CHEM 12C: 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 12B and CHEM 12BL.
Advisory:	Concurrent enrollment in CHEM 12CL recommended, as CHEM 12CL is major transfer requirement - please consult a counselor.
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

- Predict the structure and reactivity of aldehydes, ketones, amines, carboxylic acids, acid chlorides, anhydrides, esters, amides, nitriles, enolates, and bioactive molecules including carbohydrates, amino acids and peptides.
- Design multi-step syntheses of organic target molecules from simple precursors by applying a comprehensive understanding of functional group transformations.
- Propose the mechanism of a chemical transformation using curved-arrow formalism that is consistent with known kinetic data.
- Apply theoretical models that incorporate the structure-reactivity relationships of organic compounds to solving problems and rationalizing observations.

Description

During this third and final quarter of organic chemistry, students will expand their study of functional groups to include carboxylic acids and carboxylic acid derivatives, enolates, and amines. Students will also be introduced to the chemistry of polyfunctional, biologically active molecules, such as proteins and carbohydrates. There will be continued emphasis on structure-reactivity relationships, mechanisms of reaction, and multi-step syntheses. For chemistry and other STEM majors, as well as any pre-professional students studying for careers in dentistry, medicine, pharmacy, and veterinary medicine, and for any other interested students who have mastered the prerequisites.

Course Objectives

The student will be able to:

1. Expand knowledge of functional group chemistry to include ketones and aldehydes, carboxylic acids and their derivatives, and amines with an emphasis on reaction mechanisms.
2. Apply knowledge of functional groups to the chemistry of bioactive molecules, including carbohydrates and proteins.
3. Apply theoretical models that address the structure-reactivity relationships of organic compounds.
4. Design the multi-step synthesis of an expanded array of target organic molecules from simple precursors using strategies that incorporate chemo-, regio-, and stereoselectivity in the preparation of polyfunctional compounds.
5. Devise the structure of an organic compound from a combination of chemical and/or spectroscopic information.
6. Communicate effectively using the language of organic chemistry.
7. Work constructively and collaboratively in groups.

Course Content

1. Expand knowledge of functional group chemistry to include ketones and aldehydes, carboxylic acids and their derivatives, and amines with an emphasis on reaction mechanisms
    a. Aromatic compounds
        i. Electrophilic aromatic substitution: mechanism, limitations, and regioselectivity
            1. Nitration
            2. Sufonation
            3. Halogenation
            4. Friedel-Crafts alkylation and acylation
        ii. Nucleophilic aromatic substitution mechanism and limitations
        iii. Synthesis of poly-substituted aromatics
        iv. Multistep synthesis strategies
    b. Carboxylic acids
        i. Relative acidity of substituted carboxylic acids
        ii. Preparation
            1. Oxidation of alcohols or aldehydes
            2. Oxidation of benzylic carbon
            3. Hydrolysis of nitriles under acidic and basic conditions
            4. Grignard reaction with alkyl, vinyl or aryl halides and CO2
        iii. Reactivity (including partial or complete mechanism)
            1. Thionyl chloride and phosphorous tribromide to form acid halides
            2. Carboxylic acid chlorides to form anhydrides
            3. With alcohols and catalytic mineral acids to form esters
            4. With amines to form amides
            5. With LiAlH4 to form alcohols
            6. With molecular bromine and PBr3 then water to form alpha-brominated acids
    c. Carboxylic acid derivatives
        i. Relative reactivity of acid chlorides, anhydrides, esters, carboxylic acids, and amides: correlation to leaving group ability
        ii. Interconversion of derivatives via addition-elimination mechanism
        iii. Acid chloride reactivity (including partial or complete mechanism)
            1. Reduction of acid chlorides with lithium tri(tert-butoxy)aluminum hydride to form aldehydes
            2. Reaction of acid chlorides with organocuprates to form ketones
            3. Interconversion to anhydrides, esters, carboxylic acids, and amides via addition-elimination mechanism

d. Ester reactivity
    i. Interconversion with other RC(O)LG
    ii. Reduction with LiAlH4 and DIBAL
    iii. Reaction with Grignard and Organolithium reagents
e. Amide reactivity
    i. Hofmann rearrangement of amides with halogens in aqueous base
    ii. Reduction with LiAlH4 and DIBAL
    iii. Hydrolysis with acid or base catalyst
f. Nitrile reactivity
    i. Hydrolysis to amides and carboxylic acids
    ii. Reaction with Grignard reagents to form ketones
    iii. Reaction with LiAlH4 and DIBAL to form amines and aldehydes, respectively
g. Enolates
    i. Acidity and formation
    ii. Reaction with LDA under kinetic vs. thermodynamic control
    iii. α-alkylation
    iv. α-halogenation under basic and acidic conditions
    v. The haloform reaction
    vi. The aldol reaction
    vii. Claisen condensation
    viii. Mixed and directed Aldol/Claisen reactions
    ix. The acetoacetic ester and malonic ester reaction sequences
    x. Decarboxylation of β-ketoacids
    xi. Stabilized enolates as nucleophiles
        1. 1,3-dicarbonyl compounds
        2. Enamines
h. Amines
    i. Properties
    ii. Preparation
        1. From other amines via nucleophilic substitution
        2. From nitriles, amides and azides via reduction
        3. Gabriel synthesis
        4. From aldehydes and ketones via reductive amination
    iii. Reactivity (including partial or complete mechanism)
        1. Hofmann elimination
        2. Mannich reaction
        3. Nitrosation and diazotization of amines
        4. Reactions of aryldiazonium ions
        5. Reactivity of phenols

2. Apply knowledge of functional groups to the chemistry of bioactive molecules including carbohydrates and proteins
    a. Monosaccharides
        i. Fischer projections and D,L-nomenclature
        ii. Cyclic forms and mutarotation
        iii. Optical activity and structure determination
        iv. Reaction with Fehling's and Tollen's solutions
        v. Condensation with amine derivatives
        vi. Esterification and alkylation of hydroxy groups
        vii. Formation of glycosides
        viii. Sugar chain extension by cyanohydrin formation and reduction
        ix. Sugar chain shortening by Ruff or Wohl degradation
        x. Disaccharides: formation and hydrolysis
    b. Amino acids and peptides
        i. Structure
        ii. Acid/base properties
        iii. Synthesis of amino acids
            1. SN2 reaction of ammonia with α-haloacid
            2. Diethyl acetamidomalonate alkylation, hydrolysis and decarboxylation
            3. The Strecker synthesis
        iv. Peptides: primary structure and sequencing
        v. Synthesis of dipeptides using protecting groups
        vi. Edman degradation
3. Apply theoretical models that address the structure-reactivity relationships of organic compounds
    a. Kinetic vs. thermodynamic control in enolate formation and α,β-unsaturated ketone addition
    b. Relative reactivity of carboxylic acid derivatives and transition state theory
    c. Proposing mechanism of unknown reactions by analogy to defined systems
    d. Assessing conformation-dependent structural features to predict reactivity
4. Design the multi-step synthesis of an expanded array of target organic molecules from simple precursors using strategies that incorporate chemo-, regio-, and stereoselectivity in the preparation of polyfunctional compounds
    a. Polysubstituted aromatics
    b. Amino acids and dipeptides
    c. Selective reactions of β-dicarbonyl derivatives
    d. Ketones and esters via enolate chemistry sequences
    e. Comprehensive functional group transformations: interconversion of all functional group categories discussed throughout the 12ABC sequence
5. Devise the structure of an organic compound from a combination of chemical and/or spectroscopic information
6. Communicate effectively using the language of organic chemistry
    a. Explain the rationale behind a chemical trend both verbally and in writing
    b. Correlate chemical structures with their nomenclature
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 the textbook discussing the principles that govern organic reactions (e.g., electron flow, structure/reactivity relationship, etc.).
3. Homework problems that require written explanations of chemical behavior based on application of known theoretical models.

Discipline(s)

Chemistry