Syllabus for Chemistry 315 - Fall 2020

Instructor: Prof. Lawrence Williams
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Location: Chemistry and Chemical Biology Building Auditorium
Time: Monday/Wednesday 1:40–3:00 pm
Office hours: Monday and Wednesday 3:00–4:00 pm (lecture location or WRLab Rm. 276)
Textbook: Clayden, Greeves, & Warren: Organic Chemistry 2e (ISBN: 978-0-19-927029-3)

Recitation Instructor :	Prof. Heinz Roth	email: hdroth@chem.rutgers.edu	Office Hours: TBA
Special Instruction:	Kiranjot Sethi	email: kjsethi@chem.rutgers.edu	Office Hours: TBA

IT Requirements: The course will be taught online but will still be conducted with live, interactive lectures, recitations, and office hours. Quizzes and exams will start and end at specific times and all students are expected to take these assessments at the same time. We generally refer to this format as remote synchronous instruction. Online tools for student authentication and test-taking (e.g., Proctortrack, ProctorU, Respondus), or some alternative validation method, will be used. This course therefore requires that you have access to high-speed internet, a computer/laptop/tablet (but not one with a mobile OS) with webcam and microphone. If the course IT requirements are not accessible to you, please reach out to the Dean of Students deanofstudents@echo.rutgers.edu. They may be able to direct you to assistance.

Recorded Lectures and On-Line Lecture Notes: The entire semester of videos and notes have been posed on Sakai in Resources. You are expected to have reviewed and studied the notes and chapter video content prior to the first class in which the material is to be discussed. This helps guarantee that you can participate and follow the discussion of how to synthesize concepts and how to recognize correct and incorrect thinking. The textbook is an excellent resource that necessarily covers more information than what is the video and lecture notes.

Chemistry 315/16 focuses on six key concepts to understand organic structure and reactivity. This focus is what most clearly distinguish honors from non-honors organic chemistry. These concepts are:

- Organic Molecular Structure (especially Molecular Orbital Theory ideas) in Ground and Transition States
- Energy Landscapes
- Curtin-Hammett Principle
- Microscopic Reversibility
- Hammond Postulate
- Conservation of Orbital Symmetry

Homework: Problems are posed throughout the lecture notes and videos. These are not graded but are essential. Be sure to attempt all problems before the first meeting discussion of a chapter. The quiz questions are designed to require mastery over the material as exemplified in these problems. There is an eLearning Homework that you can begin immediately. It can be taken as practice as often as you like for the first two weeks or so. It will prepare you for quizzes, too. [See **Quizzes** and **eLearning**.]

Other Materials: I recommend you get a set of molecular models. Most any type will do; no need to buy an expensive set. You likely will not need the entire set, so if you can safely share with someone consider splitting a set among 2-3 others. [You can even make what you need from clay or the equivalent (to represent atoms) and a about 10 short sticks (to represent a few bonds). Construct acetone: It has sp^3 and sp^2 atoms, carbon, hydrogen, and oxygen; get the angles right; approximate relative bond lengths; show the pi bond with two longer sticks to represent p-orbitals. That will be useful for several weeks.] Regardless, it is essential that each student develop a clear understanding of 3-dimensional relationships of orbitals, atomic arrangements, molecular shapes, and symmetries. Hand-held molecular models are the only way I know of to learn these relationships in a truly meaningful way and this understanding is essential to doing well in the class.

Attendance in Lecture: Lecture attendance is mandatory. We will be using Webex, primarily, although we may find it necessary to use another platform. It is difficult to say with certainty. If you have a conflict – which should be rare! – be sure to notify me (Professor Williams) beforehand or, in the case of an emergency, as soon as reasonably possible.

Lectures: Lectures will be held in my webex office: https://rutgers.webex.com/meet/lawjw please arrive a few minutes early. We will begin promptly at 1:40 PM.

Recitation: Recitations are designed such that students can ask questions, converse with the instructor, review material and have contact with experts in the field. Recitations are especially useful for reviewing problems and concepts. Come prepared; stay engaged.

Quizzes: The assessments this semester will take the form of one quiz per week, with the quiz given on Sundays at 1 PM. You will be given 45 minutes to take them. Some quizzes are repeated the following week to help you learn the material and to give you flexibility. There are a total of 11 quizzes. There are no midterm exams. There will be a Final. All quizzes and the Final will be given online using the eLearning Platform. This brings us to three very important points:

1) Students are not allowed to share information with any others in any way during assessments. Violation of this policy is the most egregious offence a student can made against Academic Integrity. Please maintain our historically high degree of integrity – remain committed to doing your own work.

2) If you took GenChem at RU then you are already familiar with eLearning. Regardless, follow the directions provided below regarding how to login and use eLearning, and take

the Functional Group Practice homework until you know BOTH the platform and the functional groups.

3) All assessments are open book and open notes – but not open to online searches, social media, email, etc. Molecular models may be used during assessments. That said, time management is likely going impact how well you do on a quiz. Don't waste time making models or searching the notes or textbook for the right answer during assessments. This course is about thinking, so for lecture and quizzes:

- Bring a premade model (I recommend acetone for the first several weeks)
- Bring a simple Periodic Table of the Elements for reference
- Bring simple lists of key chemical names, reagents, and functional groups (for emergency reference only)
- *Study as you would for in-person assessments so you do not waste time searching when you should be thinking!*

POINTS: The dates and time of each quiz are indicated in the course schedule (below). These quizzes are worth 30 points each. Quiz #11 is mandatory. However, only 10 quizzes will be used with the final exam to determine your course grade. Hence, one of Quizzes #1-#10 is optional/may be ignored/dropped. To be clear: Quiz 11 may not be dropped. Each quiz will focus on the chapter(s) indicated. 10-30% of each quiz will be cumulative. Note: i) the cumulative component of Quiz 1 will focus on functional group names from Ch 1 but primarily Ch 2); ii) Quiz #9 will be approximately 50% cumulative, and iii) you have the option to retake Quiz #1, Quiz #5, and Quiz #10, if so desired, as per the schedule (below). If you choose to take one of the optional repeat quizzes only the higher of the two scores will be recorded in the Sakai Gradebook. The option to drop one quiz and the option to repeat certain quizzes is designed to give you flexibility, since you likely have other challenging courses this semester and they may be giving major midterm exams. Each quiz is scheduled for 45 minutes and will be given on Sundays at 1PM. We will discuss this further on the first day of classes and Announcements on Sakai will be made.

Final Exam: The final exam will be cumulative, modeled after the quizzes, and worth 100 points. The Final is scheduled for 2 hours and will be given as per the Final Schedule (TBA).

Grades: The final grade will be determined from the total points accumulated from 10 of the 30 point quizzes (300 points total; see **Quizzes**) and the Final Exam (100 points) for a maximum of 400 points. Approximate grades will be announced after each quiz. The final grade breakdown will be announced. This semester the Honors Organic class is composed of exceptionally high GPA students who are also very good at science. Historically, the grade distribution is 50% or so 'A' grades and 25% or so 'B+' grades. Although it does sometimes happen, it is uncommon to have 'D' and 'F' grades in this class.

Quiz Conflicts: Certain scheduled Rutgers activities may take precedence over common hour examinations for students who are formally registered to participate in those activities. Activities that may take precedence over common hour examinations include regularly scheduled Rutgers classes and scheduled Rutgers athletic events (see also RU Common

Hour Exam Policies and Fall '20 RU Common Hour Exam Schedule). If a student has a conflict between a common hour examination and a scheduled activity or between two or more common hour exams, or if a student has a final exam conflict, he/she **MUST notify Professor Williams of such conflict(s) before the quiz/final and not later than 9/14/2020.** Please see RU Final Exam Policies Rule#4 for what constitutes a final exam conflict.

Missed Quizzes: **All quizzes must be taken as scheduled**. **There are no makeup quizzes.** Since students are given the option to repeat several of the quizzes and to drop a quiz (except for Quiz #11), no additional accommodation for a missed quiz are not expected to be necessary. If you are absent for one of the quizzes, you should fill out a self-reported absence form, available at https://sims.rutgers.edu/ssra and you must provide a letter of excuse from your Academic Dean ***within 3 days of the quiz***. The expectation is that a missed quiz will be the one quiz you will drop.

Special Needs: Any student requiring extra time and/or other testing accommodations must provide documentation supporting their circumstances and needs directly to me within the first week of classes or immediately after these needs have been documented. ALL requests for extended time and/or other special accommodations for exams will be handled as per the policies of the Office of Disability Services (http://disabilityservices.rutgers.edu/).

Academic Integrity: All University policies on academic integrity will be strictly enforced. Any cheating on quizzes or exams or any facilitating of academic dishonesty by others will be dealt with promptly in strict accordance with the Rutgers University Academic Integrity Policy. A copy of the current Academic Integrity Policy, which went into effect on September 1, 2013, can be found at:

http://studentconduct.rutgers.edu/student-conduct-processes/academic-integrity/

Please read the policy carefully if you are not familiar with it.

Sakai Website: We will be using Sakai (URL: http://sakai.rutgers.edu/) as a classroom management system. You should check this site regularly. You will find a number of documents posted. You will need a NetID to log in, so make sure that you have one for this site. If you are registered in this course and are a Rutgers student, you will automatically be a member of the online class. Two key Sakai locations are Resources and Gradebook. Under Resources, you will find this syllabus and course schedule, lecture notes, videos, etc. Under Gradebook you will find your quiz scores and eventually your final grade.

Announcements: Any important messages or announcements from the instructors to the whole class will be delivered via the course Sakai site and will be logged in Announcements within Sakai. **It is important that you do not opt out of receiving Sakai messages and that you routinely check your Rutgers e-mail account**.

Email: You must use your Rutgers email for correspondence with Professor Williams. We cannot verify with certainty that a non-RU email belongs the specified RU student. ***Therefore, all***

emails from non-Rutgers email addresses will be ignored. This policy is in place to ensure privacy of each student.

Postings: Quiz scores and final grades will be posted only on the Rutgers Sakai site for this course (in the Gradebook). Other course information will also be posted at this site.

SASHP Peer Tutoring: This is a free service provided by Rutgers University for students who would like to schedule a one hour, one-on-one tutoring session in any of a variety of subjects. The tutor is a fellow Rutgers student who took the class in a previous semester and performed well in the class. For more information, please visit https://sashonors.rutgers.edu/261-student-life/tutoring-program

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How to do the Ch. 1&2 Practice Homework and to take a Quiz on eLearning:

Please follow the instructions provided below when joining:

1. Make sure you have the latest version of Google Chrome, Mozilla Firefox, or Safari installed on your computer.
2. Go to my.elearning.rutgers.edu.
3. Click the login button.
4. Login using your **NetID** and **Password**
5. Click on Go to Sessions or Go to Assignments (Current assignments listed here).
6. You will see a list of scheduled classes available for you to choose from for the day.
7. If you login before the start time you will need to refresh your browser for the Join Session button to become available. Click the **Join Session** button to enter the recitation (this button will be located next to the session title you would like to attend).
8. In certain instances you may need to wait for further instructions by the facilitator.

Important! eLearning online recitation system does not support and audio or video on Mobile devices (i.e. cellphones and tablets with mobile OS). You **MUST** use a desktop or laptop computer to be able to join. If you have any questions and/or experience any technical issues, please submit a ticket to the Technical Support team at https://techsupport.elearning.rutgers.edu/open.php. They will get back to you as soon as possible with a solution to your problem via email. Please make sure to provide a valid email address in your ticket form!

Lecture and Quiz Schedule

09-02	Lecture 1	Chapter 4 (*Molecular Structure and Bonding*)
	09-06	***Quiz #1 – (Ch. 4)***
09-08	Lecture 2	Chapter 4 (*Molecular Structure and Bonding*)
09-09	Lecture 3	Chapter 3 (*Spectroscopy: Determining Organic Structures)*
	09-13	***Quiz #1 – OPTIONAL REPEAT (Ch. 4)***
09-14	Lecture 4	Chapter 3 (*Spectroscopy: Determining Organic Structures)*
09-16	Lecture 5	Chapter 5 (*Organic Reactions and Mechanisms, Introduction*)
	09-20	***Quiz #2 – (Ch. 3)***
09-21	Lecture 6	Chapter 5 (*Organic Reactions and Mechanisms, Introduction*)
09-23	Lecture 7	Chapter 6 (*Nucleophilic Addition to the Carbonyl Group*)
	09-27	***Quiz #3 – (Ch. 5 and 6)***
09-28	Lecture 8	Chapter 7 (*Delocalization and conjugation*)
09-30	Lecture 9	Chapter 7 (*Delocalization and conjugation*)
	10-04	***Quiz #4 – (Ch. 7)***
10-05	Lecture 10	Chapter 8 (*Acidity, Basicity and pK_a*)
10-07	Lecture 11	Chapter 9 (*Organometallic Reagents in C–C Bond Formation*)
	10-11	***Quiz #5 – (Ch. 8 and 9)***
10-12	*Break – No Lecture*	
10-14	*Break – No Lecture*	
	10-18	***Quiz #5 – OPTIONAL REPEAT (Ch. 8 and 9)***
10-19	Lecture 12	Chapter 10 (*Nucleophilic Substitution at the Carbonyl Group*)
10-21	Lecture 13	Chapter 10 (*Nucleophilic Substitution at the Carbonyl Group*)
	10-25	***Quiz #6 – (Ch. 10)***
10-26	Lecture 14	Chapter 11 (*Reactions at C=O with Loss of the Carbonyl Oxygen*)
10-28	Lecture 15	Chapter 12 (*Equilibria, Rates, and Mechanisms*)
	11-01	***Quiz #7 – (Ch. 11 and 12)***
11-02	Lecture 16	Chapter 13 (*Proton NMR*)
11-04	Lecture 17	Chapter 13 (*Proton NMR*)
	11-08	***Quiz #8 – (Ch. 13)***
11-09	Lecture 18	Chapter 14 (*Stereochemistry*)
11-11	*Break – No Lecture*	
	11-15	***Quiz #9 – (Ch. 14 with emphasis on Review)***
11-16	Lecture 19	Chapter 15 (*Nucleophilic Substitution at Saturated Carbon*)
11-18	Lecture 20	Chapter 15 (*Nucleophilic Substitution at Saturated Carbon*)
	11-22	***Quiz #10 – (Ch. 15)***
11-23	*Break – No Lecture*	
	11-29	***Quiz #10 – OPTIONAL REPEAT (Ch. 15)***
11-30	Lecture 21	Chapter 16 (*Conformational Analysis)*
12-02	Lecture 22	Chapter 16 (*Conformational Analysis)*
	12-06	***Quiz #11 – Cannot be dropped (Ch. 16)***
12-07	*Break – No Lecture*	
12-09	*Break – No Lecture*	

TBD (see Finals Schedule) ***Final Exam*** *(cumulative)*

Learning Goals: An Overview

The broad learning goals in this class are listed below by chapter. The goals are framed somewhat as questions. Success in having mastered a learning goal is measured in terms of the ease and command with which the student is able to understand and respond thoughtfully to these questions. Of course, the answers must reflect an understanding of the structure and reactivity of organic molecules and the theory of ground and transition state governing factors. The questions are intended to be framed within the context of the chapter material. Specific and detailed learning goals for each chapter are extensive and are beyond the scope of this Overview.

Chapter 1: What is organic chemistry?
Do you recall the key ideas from General Chemistry, such as electronic structure models of bonding (Lewis dot structures, valence bond theory, resonance, molecular orbital theory), thermodynamics, kinetics, and acid/base theory? What are the important trends of Periodic Table? What are organic compounds? Is color a molecular property? Can you draw and identify phenol, benzene, aniline, pyridine, and thiophene?

Chapter 2: Organic structures
What are hydrocarbon frameworks? What are functional groups? How to draw organic molecules? How to classify carbon atoms by oxidation level? How to name compounds? What do chemists really call compounds? What is meant by the skeleton of an organic molecule? What are the common abbreviations of groups, reagents, solvents, conditions, and other shorthand notation used by organic chemists? How to draw easily understood molecules? What is meant by a natural product? What is meant by a synthetic compound? What are primary metabolites? What are secondary metabolites?

Chapter 3: Determining organic structures
What is X-ray crystallography? What is mass spectrometry? What is carbon nuclear magnetic resonance spectroscopy? What is proton NMR spectroscopy? What is infrared spectroscopy? How to infer structural information from spectroscopic data?

Chapter 4: Structure of molecules
What is the aufbau principle? How do we know that electrons have different energies? How do electrons ‘fill’ atomic orbitals? How do atomic orbitals combine to make molecular orbitals? What is the linear combination of atomic orbitals theory? Why do organic molecules adopt linear, planar, tetrahedral, and more complex structures? What is hybridization? What is the connection between shape and electronic structure? How to draw the shapes and depict the energetics of molecular orbitals in simple molecules in simple ways? How to predict ‘locations’ of lone pairs and empty orbitals?

Chapter 5: Organic Reactions
Why don't molecules typically react with one another? Why do molecules sometimes react with one another? How does molecular shape and structure determine reactivity? Do chemical reactions involve electrons moving from full to empty orbitals? How to depict chemical reactions? How to identify nucleophiles and electrophiles? How to represent the movement of electrons using curly arrows?

Chapter 6: Nucleophilic addition to the carbonyl group

How and why does the carbonyl group react with nucleophiles? How to explain the reactivity of the carbonyl group using molecular orbital theory and curly arrow convention? What sorts of molecules can be made by the reaction of nucleophiles with carbonyl groups? How does acid or base improve accelerate reactions of the carbonyl group?

Chapter 7: Delocalization and Conjugation
What are the interactions between orbitals over many bonds? How does stabilization by sharing electrons over more than 2 atoms work? Where does color of organic compounds come from? How does molecular shape and structure determined reactivity? How does one indicate structural factors using the curly arrow notation? What is the structure of aromatic compounds what does the term aromatic mean?

Chapter 8: Acidity, basicity, and pKa
Why are some molecules acidic and other molecules basic? Why are some acids strong and other acids weak? Why are some bases strong and other bases weak? How to estimate acidity and basicity using pH and pKa? How are structure and equilibria impacted in proton transfer reactions? Which protons in a complex molecule are acidic? Which protons in a complex molecule are most acidic? Least acidic? Which lone pairs in a complex molecule are basic? Which lone pairs and a complex molecule are least basic? Most basic? How do acid and base ideas affect reactivity and solubility? What quantitative descriptions of acids and bases can be used to understand reactivity? Solubility? Medicine design?

Chapter 9: Using organometallic reagents to make C-C bonds
What is an organometallic reagent? Are organometallic reagents nucleophilic? Basic? Acidic? How does electronegativity and polarization impact bonding? What is a Gignard reagent what are organolithium reagents? How are organometallic reagents made from halogenated compounds? How are organometallic reagents made by deprotonation of carbon atoms? How are organometallic reagents used to make new carbon-carbon bonds from carbonyl containing compounds ?

Chapter 10: Nucleophilic substitution at the carbonyl group
Understanding nucleophilic attack followed by loss of a leaving group at a carbonyl compound ? What makes a good nucleophile? What makes a good leaving group? What is a tetrahedral intermediate and why is it relevant? How to make acid derivatives? What is the reactivity of an acid derivative? How to make ketones from acids? How to reduce acids to alcohols?

Chapter 11: Nucleophilic substitution at C=O with loss of oxygen
What is meant by replacement of a carbonyl oxygen? What is acetal formation? What is imine formation? What is the stability of imines? What is the Strecker reaction what is the Wittig reaction? How do we draw reaction mechanisms for reactions at carbonyl oxygens that occur with loss of the carbonyl oxygen?

Chapter 12: Equilibria, rates, and mechanisms
What controls equilibria processes? Went is free energy enthalpy and entropy? What controls reaction rates? What are intermediates? What are transition states? How does catalysis with acid or hydroxide work? What are the effects of temperature on reaction rates and equilibria? What effect does solvent have on rate and equilibria? What is a rate equation and how does it relate to the reaction mechanism?

Chapter 13: ^{1}H-NMR: Proton nuclear magnetic resonance
What is proton NMR are and how to interpret NMR spectra? What is the difference between proton NMR and carbon NMR? What is proton-proton coupling? What is proton integration? What is chemical shift? How to use NMR spectroscopy to determine the structure of an unknown molecule?

Chapter 14: Stereochemistry
What is meant by the 3 dimensional shape of molecules? What is the mirror image of a molecule of? What is the symmetry of a molecule? How are mirror image molecules separated? What are diastereomers? What are epimers? How does shape govern biological activity? How to present stereochemical information as part of a drawing of an organic molecule? How can chemical reactions give mirror image products?

Chapter 15: Nucleophilic substitution at saturated carbon
What is nucleophilic attack on a saturated carbon atom? What are the products? How does substitution at the saturated carbon atom differ from attack at a carbonyl containing compound? How to draw the two mechanisms of nucleophilic substitution? How to draw and describe the intermediates and transition states in substitution reactions? How does substitution influence stereochemistry in nucleophilic addition reactions? What sort of nucleophiles can substitute and what sort of leaving groups can be substituted in nucleophilic substitution reactions? What sorts of molecules can be made from substitution reactions and what can they be made from?

Chapter 16: Conformational analysis
What is meant by three-dimensional shape of molecules? What is meant by conformation? What effect does a molecule shape have on its reactivity? What are the energetic profiles of single bond rotations? What is the low energy conformation of a rotomer? What is a transition structure in a rotomer? Are saturated organic compounds flat molecules? What are the conformations of 6 membered rings? What is a chair structure? What is a boat structure? What is a twist boat structure? What are the differences in the energies between the possible conformations of 6 membered rings? How to draw 6 membered ring compounds accurately? How do ground state effects bear on transition state structures?

I have a comprehensive list of learning goals, but it is long (70+ pages for Chem 315/6 combined). Since it can be overwhelming, I will stick with this simplified list for now.