Course Number and Title: CHM 241 Organic Chemistry II

Campus Location:
Georgetown, Dover, Stanton, Wilmington

Effective Date:
2018-51

Prerequisite:
CHM 240

Co-Requisites:
None

Course Credits and Hours:
4.00 credits
3.00 lecture hours/week
3.00 lab hours/week

Course Description:
This course, a continuation of Organic Chemistry I, covers molecular structure, bonding, nomenclature, properties, reactions, spectrometric analysis of aromatic compounds, alcohols, phenols, ethers, aldehydes, ketones, carboxylic acids, carboxylic acid derivatives, amines, and polymers. The laboratory consists of related isolation, purification, synthesis, and analysis techniques.

Required Text(s):
Obtain current textbook information by viewing the campus bookstore - https://www.dtcc.edu/bookstores online or visit a campus bookstore. Check your course schedule for the course number and section.

Additional Materials:
None

Schedule Type:
Classroom Course

Disclaimer:
None

Core Course Performance Objectives (CCPOs):

1. Examine the relationship between molecular structure and the chemical and physical properties of various organic families. (CCC 6; PGC BIS 1, CEM 1, CHM 1)
2. Examine major types of organic reactions, including but not limited to oxidation, reduction, rearrangement, substitution, addition, and elimination. (CCC 6; PGC BIS 1, CEM 1, CHM 1)
3. Apply the International Union of Pure and Applied Chemistry (IUPAC) rules of nomenclature to name compounds in various organic families. (CCC 6; PGC BIS 1, CEM 1, CHM 1)
4. Compare common methods of synthesis and reactions of various organic families. (CCC 6; PGC BIS 1, CEM 1, CHM 1)
5. Describe natural and industrial sources and applications and uses of important organic families. (CCC 6; PGC BIS 1, CEM 1, CHM 1)
6. Explain methods of synthesis, properties, and uses of common polymers. (CCC 6; PGC BIS 1, CEM 1, CHM 1)
7. Interpret simple nuclear magnetic resonance spectra. (CCC 6; PGC BIS 1, CEM 8, CHM 8)
8. Safely assemble and conduct effective organic reactions, separations, and product identifications. (CCC 2, 6; PGC BIS 2, 6, CEM 1, 2, 3, 6, 8, 9, CHM 1, 2, 3, 6, 8, 9)
9. Document laboratory observations and data in a laboratory notebook in accordance with accepted professional standards. (CCC 1; PGC BIS 3, CEM 4, 7, CHM 4, 7)

See Core Curriculum Competencies and Program Graduate Competencies at the end of the syllabus. CCPOs are linked to every competency they develop.

Measurable Performance Objectives (MPOs):
Upon completion of this course, the student will:

1. Examine the relationship between molecular structure and the chemical and physical properties of various organic families.
    1. Discuss how substituents affect reactivity and orientation in electrophilic aromatic substitution reactions by resonance and inductive effects.
    2. Identify o-, p-, and m-directors, and activating and deactivating groups.
    3. Discuss the mechanism and utility of nucleophilic aromatic substitution.
    4. Describe the effects of a hydroxyl group on boiling point and solubility and how they result from hydrogen bonding.
    5. Compare the acidity and basicity of water and alcohols.

6. Relate the oxidation level of carbon in alcohols to other organic compounds.
7. Compare the acidity of water, alcohols, carboxylic acids, and phenols.
8. Discuss the reactivity of phenols in electrophilic aromatic substitution.
9. Describe the physical properties, chemical reactivity, and hazards of ethers.
10. Describe the geometry and polarity of the carbonyl group.
11. Relate the oxidation level of carbon in aldehydes and ketones to other organic compounds.
12. Compare the relative reactivities of aldehydes and ketones in nucleophilic addition reactions.
13. Describe the geometry, polarity, and acidity of the carboxyl group.
14. Discuss the dissociation of carboxylic acids and the role of resonance.
15. Relate the oxidation level of carbon in carboxylic acids to other organic compounds.
16. Relate the acid strength of carboxylic acids to their acid dissociation constant (K_a) or negative logarithm of acid dissociation constant (pK_a).
17. Describe the inductive and resonance effects of substituents on the acidity of substituted aliphatic and benzoic carboxylic acids.
18. Describe the relative reactivity of acid halides, acid anhydrides, amides, and esters in nucleophilic acyl substitution reactions.
19. Discuss and write equations illustrating, keto-enol tautomerism of carbonyl compounds with alpha-hydrogens.
20. Describe the physical properties and hydrogen bonding abilities of amines.
21. Relate the base strength of amines to their base dissociation constant (K_b) or negative logarithm of base dissociation constant (pK_b).
22. Describe the inductive effects of substituents on aliphatic amines.
23. Describe the inductive and resonance effects of substituents on arylamines.

2. Examine major types of organic reactions, including but not limited to oxidation, reduction, rearrangement, substitution, addition, and elimination.
    1. Describe the mechanism of electrophilic aromatic substitution.
    2. Write equations for side chain oxidation and halogenation of arenes.
    3. Write equations for reduction reactions of aromatic rings.
    4. Write equations for reduction of alkyl aryl ketones.
3. Apply the International Union of Pure and Applied Chemistry (IUPAC) rules of nomenclature to name compounds in various organic families.
    1. Name alcohols using common names and IUPAC rules.
    2. Classify alcohols as primary, secondary, or tertiary.
    3. Name thiols using common names and IUPAC rules.
    4. Name phenols, naphthols, and thiophenols using common names and IUPAC rules.
    5. Name ethers and epoxides using common names and IUPAC rules.
    6. Name aldehydes and ketones using common names and IUPAC rules.
    7. Name the C1–C6 aliphatic acids, the C2–C4 dicarboxylic acids, acrylic, benzoic, phthalic, and salicylic acid using common names and IUPAC rules.
    8. Name substituted acids using the IUPAC system (numbers) and traditional system (Greek letters).
    9. Write the names and structural formulas for carboxylic acid salts, acid halides, acid anhydrides, amides, esters, and nitriles.
    10. Classify aliphatic amines as primary, secondary, or tertiary.
    11. Name amines, including the major heterocyclic amines, using common names and IUPAC rules.
    12. Name quaternary ammonium salts and amine salts.
4. Compare common methods of synthesis and reactions of various organic families.
    1. Write equations for bromination, chlorination, nitration, and sulfonation of aromatic compounds.
    2. Write equations for Friedel-Crafts alkylation and acylation reactions.
    3. Write equations for the synthesis of alcohols from alkenes by hydroboration and oxymercuration.
    4. Write equations for the synthesis of alcohols by reduction of carbonyl compounds.
    5. Write equations for the synthesis of alcohols by addition of Grignard reagents to carbonyl compounds.
    6. Write equations for the conversion of alcohols to alkenes.
    7. Write equations for the conversion of alcohols to alkyl halides, tosylates, and inorganic esters.
    8. Write equations for the reactions of alcohols with oxidizing agents.
    9. Write equations for the synthesis of thiols and the interconversions of thiols and disulfides.
    10. Write equations for the synthesis of phenols from sulfonic acids and from anilines.
    11. Write equations for the reaction of phenols with bases.
    12. Write equations for the synthesis of ethers by dehydration of alcohols and the Williamson synthesis.
    13. Write equations to illustrate the cleavage of ethers with acids.
    14. Write equations for the epoxidation of alkenes.
    15. Write equations for ring-opening reactions of epoxides.
    16. Write equations for the oxidation and alkylation of sulfides.
    17. Write equations for the synthesis of aldehydes and ketones by oxidation of alcohols, hydration of alkynes, and Friedel-Crafts acylation.
    18. Write equations for and describe the products of, the nucleophilic addition reactions of aldehydes and ketones with water, cyanide, Grignard reagents, borohydride, amines, hydrazine and alcohols.
    19. Write equations showing how the Wittig reaction is used to synthesize alkenes from alkyl halides and carbonyl compounds.
    20. Write equations for the synthesis of carboxylic acids by oxidation of arenes, alkenes, or alcohols, hydrolysis of nitriles and carboxylation of Grignard reagents.
    21. Write equations for the reaction of carboxylic acids with reducing agents.

22. Describe the decarboxylation of acids by the Hunsdiecker reaction.
23. Write equations for the conversion of carboxylic acids into acid halides, acid anhydrides, amides and esters.
24. Write equations for the synthesis of acid halides, acid anhydrides, amides, esters and nitriles.
25. Write equations for the reactions of acid halides, acid anhydrides, amides, esters, and nitriles with water, alcohols, amines, reducing agents, and organometallic reagents.
26. Define *enolate ion,* and describe its formation and use.
27. Write equations for the synthesis of substituted carboxylic acids by the malonic ester synthesis.
28. Describe and write equations illustrating each step in the mechanism of the aldol reaction.
29. Discuss the role of resonance and equilibria in the aldol reaction.
30. Show how the aldol reaction can be used to synthesize enones.
31. Describe the uses and limitations of the mixed aldol reaction.
32. Write equations for the synthesis of amines by substitution of alkyl halides with ammonia, azide, and phthalimide (Gabriel synthesis).
33. Write equations for the synthesis of amines by reductive amination of ketones and aldehydes.
34. Write equations for the reaction of amines with inorganic acids, alkyl halides, and acid chlorides.
35. Write equations for the synthesis of arylamines by reduction of aromatic nitro compounds.
36. Discuss the reactivity of arylamines in electrophilic aromatic substitution.
37. Write equations for the synthesis of diazonium salts.
38. Write equations for the conversion of diazonium salts into arenes, aryl halides, nitriles, and phenols.
39. Write equations for the coupling reactions of diazonium salts with arylamines and phenols.

5. Describe natural and industrial sources and applications and uses of important organic families.
    1. Describe the industrial processes used for the synthesis of and the uses for methanol, ethanol, and ethylene glycol.
    2. Describe the industrial processes used for the synthesis of and the uses for phenol.
    3. Discuss the synthesis and commercial uses of ethylene oxide.
    4. Discuss the uses of crown ethers.
    5. Describe the industrial processes used for the synthesis of formaldehyde and acetaldehyde.
    6. Discuss the use of amines in the resolution of enantiomers.
    7. Describe the industrial processes used for the synthesis of simple amines.
    8. Discuss the use of quaternary ammonium salts as phase-transfer catalysts.
    9. Discuss the significance of some representative alkaloids.
6. Explain methods of synthesis, properties, and uses of common polymers.
    1. Describe the mechanism of formation of chain-growth and step-growth polymers, and identify important examples of each.
    2. Identify the monomer characteristics optimal for radical, cation, and anion-initiated polymerization.
    3. Describe atactic, isotactic, and syndiotactic structural characteristics.
    4. Describe the regio-and stereochemical outcomes of polymerizing butadiene, chloroprene, and isoprene.
    5. Distinguish homopolymers, block, and graft copolymers.
    6. Define and distinguish *thermoplastic* and *thermosetting* polymers.
    7. Define *plasticizer,* and describe how plasticizers are used.
7. Interpret simple nuclear magnetic resonance spectra.
    1. Describe the principles of absorption of radio frequency (RF) energy by nuclei in a magnetic field.
    2. Describe the operation of a nuclear magnetic resonance (NMR) spectrometer.
    3. Define chemical shift, shielding, and deshielding.
    4. Interpret the integration of proton NMR signals; define *chemical equivalence*.
    5. Interpret first-order spin-spin splitting patterns in proton NMR spectra.
    6. Use correlation charts and tables to interpret proton NMR spectra, and deduce structural features.
    7. Describe the kind of structural information obtainable with ^{13}C NMR.
8. Safely assemble and conduct effective organic reactions, separations, and product identifications.
    1. Discuss the hazards of diazonium salts.
    2. Use physical and chemical tests and infrared (IR) spectrometry to identify organic compounds.
    3. Assemble and operate organic laboratory apparatus for performing multi-step syntheses at room temperature and at reflux and with water sensitive reagents such as acid halides and Grignard reagents.
    4. Separate, isolate, purify, and identify the products of a multi-step synthesis using recrystallization, distillation, extraction, column chromatography, and thin layer chromatography.
    5. Use the secondary chemical literature to identify an unknown organic compound.
    6. Observe and adhere to accepted good laboratory practices for working safely and maintaining conditions for high quality work in an organic laboratory.
9. Document laboratory observations and data in a laboratory notebook in accordance with accepted professional standards.
    1. Obtain and record laboratory observations and data in a laboratory notebook in accordance with accepted professional standards.
    2. Apply IUPAC nomenclature to organic compounds.
    3. Obtain data on the chemical and physical properties of substances using printed and online resources.

Evaluation Criteria/Policies:
Students must demonstrate proficiency on all CCPOs at a minimal 75 percent level to successfully complete the course. The grade will be determined using the Delaware Tech grading system:

92	–	100	=	A
83	–	91	=	B
75	–	82	=	C
0	–	74	=	F

Students should refer to the Student Handbook - https://www.dtcc.edu/handbook for information on the Academic Standing Policy, the Academic Integrity Policy, Student Rights and Responsibilities, and other policies relevant to their academic progress.

Core Curriculum Competencies (CCCs are the competencies every graduate will develop):

1. Apply clear and effective communication skills.
2. Use critical thinking to solve problems.
3. Collaborate to achieve a common goal.
4. Demonstrate professional and ethical conduct.
5. Use information literacy for effective vocational and/or academic research.
6. Apply quantitative reasoning and/or scientific inquiry to solve practical problems.

Program Graduate Competencies (PGCs are the competencies every graduate will develop specific to his or her major):
Biological Sciences

1. Apply knowledge of the theories and principles of biology and biotechnology.
2. Employ good laboratory practices (GLP) and safety guidelines to conduct common laboratory operations.
3. Employ standard laboratory documentation practices for data management and laboratory notebooks.
4. Utilize chemical principles and apply mathematics in the preparation of laboratory solutions.
5. Analyze samples by common quantitative and qualitative techniques.
6. Perform separation techniques on biological samples and interpret results.
7. Perform laboratory techniques used in microbiology, immunology and biotechnology.
8. Apply calculus to the solution of problems.
9. Demonstrate professional behavior and communications skills.

Chemistry

1. Apply knowledge of the theories and principles of chemistry.
2. Follow safety procedures.
3. Perform basic laboratory operations and techniques.
4. Keep a laboratory notebook following standard laboratory practices and present data in an organized written format.
5. Prepare common laboratory solutions.
6. Prepare and purify samples using common techniques.
7. Communicate in a professional manner.
8. Analyze samples by common qualitative and quantitative techniques.
9. Use and maintain common laboratory instruments and equipment.
10. Apply mathematical concepts to the solution of scientific problems.

Chemistry Math Concentration

1. Apply knowledge of the theories and principles of chemistry.
2. Follow safety procedures.
3. Perform basic laboratory operations and techniques.
4. Keep a laboratory notebook following standard laboratory practices and present data in an organized written format.
5. Prepare common laboratory solutions.
6. Prepare and purify samples using common techniques.
7. Communicate in a professional manner.
8. Analyze samples by common qualitative and quantitative techniques.
9. Use and maintain common laboratory instruments and equipment.
10. Apply differential and integral calculus in the solution of problems.

Disabilities Support Statement:
The College is committed to providing reasonable accommodations for students with disabilities. Students are encouraged to schedule an appointment with the campus Disabilities Support Counselor to request an accommodation needed due to a disability. A listing of campus Disabilities Support Counselors and contact information can be found at the disabilities services - https://www.dtcc.edu/disabilitysupport web page or visit the campus Advising Center.