CHEM 0012B - ORGANIC CHEMISTRY II

Catalog Description

Prerequisite: Completion of CHEM 12A with grade of "C" or better
Advisory: Eligibility for ENGL 1A strongly recommended
Hours: 162 (54 lecture, 108 laboratory)
Description: Focuses on carbon based molecules and emphasizes structure, kinetics, thermodynamics, spectroscopy, and synthesis. Includes the emerging field of "Green Chemistry." Required for majors in Chemistry as well as many other related fields. (combined with CHEM 12A, C-ID CHEM 160S) (CSU, UC)

Course Student Learning Outcomes

- CSLO #1: Use experimental data to derive the structure of molecules, draw them and predict how their structure will affect their reactivity. Focus on Alkynes, Aromatics and Carbonyls.
- CSLO #2: Predict and draw mechanisms leading to products given the structure of reactant molecules. Focus on Alkynes, Aromatics and Carbonyls.
- CSLO #3: Outline a retrosynthesis and create a synthetic scheme given a target molecule. Focus on Alkynes, Aromatics and Carbonyls.

Effective Term

Fall 2022

Course Type

Credit - Degree-applicable

Contact Hours

162

Outside of Class Hours

108

Total Student Learning Hours

270

Course Objectives

Given the periodic chart and other appropriate reference materials, students will be able to perform the following on examinations, laboratory exercises, or in laboratory experiments:
Lecture Objectives:
1. Predict missing reactants, reagents or products from the following reactions (including regio- and stereo-chemical considerations): Diels-Alder reaction, Electrocyclic reactions of conjugated alkenes, Electrophilic aromatic substitutions, hydration of a carbonyls, hemiacetals and full acetals formations and deprotections, Cyanohydrin formations and hydrations, Wittig reaction, Baeyer-Villiger oxidation, Keto-Enol Tautomerization, Enolate alkylation, Aldol Condensation and dehydration, Robinson Annulation, Oxidation of primary alcohols to carboxylic acids, hydrolysis of Nitritles, Acid Chloride synthesis, reactions of Carboxylic acids, Amide reactions, Amine synthesis, Nucleophilic Aromatic substitution, Benzyne reactions, Claisen Rearrangement, Claisen Condensation, Beta-Dicarbonyl Alkylation, Decarboxylation of Beta-Keto Acids, Cyclization of linear sugars to hemiacetals, Mutarotation of Cyclic Hemiacetal Saccharides;
2. draw curved arrow mechanisms for selected reactions listed in outcome 1 above;
3. develop retrosynthetic and synthetic routs to make organic compounds from simpler components using the reactions from outcome 1 above;
4. outline the main components of UV, NMR, IR, MS, Polarimetry, GC and HPLC spectrometers;
5. determine the structure of unknown organic molecules given some or all of the spectra or data from the instruments listed in outcome 4 above;
6. discuss the significance of the "Green" Chemistry components of laboratory experiments;
7. define: an Allylic carbon, Conjugated Pi bonds, Diene, s-Cis and s-Trans conjugated dienes, Dienophile, Endo and Exo Diels-Alder products, Aromaticity, Acid derivative, Saccharide, Carbohydrate, Aldose, Ketose, Pentose, Hexose, Monosaccharide, Disaccharide, Polysaccharide, Epimers, Epimerization, Anomers, Anomeric Carbon, D-Saccharides, L-Saccharides, Pyranoses, Acetal, Hemiacetal, Alpha-D-Glucopyranose, Beta-D-Glucopyranose, Mutarotation, Reducing Sugars, Cellulose, Beta-linked polysaccharides, Starch, Glycogen and Alpha-liked polysaccharides, "N-terminal" and "C-terminal" of a Peptide, the 12 principals of Green Chemistry;
8. draw resonance for Allylic and Benzylic radicals, carbocations and anions;
9. compare and contrast reactions under Kinetic vs. Thermodynamic control;
10. draw simple, linear, conjugated Pi Molecular Orbital Diagrams;
11. explain how extended conjugation in organic molecules gives them color;
12. derive IUPAC names of molecules with the following functional groups: Substituted benzene, Aldehydes, Ketones, Carboxylic Acids, Amines, Esters, Amides and be able to use the nomenclature functional group prioritization rules to name molecules with multiple functional groups;
13. predict if cyclic organic compounds are Aromatic, Anti-aromatic or neither;
14. use the concept of aromaticity to predict the pKa of 1,3-cyclopentadiene;
15. use the concepts of induction and resonance to predict the acidity and reactivity of substituted benzene rings;
16. draw the mechanism of an acidic and a basic addition to a carbonyl carbon;
17. use the Acetals as protecting groups (stable to base; NaOH, Grignards, organolithiums, alkyne anions, etc.) in synthetic schemes;
18. predict the acidity of alpha carbons of carbonyls;
19. describe how a Dean-Stark Trap operates;
20. explain why the amide C-N bond has restricted rotation and lower electrophilic reactivity (Resonance) and how this effects the temperature dependence of Amide NMR spectrums;
21. predict that when an amine is added to an acidic aqueous solution the positive charge it gains, usually results in it being water soluble;
22. predict that Beta-Dicarbonyls are more acidic than single Carbonyl compounds;
23. draw the cyclic and linear forms of monosacchrides;
24. predict the aromaticity of Heterocycle and explain how this effects their reactivity;
25. state that Heterocycles are found in many important Biological molecules and drugs;
26. state the Dogma of Biochemistry: (a) Nucleotides polymerize to form DNA, (b) DNA is transcribed as mRNA, (c) mRNA and tRNA polymerize

Amino Acids to form Polypeptides (Translation), (d) Polypeptides fold up to form Proteins, (e) Proteins can be Structural or Enzymes (Biological Cat.);
27. predict the protonation state of all acidic/basic functional groups in amino acids that are buffered to a certain pH;
28. draw polypeptides;
29. predict the planarity of an Amide O-N-C bond by considering resonance;
30. derive an amino acid sequence from hydrolysis and Edman Degradation data.
Laboratory Objectives:
1. outline the main components of UV, NMR, IR, MS, Polarimetry, GC and HPLC spectrometers;
2. determine the structure of unknown organic molecules given some or all of the spectra or data from the instruments listed in outcome 4 above;
3. discuss the significance of the "Green" Chemistry components of laboratory experiments;
4. define: an Allylic carbon, Conjugated Pi bonds, Diene, s-Cis and s-Trans conjugated dienes, Dienophile, Endo and Exo Diels-Alder products, Aromaticity, Acid derivative, Saccharide, Carbohydrate, Aldose, Ketose, Pentose, Hexose, Monosaccharide, Disaccharide, Polysaccharide, Epimers, Epimerization, Anomers, Anomeric Carbon, D-Saccharides, L-Saccharides, Pyranoses, Acetal, Hemiacetal, Alpha-D-Glucopyranose, Beta-D-Glucopyranose, Mutarotation, Reducing Sugars, Cellulose, Beta-linked polysaccharides, Starch, Glycogen and Alpha-liked polysaccharides, "N-terminal" and "C-terminal" of a Peptide, the 12 principals of Green Chemistry;
5. derive IUPAC names of molecules with the following functional groups: Substituted benzene, Aldehydes, Ketones, Carboxylic Acids, Amines, Esters, Amides and be able to use the nomenclature functional group prioritization rules to name molecules with multiple functional groups;
6. predict that when an amine is added to an acidic aqueous solution the positive charge it gains, usually results in it being water soluble;
7. use Nuclear Magnetic Resonance (NMR, 60 MHz) Spectrometer (Proton and Carbon spectra, 2D: COSY, HETCOR and DEPT), the Fourier Transform Infrared (FT-IR) Spectrometer (with an ATR adapter) and the melting point apparatus by independently running many samples;
8. use the High Performance Liquid Chromatography (HPLC) system by running multiple samples in small groups;
9. apply the standard laboratory techniques such as liquid-liquid extractions, crystallizations, distillations, chromatography (thin layer), notebook data recording and experimental report generation (written and oral) by independently performing these tasks;
10. use a Polarimeter by independently running a sample on ours;
11. perform some “green Chemistry” experiments;
12. use all of the above techniques to perform 2 multiple step organic syntheses.

General Education Information

- Approved College Associate Degree GE Applicability
- CSU GE Applicability (Recommended-requires CSU approval)
- Cal-GETC Applicability (Recommended - Requires External Approval)
- IGETC Applicability (Recommended-requires CSU/UC approval)

Articulation Information

- CSU Transferable
- UC Transferable

Methods of Evaluation

- Problem Solving Examinations
  - Example: Draw the structure of 5-Hydroxy-5-methylhexanoic acid. Rubric: 5 point problem, partial credit given for the following; (a) 2 points for drawing an acid, (b) 1 point for adding the hydroxyl group, (c) 1 point for adding the methyl group, and (d) 1 point for having groups on the correct carbons.
- Reports
  - Example: Write a formal report in the format of the Journal of Organic Chemistry on the Synthesis of Ortho-Ethylacetophenone starting with Acetophenone and any other carbon source.
- Skill Demonstrations
  - Example: Here is a sample skill demonstration on drawing curved arrow mechanisms; Draw the (a) product and (b) curved arrow mechanism for an Enamine Alkylation and hydrolysis. [This links to lecture course objective 2] Rubric: 10 point problem, partial credit for the following; (a) 3 point for the Alkylation and (b) 7 points for the hydration (incorrect arrows and/or formal charges will deduct points from (a) and (b) above).

Repeatable

No

Methods of Instruction

- Laboratory
- Lecture/Discussion
- Distance Learning

Lab:

1. After reading the experiment in the laboratory text, outlining the procedure and listening to the introduction of the experiment, the students will perform the Aldehyde Enigma experiment. After the synthesis, workup and purification of this reactions two products the student will use NMR, IR, mp and experimental data to determine the structure of the two unknown products.

Lecture:

1. After lecturing on the Aldol condensation three types of problems are presented to the student to work on in small groups and the instructor walks around the groups and gives assistance. The problems are; (a) draw the curved arrow mechanism of the Aldol condensation of Propanal under basic conditions, (b) provide the products of the reaction between Ethanal and Benzaldehyde under basic conditions and (c) draw the Retrosynthesis and Synthesis of cis- and trans-2-Butenal starting from three carbon or less starting organic compounds. If the course is online the lecture material will be presented with videos and a slide lecture presentation. Problem solving will take place on a shared interactive white board via a Google Jamboard. The instructor will interact and assist in the problem-solving process on the shared whiteboard as students solve the problem.

Distance Learning

1. After lecturing on the Aldol condensation three types of problems are presented to the student to work on in small groups and the instructor walks around the groups and gives assistance. The problems are; (a) draw the curved arrow mechanism of the Aldol condensation of Propanal under basic conditions, (b) provide the

products of the reaction between Ethanal and Benzaldehyde under basic conditions and (c) draw the Retrosynthesis and Synthesis of cis- and trans-2-Butenal starting from three carbon or less starting organic compounds. If the course is online the lecture material will be presented with videos and a slide lecture presentation. Problem solving will take place on a shared interactive white board via a Google Jamboard. The instructor will interact and assist in the problem-solving process on the shared whiteboard as students solve the problem.

Typical Out of Class Assignments
Reading Assignments

1. Read and "Pre-lab" the experiment in which you will perform Green Nitration of Aromatic compounds and characterize the product ratio via GC Chromatography. A "Pre-Lab" includes writing a procedure that will be followed to perform the experiment. 2. Read the chapter on Amines and answer the homework questions given out by the instructor related to the reading.

Writing, Problem Solving or Performance

1. Write up a report on the results from the Green Nitration of Aromatic compounds experiment. The report will include a discussion of the results of the reaction as ascertained from GC Chromatographic data and the Green Chemistry aspects of the reaction. 2. Write up a formal report for the synthesis of Biodiesel. This report will include (a) title, (b) author name, (c) abstract, (d) keywords, (e) introduction, (f) results, (g) discussion, (h) conclusion, (i) acknowledgements, (j) experimental and (k) references in the format of the Journal of Organic Chemistry. 3. An oral presentation on the multi step synthesis of an organic will be performed.

Other (Term projects, research papers, portfolios, etc.)
Required Materials

- Organic Chemistry, Structure and Function
  - Author: K. Peter C. Vollhardt and Neil E. Schore
  - Publisher: WH Freeman
  - Publication Date: 2018
  - Text Edition: 8th
  - Classic Textbook?:
  - OER Link:
  - OER:
- A Microscale Approach to Organic Laboratory Techniques
  - Author: Donald L. Pavia, et al
  - Publisher: Cengage
  - Publication Date: 2018
  - Text Edition: 6th
  - Classic Textbook?:
  - OER Link:
  - OER:

Other materials and-or supplies required of students that contribute to the cost of the course.