Design multi-step syntheses of organic target molecules from simple precursors
1. Recognize incompatible functional groups and anticipate multiple products
 2. Assess the advantages and disadvantages of alternative strategies in the synthesis of an organic target compound
- E. Interpret spectroscopic data to elucidate structural information about an organic compound
1. Nuclear magnetic resonance
 - a. Chemical shift
 - b. Spin coupling
 - c. Peak integration
 - d. Sensitivity and resolution: low field vs. high field spectrometers
 - e. Chemical equivalence and magnetic equivalence
 - f. First-order versus second-order spectra
 - g. Diastereotopicity
 - h. Given the molecular formula and the ^1H NMR spectrum, deduce the structure of simple organic compounds
 2. Infrared spectroscopy
 - a. Molecular vibrations and absorption of IR electromagnetic radiation
 - b. Characteristic IR bands of common functional groups
 - c. Strengths and limitations of IR spectroscopy
 3. Mass spectrometry
 - a. Electron ionization
 - b. Features of mass spectra useful in structure elucidation
 - c. Fragmenting patterns and stability of radical cations
 - d. The molecular ion peak and molar mass
 - e. Isotopic abundance and $M+1$ or $M+2$ signals
 4. UV-Vis spectroscopy
 - a. Electronic energy levels and absorption of UV-Vis electromagnetic radiation
 - b. Color and extended conjugation
 5. Synthesize data from MS, IR, ^1H and ^{13}C NMR to determine the structure of an unknown organic compound
- F. Communicate effectively using the language of organic chemistry
- G. Work constructively and collaboratively in groups

Lab Content

Not applicable.

Special Facilities and/or Equipment

None.

Method(s) of Evaluation

Quizzes

Written short answer examinations

Final cumulative examination: short answer and multiple choice

Method(s) of Instruction

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