Organic Chemistry II | Lecture and Lab

**Academic Year 2020-2021**

# Course Information

| Course Numbers | Total Credits | Time Requirement |
|---|---|---|
| **OCHM316/OCHM316L** | **4 (3 Lecture + 1 Lab)** | **75 hrs (Lecture 45hrs + Lab 30hrs)** |

# Course Details

### Recommended Prerequisites

Organic Chemistry I Lecture/Lab (CHEM311 and CHEM311L) or equivalent.

### Course Description

This course is the second in a two-part series, which furthers elaborates functional groups with emphasis on alcohols, phenols, ethers, aldehydes, ketones, amides, esters, amines, and carboxylic acids once the nature and reactivity of these functional groups is understood, important biological examples will be stressed and elaborated. Biochemistry, particularly the properties and metabolism of biological macromolecules such as nucleic acids, lipids, and proteins will be introduced.

### Lecture and Laboratory Communication

A website will be set up on Canvas by your instructor.
Log in with your Username and password: **https://scuhs.instructure.com**

### Faculty Information

Refer to the Canvas course webpage for this information.

### Class Meeting Times

Refer to Canvas course webpage for this information.

# Instructional Materials

### Required Text(s)

Lecture: Organic Chemistry with Biological Topics 6th Edition by Janice Smith and Heidi Vollmer-Snarr
ISBN: 1260516393 (Connect©) or Organic Chemistry (8th Edition) by L. G. Wade Jr ISBN-10: 0321768418. An electronic textbook is provided to students through Canvas.

### Lab

SCU Organic Chemistry II Laboratory Manual (available on Canvas)

# Course Purpose

## Student Learning Outcomes

At the conclusion of this course, a successful student should be able to:

1. Recognize many functional groups and their reactivity (CLO 1-47)
2. Demonstrate the use of nuclear magnetic resonance spectroscopy, mass spectrometry and infrared spectroscopy for organic structure elucidation (CLO 1-9).
3. Understand the fundamentals of electronic structure and bonding in conjugated and aromatic systems, and reactivity patterns of conjugated and aromatic molecule (CLO 15-28)
4. Demonstrate an understanding of the chemical environment and the role that organic molecules play in the natural and the synthetic world (CLO 1-47)
5. Demonstrate proficiency in assembling basic laboratory glassware, performing fundamental laboratory techniques, making and recording relevant experimental observations and interpreting the results. (CLO 1-47)

**Course Learning Objectives: Please refer to the appendix for a full list of course objectives.**

## Course Schedule

**(subject to slight modifications by the instructor)**

*The reading chapters refer to the Smith and Volmer textbook.*

| Day | Lecture | Reading | Assessment |
|---|---|---|---|
| **1** | Mass Spectrometry and Infrared Spectroscopy | Section A and B | Class Participation |
| **2** | Nuclear Magnetic Resonance Spectroscopy | Section C | Class participation |
| **3** | Introduction to Carbonyl Chemistry; Organometallic Reagents; Oxidation and Reduction | Chapter 13 | Class participation<br>Exam 1 |
| **4** | Aldehydes and Ketone Nucleophilic Addition | Chapter 14 | Class participation |
| **5** | Carboxylic Acids and Nitriles<br>Carboxylic Acids and Their Derivatives-Nucleophilic Acyl Substitution | Chapter 15<br>Chapter 16 | Class participation<br>Exam 2 |
| **6** | Substitution Reactions of Carbonyl Compounds of alpha carbon<br>Carbonyl Condensation Reactions | Chapter 17<br>Chapter 18 | Class participation |
| **7** | Benzene and Aromatic compounds<br>Reaction of Aromatic Compounds | Chapter 19<br>Chapter 20 | Class participation<br>Exam 3 |
| **8** | Radical Reactions | Chapter 21 | Class participation |
| **9** | Amines | Chapter 22 | Class participation |
| **10** | **Review and Final Exam** | | **Final Exam** |

## Tentative Grading Procedures

**Lecture**

| Assessment | Points | Weight (%) |
|---|---|---|
| **Exam 1** | 100 | ~16% |
| **Exam 2** | 100 | ~16% |
| **Exam 3** | 100 | ~16% |
| **Exam 4** | 100 | ~16% |
| **Participation** | 60 | 10% |
| **Homework** | 150 | 25% |
| **Total** | 610 | 100% |

## Lab Schedule

**(subject to slight modifications by the instructor)**

| Laboratory | Assessment |
|---|---|
| Check-in: Check in/safety | Class participation |
| Experiment 1:  Infrared Spectroscopy | Lab notebook |
| Experiment 2: Nuclear Magnetic Resonance | Quiz 1<br>Lab notebook |
| Experiment 3: Alcohols and Phenols | Lab notebook |
| Experiment 4: Organic Function Groups | Quiz 2<br>Lab notebook |
| Experiment 5: Properties of Carboxylic Acids and Esters | Lab notebook |
| Experiment 6: Regioselective Nitration | Quiz 3<br>Lab notebook |
| Experiment 7: Synthetic Polymers | Lab notebook |
| Experiment 8: TBA | Lab notebook |
| Review/Check-out | Quiz 4 |

## Tentative Grading Procedures

**Lab**

| Assessment | Points | Weight (%) |
|---|---|---|
| **Lab Quizzes (4 x 50 points)** | 200 | 52 |
| **Lab Notebook** | 180 | 47 |
| **Participation** | 5 | 1 |
| **Total** | 385 | 100 |

## Lab Notebook:

- Pre-Lab: 40% of Total Assignment points (includes title, purpose, hypothesis, materials, procedure, prelab questions and worksheets)
- Post Lab: 50% of Total Assignment points (includes data, observations, calculations, post lab questions and conclusion)
- Neatness, grammar and clarity: 10% of Total assignment points

## Grading scale:

Please note letter grades will be assigned only at the end of the trimester.

**A** = 90% to 100%

**B** = 80% - less than 90%

**C** = 70% - less than 80%

**D** = 60% - less than 70%

**F** = less than 60%

**W** = Withdrawal

### Grading procedures:

The format of this assessment may include multiple choice, short answer, labelling, fill-in-the-blank, or calculation examinations. Participation points are required and will be assigned by the instructor as the course progresses through your general performance and regards for the rules of the laboratory and safety procedures.

## Academic Integrity

Visit SCU's **Academic Integrity** page to review policies for professionalism and academic integrity.

## Teaching Methods and Activities

Because of the demands of the course, successful chemistry students don't wait until exam time to begin studying. Instead, you should plan to follow the chemistry rule that every hour spent in class requires two to three hours of effort outside of class to succeed in this course. As an example, let's say you've just been assigned reading on Lewis structures. Don't let a day go by without learning how to write and interpret Lewis structures. Future work will most likely use these bonding diagrams, and they are likely to reappear in lectures, quizzes and exams. Procrastination doesn't simply mean that you won't understand Lewis structures—you'll also be lost for every subsequent reading and lecture that employs these diagrams. Staying on top of work and avoiding procrastination will help you build foundational knowledge and ensure you are equipped to learn subsequent material.

### Lecture Exams:

There will be a total of 4 non-cumulative tests given during the course of this class. Each test will cover any and all material (lecture + homework + assigned reading) from the previous week of class. The tests will include multiple choice and free response questions, and there will be partial credit for only correct works shown for free response questions.

### Lecture Participation:

Points are received from participation during in-class activities. Attendance is not the same thing as participation. Students are expected to be involved and engaged in all classroom activities (which may include formative quizzes and other assessments graded on participation).

### Attendance:

Punctual attendance at each of your regularly scheduled laboratory and period is required. Additionally, you are required to stay until you and/or your group have completed the experiment. Check out with your lab instructor before leaving the laboratory after completing the experiment. You are expected to attend every one of your scheduled lab meeting times. However, if you find yourself in a situation where you are unable to attend lab, please email your instructor right away.

### Required Attire

Close-toed shoes, professional attire and lab coats are mandatory during all lab hours. No shorts, heels, or flip-flops will be allowed in the laboratory; hair longer than shoulder-length must be pulled back and held with a clip or hair tie. Gloves, goggles and additional safety equipment will be required per experiment.

Laboratory Quizzes will be given the week after your experiment and its modality will be indicated by the Professor. These quizzes will be closely based on the reports and prelabs.

Evaluation of Experimental Technique: You will be assessed on your general performance and regards for the rules of the laboratory and safety procedures.

Attendance for lab: Punctual attendance at each of your regularly scheduled laboratory and period is required. Additionally, you are required to stay until you and/or your group have completed the experiment. Check out with your lab instructor before leaving the laboratory after completing the experiment. You are expected to attend

every one of your scheduled lab meeting times. However, if you find yourself in a situation where you are unable to attend lab, please email your instructor right away.

### Classroom Expectations

Please be professional, prompt, prepared, and polite at all times.

The professor will adhere to all policies as found in the Student Handbook. Cellular phones must be kept on silent during class and lab times. Students may not use a phone as a calculator. As a safety precaution, no food or drinks are allowed inside the lab, but there will be a designated break for eating and drinking outside of the lab.

## Best Practices for Studying Chemistry

- Read before and read after each class. Skim the chapter before it is covered in lecture to become comfortable with some of the terms associated with each topic. Review each chapter after it is covered in class to enhance your understanding of what was covered in class.
- Participate during class by taking notes during class and looking over them afterwards. Don't skip class, arrive late, or leave early. Ask questions for clarification when you don't understand the material.
- Stay on top of the homework and assignments. Do the assigned problems as close to the time as when the topic is covered in the class to increase the depth of your understanding of specific concepts and will help you learn the material more efficiently and effectively.
- Do not wait until the night before the homework is due to start the assignment. You will get more out of it if you take the time to really learn the concepts and review the material without being rushed.
- Find a group of students to study with. Seek out students dedicated to doing well in the course. This makes studying more fun and helps you learn the material better by teaching what you know and learning from your peers what you don't know. Explaining these concepts to others will help you learn the material even better.
- Stay focused by finding an environment where you can study with few distractions.

## University Policies

### Accommodations

As a learning-centered community, Southern California University of Health Sciences recognizes that all students should be afforded the opportunity to achieve their academic and individual potential. The University recognizes and supports the standards set forth in Section 504 of the Rehabilitation Act and

the American with Disabilities Act (ADA). In accordance with its mission and federal and applicable state laws, the University is committed to making reasonable accommodations for qualified applicants for admission and enrolled students with disabilities. A student who needs accommodation(s) due to a disability should contact the Academic Support Office located in the Learning Resource Center.

### Faculty and Dr./Patient Relationships

SCU faculty are highly skilled. However, per University Policy, health care is offered to students through the University Health System only. Neither preclinical nor clinical faculty can provide advice, assessment, treatment,

or other elements that would be considered part of a Doctor-Patient relationship outside of a clinical setting established for that purpose.

### Learning Activities

Students are expected to spend at least two hours for each lecture hour of course time per week in activities and assessments outside the classroom. Examples of activities include, but are not limited to: writing papers; reading articles or text; small group work; presentations; completing assignments; preparation for assessments; online activities and other activities that do not include direct instructor interaction and involvement.

All university policies apply to this course and all others. For full policy information please consult the university SCU Policy Manual. For a quick reference guide to the following policies: make-up examination, F-challenge examination, grade posting, results of failing grades, student support information, syllabus amendments, special needs, student conduct, and attendance, please consult the academic policies document housed on the **Online Student Services .**

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## Appendix A: Course Learning Objectives

At the conclusion of this course, a successful student should be able to:

**Infrared Spectroscopy and Mass Spectrometry**

1. Identify the reliable characteristic absorptions in an infrared spectrum.
2. Propose which functional groups are likely to be present in the molecule.
3. Explain which functional groups cannot be present in a molecule because their characteristic peaks are absent from the IR spectrum.
4. Use a mass spectrum to determine a compound's molecular weight, and propose which elements are likely to be present.
5. Given a structure, predict the major ions that will be observed in the mass spectrum from fragmentation of the molecular ion. Use these predictions to determine whether a proposed structure is consistent with the spectrum.

**Nuclear Magnetic Resonance Spectroscopy**

6. Use the chemical shifts, splitting patterns, and integrations shown in a proton NMR spectrum to propose structures for possible compounds.
7. Use the number of peaks and their chemical shifts in a $^{13}C$ NMR spectrum to determine the number of types of carbon atoms in the compound and what functional groups they might represent.
8. Given a chemical structure, predict the major features of its proton and $^{13}C$ NMR spectra.
9. Combine the information from NMR spectra, IR spectra, and mass spectra to determine the structures of unknown organic compounds.

**Ethers, Epoxides and Thioethers**

10. Draw and name ethers and heterocyclic ethers, including epoxides. Explain the trends in their boiling points, solubilities, and solvent properties.
11. Determine the structures of ethers from their spectra, and explain their characteristic absorptions and fragmentations.
12. Devise efficient laboratory syntheses of ethers and epoxides.
13. Predict the products of reactions of ethers and epoxides.
14. Propose mechanisms showing the formation and reactions of ethers and epoxides.

**Conjugated Systems, Orbital Symmetry, and Ultraviolet Spectroscopy**

15. Explain how to construct the molecular orbitals of butadiene and other conjugated systems.
16. Draw resonance forms and propose mechanisms to explain the observed products and the enhanced rates of reactions involving conjugated reactants and resonance- stabilized intermediates.

17. Predict the products of Diels–Alder reactions and determine which Diels–Alder reaction will give a specific synthetic product.
18. Predict which cycloadditions are thermally allowed and which are photochemically allowed by comparing the symmetry of the molecular orbitals of the reactants.
19. Use values of $l_{max}$ from UV–visible spectra to estimate the length of conjugated systems.

**Aromatic Compounds**

20. Determine whether Hückel's rule applies to a given structure, and predict whether the compound will be aromatic, antiaromatic, or nonaromatic.
21. Show how to construct the molecular orbitals of a conju- gated cyclic system similar to benzene and cyclobutadiene.
22. Predict whether a given heterocyclic structure will be aromatic. For heterocycles containing nitrogen, determine whether nitrogen's lone pairs are used in the aromatic system, and predict whether the nitrogen atom is strongly or weakly basic.
23. Use IR, NMR, UV, and mass spectra to determine the structures of aromatic compounds. Given an aromatic compound, predict the distinguishing features of its spectra.

**Reactions of Aromatic Compounds**

24. Understand the mechanisms of electrophilic and nucleophilic aromatic substitutions.
25. Predict the products of these reactions and use them in syntheses.
26. Explain how substituents on the aromatic ring promote substitution at some positions but not at others.
27. Predict the coupling products of organometallic substitutions and use them in syntheses.
28. Predict the products of oxidation and reduction of the aromatic ring, including hydrogenation, chlorination, and Birch reduction. Predict the products of the oxidation of phenols.

**Ketones and Aldehydes**

29. Draw and name ketones and aldehydes and use spectral information to determine their structures.
30. Propose single-step and multistep syntheses of ketones and aldehydes from compounds containing other functional groups.
31. Predict the products and propose mechanisms for the reactions of ketones and aldehydes with oxidizing and reducing agents, amines, alcohols, and phosphorus ylides.
32. Propose multistep syntheses using ketones and aldehydes as starting materials and intermediates. Protect the carbonyl group if necessary.

**Amines**

33. Draw and name amines and use spectral information to determine their structures.
34. Compare the basicity of amines with other common bases, and explain how their basicity varies with hybridization, aromaticity, resonance, and induction.

35. Describe the trends in the physical properties of amines and contrast their physical properties with those of their salts.
36. Predict the products and propose mechanisms for the reactions of amines with ketones, aldehydes, acid chlorides, nitrous acid, alkyl halides, and oxidizing agents.
37. Propose single-step and multistep syntheses of amines from compounds containing other functional groups.

**Carboxylic Acids**

38. Draw and name carboxylic acids and dicarboxylic acids and use spectral information to determine their structures.
39. Describe the trends in the acidity and physical proper- ties of carboxylic acids and explain how their acidity varies with their substituents.
40. Propose single-step and multistep syntheses of carboxylic acids from compounds containing other functional groups.
41. Predict the products and propose mechanisms for the reactions of carboxylic acids with reducing agents, alcohols, amines, and organometallic reagents.
42. Propose multistep syntheses using carboxylic acids and acid chlorides as starting materials and intermediates.

**Carboxylic Acid Derivatives**

43. Draw and name carboxylic acid derivatives, and use spectral information to determine their structures.
44. Describe the trends in physical properties of acid derivatives, and compare the relative reactivity of esters, thioesters, amides, nitriles, anhydrides, and acid chlorides.
45. Propose single-step and multistep syntheses of acid derivatives from compounds containing other functional groups.
46. Predict the products and propose mechanisms for the reactions of carboxylic acid derivatives with reducing agents, alcohols, amines, and organometallic reagents.
47. Propose multistep syntheses using acid derivatives as starting materials and intermediates.