Syllabus for Chemistry 315 - Fall 2022

Instructor: Prof. Lawrence Williams
lwilliams@chem.rutgers.edu

Location: CCB AUD
Time: Monday/Wednesday 2:00–3:20 pm
Office hours: Monday and Wednesday 3:30–4:30 pm (CCB 4217)
Textbook: Clayden, Greeves, & Warren: Organic Chemistry 2e (ISBN: 978-0-19-927029-3)

Recitaiton Instructors: Prof. Heinz Roth, email: hdroth@chem.rutgers.edu Office Hours: TBA
Kiranjot Sethi, email: kjsethi@chem.rutgers.edu Office Hours: TBA

Recorded Lectures and On-Line Lecture Notes: The entire semester of lecture videos and lecture notes have posted on Canvas (under Files; under Assignments we are in the process of creating copies of these videos with Closed Captioning for those who are interested). *You are expected to have reviewed and studied all of the notes and video content of each chapter prior to the first class in which that chapter is to be discussed.* This helps guarantee that you can participate in and follow the discussion of how to synthesize concepts and how to recognize correct and incorrect thinking. The textbook is an excellent resource that covers more information than the course (video, lecture notes, and lecture discussions).

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: There are two types of homework problems.

- The first are those posed throughout the lecture notes and videos. These are not graded but are very good guides for exam-type questions. I recommend you study these problems before the first meeting discussion of a chapter.
- The second are graded. We will use eLearning for graded Homework. These will be available after the Wednesday lecture and must be completed before the following Monday. If you are prepared (have studied the chapter materials) you should be able to complete the homework after focused effort within 40 minutes. There is no time-limit, however, and these can be taken as many times as you like. Importantly, *only homework completed within the Wed-Sun grading window* will be graded; only your highest score will be logged. After the window closes, you can continue to do the homework problems as practice as often as you like. But these will not be logged into Sakai Gradebook. The point of the homework is to help you develop the problem-solving skills required to excel in this class. [See below for more details about eLearning homework assignments.] To receive credit for homework you must get a perfect score. Since we are not neurotic about what perfect is, and since there can be errors in questions and errors in your understanding, a perfect score is an unmodified 80% or more on a homework (24+/30). *Remember, to receive credit for a homework assignment you must complete the homework in the grading window* ***and*** *score at least 80%.* Credit in this sense means full credit. Each Homework is worth 10 points. Taken together, homework is equivalent to a Mid-term Exam (i.e. 100 points).

Other Materials: Molecular models are required. The Bookstore sells a suitable set. But 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 one or two other students. By far the most underestimated aspect of organic chemistry is the need to develop an ***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. Your apps will not suffice; computer graphics will not suffice.

Attendance in Lecture: Lecture attendance is mandatory. 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. If, for any reason, we conduct a meeting online, we will use Webex (https://rutgers.webex.com/meet/lawjw).

Lectures: Lectures will be held in the auditorium of the new chemistry building as per the class schedule. We will begin promptly.

Recitation: Recitation attendance is mandatory. Recitation is designed to allow you to ask questions, to converse with an internationally renowned scientist and expert in the field, and to review material. Recitations are especially useful for reviewing problems and concepts. Professor Roth has deep insight especially into molecular structure, mechanism, and spectroscopy. He loves the material, has a delightful and lighthearted sense of humor, and there is nothing that makes him happier than a sincere question. It is your responsibility to come prepared; it is your responsibility to stay engaged.

Assessments: The assessments this semester will take the form of one homework assignment per week (most weeks, as described above), three mid-term exams, and a final exam. Homework will be given

online using the eLearning platform (you may be familiar with this platform from General Chemistry), exams will be given in-person during class time, except for the final, which will be given during final's week. This brings us to six important points:

1) <u>Students are not allowed to share information with any others in any way during exams</u>, but you are encouraged to work together through the homework and to practice homework questions. ***Violation of this policy is the most egregious offence a student can make against Academic Integrity.*** Please maintain our historically high degree of integrity; remain committed to doing your own work during exams.

2) All assessments are closed book and closed notes, etc. Molecular models may be used during assessments. This course is about thinking, so for lecture, homework, and exams:

- Bring a premade model (I recommend acetone for the first several weeks)
- Bring a simple Periodic Table of the Elements for reference (paste it within sight of your study station for easy reference). There are large Periodic Tables in the classroom that are easy to see from any location.
- Paste the lists of key chemical names, reagents, and functional groups within sight of your study station for easy reference. Know these for exams.
- Put down your pencil and think.

3) If you took GenChem at RU then you are already familiar with eLearning. Regardless, directions are provided on pg 6 of this document (i.e. login, use, etc.).

4) There are 10 graded homework assignments; 'credit' = 10 points; total possible = 100 points.

5) There are three **midterm exams**, each worth 100 points. These will be administered on Canvas.

6) The **final exam** will be cumulative and worth 200 points. The Final is scheduled for 2 hours and will be given as per the Final Schedule (TBA).

Points: Homework and exam dates are indicated in the course schedule (below). Homework is listed as being worth 30 points each and you must receive 24 points to be given *full credit*. At the end of the semester, homework scores will be normalized to 100 points. Hopefully, everyone will receive 100 points for homework. The three midterms are worth 100 points each. The final is worth 200 points. Therefore, the total points that can be earned in this class is 600.

Grades: The final grade will be determined from the total points accumulated. Approximate grades will be announced after each exam. The final grade breakdown will be announced. Each semester the Honors Organic class is composed of exceptionally high GPA students who are also very good at science. Historically, the grade distribution is 60% 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. Grades are not assigned on a 'curve', which usually is meant to indicate that the students are competing for their grade. In this class, if you earn 80%+ you have a strong A grade regardless. I sometimes apply a mathematical curve to normalize exam grades (e.g. exam 1 and exam 2). This prevents a low score on one exam from adversely impacting your total points and final grade. I give a great deal of thought to grades and do a considerable amount of numerical analysis (Test Theory/Item Response Theory) to evaluate my exams and to ensure they are not flawed (and to correct a flaw should one be identified). Ask me about it. Students are normally surprised to learn the depths of the analysis. And if you want to know the grade cutoffs for an exam – ask me.

Conflicts: Certain scheduled Rutgers activities may take precedence over our in-class mid-term exams, but this is exceedingly rare and only for students who are formally registered to participate in such an activity. If a student has a conflict, that student **MUST notify Professor Williams of such conflict(s) not later than 9/16/2022.** Please see RU Final Exam Policies Rule#4 for what constitutes a final exam conflict.

Missed Homework and Missed Exams: All homework must be taken as scheduled. There are no makeup homework assignments. Students are given the option to repeat the homework and are given several days to do so during the grading window only: Wed-Thu-Fri-Sat-Sun. If you have an emergency of such significance that you are unable to do a homework assignment in the grading window, I expect you to have many more problems than a homework from honors organic. Focus on that emergency and work with the Dean of Students office (DOS). Follow the same procedure if you miss an exam. Only emergencies approved by the DOS will be considered. Absence from an exam should follow the normal procedure: 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 the DOS (to me) ***within 3 days of the exam*** or as soon as the emergency allows. There are no makeup exams. If you have an excused absence, your missed exam grade will be assigned based on the average of all other exams (midterms and final).

Special Needs: 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 (ODS) (http://disabilityservices.rutgers.edu/). Any student requiring extra time and/or other testing accommodations must provide documentation supporting their circumstances to ODS and to send me the appropriate ODS form within the first week of classes or immediately after these needs have been documented.

Academic Integrity: All University policies on academic integrity will be strictly enforced. Any cheating on exams or any facilitating of academic dishonesty 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.

Canvas Website: As you almost certainly know, we will be using Canvas as a classroom management system. You should check this site regularly. You will find a number of documents posted. If you are registered in this course and are a Rutgers student, you will automatically be a member of the online class. Three key Canvas locations are Files, Assignments, and Grades. Under File, you will find this syllabus and course schedule, lecture notes, videos, etc. All the lecture content is already posted. Under Assignments you will find a copy of the videos with Closed Captioning, this list is not yet complete, but my hope is that it will be complete soon. Under Grades you will find your Homework and Exam scores and eventually your final grade.

Announcements: Any important messages or announcements from the instructors to the whole class will be delivered via Canvas Announcements. **It is important that you do not opt out of receiving Canvas 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. ***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 Canvas site for this course (in Grades). 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. Often 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

IT Requirements: ***This is an in-person class.*** However, if any portion of this course is taught online it will still be conducted with live, interactive lectures (recitations and/or office hours). We generally refer to this format as remote synchronous instruction. The 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 assist you.

How to do the Homework 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 to begin.
8. In certain instances you may need to wait for further instructions by the facilitator.

Important! eLearning online system does not necessarily support your Mobile device (i.e. certain cellphones and tablets). You **may be required** to use a desktop or laptop computer. If you have any questions and/or experience any technical issues, please notify the support IT Help Desk.

Lecture, Homework, and Exam Schedule

09-07	Lecture 1	Chapter 4 (*Molecular Structure and Bonding*)
		Homework #1 – (Ch. 2) – Due 09-11; ***Ungraded***
09-12	Lecture 2	Chapter 4 (*Molecular Structure and Bonding*)
09-14	Lecture 3	Chapter 4 (*Molecular Structure and Bonding*)
		Homework #2 – (Ch. 4) – ***Due 09-18***
09-19	Lecture 4	Chapter 3 (*Spectroscopy: Determining Organic Structures)*
09-21	Lecture 5	Chapter 3 (*Spectroscopy: Determining Organic Structures)*
		Homework #3 – (Ch. 4) – ***Due 09-25***
09-26	Lecture 6	Chapter 5 (*Organic Reactions and Mechanisms, Introduction*)
09-28	Lecture 7	Chapter 5 (*Organic Reactions and Mechanisms, Introduction*)
		Homework #4 – (Ch. 3) – ***Due 10-02***
10-03	***Exam 1***	*(Lectures 1-7)*
10-05	Lecture 8	Chapter 6 (*Nucleophilic Addition to the Carbonyl Group*)
		Homework #5 – (Ch. 5&6) – ***Due 10-09***
10-10	Lecture 9	Chapter 7 (*Delocalization and conjugation*)
10-12	Lecture 10	Chapter 7 (*Delocalization and conjugation*)
		Homework #6 – (Ch. 7) – ***Due 10-16***
10-17	Lecture 11	Chapter 8 (*Acidity, Basicity and pK_a*)
10-19	Lecture 12	Chapter 9 (*Organometallic Reagents in C–C Bond Formation*)
		Homework #7 – (Ch. 8 and 9) – ***Due 10-23***
10-24	Lecture 13	Chapter 10 (*Nucleophilic Substitution at the Carbonyl Group*)
10-26	Lecture 14	Chapter 10 (*Nucleophilic Substitution at the Carbonyl Group*)
		Homework #8 – (Ch. 8 and 9) – Due 10-30; ***Ungraded***
10-31	***Exam 2***	*(Lectures 8-14)*
11-02	Lecture 15	Chapter 12 (*Equilibria, Rates, and Mechanisms*)
		Homework #9 – (Ch. 10) – ***Due 11-06***
11-07	Lecture 16	Chapter 11 (*Reactions at C=O with Loss of the Carbonyl Oxygen*)
11-09	Lecture 17	Chapter 13 (*Proton NMR*)
		Homework #10 – (Ch. 11 & 12) – ***Due 11-13***
11-14	Lecture 18	Chapter 13 (*Proton NMR*) – ***No office hours held this day***
11-16	Lecture 19	Chapter 14 (*Stereochemistry*)
		Homework #11 – (Ch. 13) – Due 11-20; ***Ungraded***
11-21 & 11-23		***Break – No Lecture, No Homework***
11-28	Lecture 20	Chapter 14 (*Stereochemistry*)
11-30	Lecture 21	Chapter 15 (*Nucleophilic Substitution at Saturated Carbon*)
		Homework #12 – (Ch. 14) – ***Due 12-04***
12-05	***Exam 3***	*(Lectures 15-21)*
12-07	Lecture 22	Chapter 15 (*Nucleophilic Substitution at Saturated Carbon*)
		Homework #13 – (Ch. 15) – ***Due 12-11***
12-12	Lecture 23	Chapter 16 (*Conformational Analysis)*
12-14	Lecture 24	Chapter 16 (*Conformational Analysis)*
		Homework #14 – (Ch. 16) – Due 12-18; ***Ungraded***
TBD	***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 student's ability to 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 determine reactivity? 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 in 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 Grignard 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
What is 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? What is free energy enthalpy and entropy? What determines reaction rate? 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 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? 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 does ground state conformation effects bear on transition 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.