

# Queen's University

## CHEM/ENCH-212 – Principles of Chemical Reactivity

### 2025 Fall Semester Syllabus

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**Office Hours:** [REDACTED]  
Additional appointments can be scheduled *via* email on request.

**Textbook:** *Organic Chemistry*, Second Edition, Clayden, J.; Greeves, N.; Warren, S. Oxford University Press, New York, 2012 (*Required Textbook*).  
*Atkins' Physical Chemistry*, Twelfth Edition, Atkins, P., De Paula, J., Keeler, J. Oxford University Press, New York, 2023 (*Supplemental Textbook*).

**Lectures:** [REDACTED]

The lecture material will be posted as PDF files using onQ. It is recommended that students read the **assigned** sections **before** the lectures. The instructor will also provide additional handouts and notes during the lectures as deemed necessary.

**Learning Goals:** This course introduces the fundamental principles of organic reactivity, focusing on how molecules react, how these processes are studied through kinetics, and how solvent and electronic effects shape outcomes. Students will see how stereoelectronic and mechanistic factors guide the prediction of chemical reactivity. These principles will be illustrated through important reactions that form new carbon–carbon and carbon–heteroatom bonds. Success in the course will depend on *thoughtful engagement* with the textbook and assigned readings. By the end of the course, students will be able to analyze reaction pathways and anticipate the reactivity of common organic partners.

**Learning Outcomes:** Students should garner the following skills upon completing this course:

1. Identify reactive sites on reactants and reagents.
2. Determine the rate law expression for simple chemical processes.
3. Interpret the meaning of transition state theory and associated activation parameters.
4. Predict and justify the impact of solvent and electronic effects on chemical reactions.
5. Analyze experimental kinetic data and critically evaluate and communicate the results.

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## **CHEM/ENCH-212 Course Material:**

The following is a list of the course topics that form the basis of this course. The relevant reading material from Clayden and Atkins is provided in parentheses.

### **Chemical Reactivity – Introduction**

- General description of reactions: Substitution and elimination reactions (Clayden, pp. 328–329, pp. 382–384)
- Visualizing reaction mechanisms (Clayden, pp. 116–124)
- Energy profiles and potential energy surfaces (Clayden, pp. 250–252)
- Concepts of molecular encounters (Clayden, pp. 107–115)

### **Nucleophilic Substitution Reactions (Clayden Chapter 15)**

- Structure-reactivity relationships (Clayden, pp. 332–340, pp. 344–349, pp. 351–359)
- Stereochemical outcomes of substitution reactions (Clayden, pp. 343–344)

### **Kinetics – How Fast Do Chemical Reactions Go?**

- Rate laws and rate constants: 1<sup>st</sup>- and 2<sup>nd</sup>-order substitution reactions ( $S_N1$  and  $S_N2$ ), (Clayden, pp. 257–262, pp. 328–332; Atkins Section 20A.2, Section 20E)
- Kinetics of consecutive elementary reactions (Atkins Section 20E.3, 20E.4, 20E.5)
- Temperature dependence of rate constants (Atkins Section 20D)
- Measuring rate constants (Atkins Section 20B)

### **Reaction Dynamics**

- Collision theory (Atkins Section 1B, Section 21A.1)
- Diffusion-controlled reactions (Atkins Section 21B.1)
- Transition state theory (Atkins Section 21C.1, 21C.2, Clayden pp. 251–253)

### **Elimination Reactions (Clayden Chapter 17)**

- General description of  $E1$  and  $E2$  reactions (Clayden, pp. 382–387)
- Elimination vs. substitution (Clayden, pp. 384–391)
- Regiochemical and stereochemical outcomes in elimination reactions (Clayden, pp. 391–399)
- The  $E1_{cb}$  reaction (Clayden, pp. 399–404)

### **Electrophilic Aromatic Substitution Reactions (Clayden Chapter 21)**

- General description of EAS reactions (Clayden, pp. 471–478)
- Reactions of substituted benzenes (Clayden, pp. 479–492)

### **Organocatalysis (Clayden in Chapter 41 – Time permitting)**

**Lecture Material:** The primary source for this course is the lecture notes, which take precedence over the textbook and online resources. Examinations will assess your understanding of the material presented in the lecture notes.

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**Assigned Reading:** The recommended reading in the lecture notes and/or syllabus is examinable and part of the required course material.

## Supplemental Reading

The following chapters are useful introductory and supplemental material for CHEM/ENCH-212. You **do not** need to read everything listed below, but the materials listed here may help you feel more comfortable with certain concepts presented in the lecture. If some chemical concepts presented in the lecture need a more detailed explanation, these chapters may help!

## Organic Chemistry by Clayden, 2nd Edition

- **Chapter 1:** What is organic chemistry? (an interesting read)
- **Chapter 2:** Organic structures (Good for learning how to draw organic structures efficiently)
- **Chapter 4:** Structure of molecules (useful for learning how atomic orbitals combine to form molecular orbitals)
- **Chapter 5:** Organic reactions (very useful for understanding the art of curly arrow drawing)
- **Chapter 8:** Acidity, basicity, and pKa (very good for understanding what pKa values indicate, as well as how to understand/predict how pKa values will change with the structure of a molecule)

## Useful Software:

Free online testing and learning tools are available from the RSC website: <http://www.rsc.org/learn-chemistry/mechanism-inspector/>

Free online reaction animations (as well as orbitals animations) are available at the following website: <http://www.chemtube3d.com/>

Data processing associated with the laboratory component of the course will require the use of Microsoft Excel.

**Tutorial Problem Sets/Tutorial Assignments/Tutorial Quizzes:** Tutorial Problem Sets and Tutorial Assignments will be posted in advance on the CHEM/ENCH-212 OnQ site. Try to work through all the practice problems before attending the Tutorial. These are not marked, but it is highly recommended that you complete these problems in preparation for the mid-term and final exams. TAs will go over these practice problems each week during the tutorials. Practice Quizzes will also be delivered in the tutorials. **These items will not be graded; however, your mandatory attendance during the tutorials will be graded (10% of the course grade).** The solutions to the Problem Sets and Assignments will be posted on onQ after all sections have worked through the material.

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**Tutorials: Attendance is mandatory**, and you will be given an attendance mark. There are **ten** tutorials, but you can miss **two** without penalty (by universal design for learning). In onQ, the calculation will drop your lowest two of the ten grades. **NO EXCEPTIONS, NO CHANGES WILL BE MADE TO THE POLICY. ALL ABSENCES will be entered as ZERO regardless of the situation.**

Tutorial attendance will count towards 10% of your final grade in the course, so please make sure you attend at least 8/10 tutorial sessions for full marks.

## **Tutorial Locations:**



Tutorials begin **September 9 and 11, 2025**, depending on your TUTORIAL section. **PLEASE MAKE SURE TO ATTEND YOUR PROPER TUTORIAL SECTION TO OBTAIN THE FULL ATTENDANCE MARKS.**

The tutorial TAs will review Problem Sets/Assignments to clarify challenging concepts and provide an opportunity to ask questions about course topics. They will also administer very short Practice Quizzes to help you prepare for exams. Attendance in the 11 Tutorials is worth 10% of your final grade (we will drop the lowest two tutorial attendance grades). Be sure to attend the proper Tutorial section (check Solus).

**Laboratories:** All labs must be attended as scheduled. **All students *must* attend the introductory lab (lab group organization, lab safety, and lab quiz).** Students will be organized in Pools and given a lab group number (for you and your lab partner). After the Introductory Lab, regular 3-hour laboratory will be held on alternate weeks (please see the schedule posted on OnQ).

Students will rotate between the following **six** experiments (depending on lab group #):

- **Experiment 1: Kinetics of Nucleophilic Substitution ( $S_N1$  Reaction Kinetics)**
- **Experiment 2: Alkaline Hydrolysis of Ethyl Acetate (Second-order Reaction Kinetics)**
- **Experiment 3: Photo-isomerization Kinetics of 4-Hydroxyazobenzene**
- **Experiment 4: Stopped-Flow Kinetics – Reaction of  $Fe^{3+}$  and  $SCN^-$  Ions**
- **Experiment 5: Enzyme-Catalyzed Oxidation of DOPA**
- **Experiment 6: Gas Viscosity – Determination of Collision Cross Section for Gases**

To pass the lab component, students will be required to perform (and pass) 5 of the 6 listed above experiments in accordance with the experiment schedule specific to individual lab

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groups. The laboratory schedule is printed in the CHEM/ENCH-212 Laboratory Manual and accessed from the onQ course site. Students repeating the course should request a laboratory exemption; if not granted, they will work alone in the lab.

**Safety Training:** WHMIS training is mandatory for participation in the laboratory component of the course.

**Grade Scheme:** The grade will be determined in the following manner:

- **Midterm Exam** – 25%
- **Final Exam** – 40% (3 hours, TBD)
- **Tutorials** –10% (Attendance)
- **Laboratories** 25% (Lab administrative details, assessment guidelines, and individual marking schemes are printed in the CHEM/ENCH-212 Lab Manual).

**IMPORTANT:** Students must pass **BOTH** the lecture and laboratory components to complete the course successfully. Failure in either component will result in a failing grade, recorded as **47% or the actual mark achieved, whichever is lower**. Students who do not attend all laboratory sessions may be assigned a grade of *Incomplete (IN)* and will be required to complete and pass the missed laboratory sessions the following year before the *IN* is cleared from their transcript.

**There are NO MAKE-UP EXAMS in CHEM/ENCH-212. Please report any Midterm conflicts well in advance to the instructor; your final exam will be worth more to compensate for the missed examination. NO EXCEPTIONS and NO RE-WRITES.**

**onQ:** Grades and relevant information for this course will be posted on the onQ site.

## Grading Method:

All components of this course will receive numerical percentage marks, which will include adjustments based on the average grade. The final grade you receive for the course will be derived by converting your numerical course average to a letter grade according to Queen's Official Grade Conversion Scale below:

**Queen's Official Grade Conversion Scale**

Grade	Numerical Course Average (Range)	Grade	Numerical Course Average (Range)
A+	90-100	C	63-66
A	85-89	C–	60-62
A–	80-84	D+	57-59
B+	77-79	D	53-56
B	73-76	D–	50-52
B–	70-72	F	49 and below
C+	67-69	I	Incomplete

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**Location and Timing of Final Examinations:** As noted in Academic Regulation 8.2.1, “the final examination in any class offered in a term or session (including Summer Term) must be written on the campus on which it was taken, at the end of the appropriate term or session at the time scheduled by the Examinations Office.” The exam period is listed in the key dates prior to the start of the academic year in the Faculty of Arts and Science Academic Calendar and on the Office of the University Registrar’s webpage. A detailed exam schedule for the Fall Term is posted before the Thanksgiving holiday; for the Winter Term it is posted the Friday before Reading Week and for the Summer Term the window of dates is noted on the Arts and Science Online syllabus prior to the start of the course. Students should delay finalizing any travel plans until after the examination schedule has been posted. Exams will **NOT** be moved or deferred to accommodate employment, travel /holiday plans or flight reservations.

**Acknowledgement of Territory:** Queen's University is situated on traditional [Anishinaabe and Haudenosaunee Territory](#).

**Equity, Diversity, and Inclusivity:** In this course, we are committed to fostering an inclusive and respectful learning environment where all students feel valued and supported. Diversity of backgrounds, perspectives, and experiences enriches the study of chemistry and strengthens our academic community. Students have the right to learn in a safe, welcoming space free from discrimination or harassment. I encourage you to bring your whole self to class, and I will work to ensure your contributions are respected. If you encounter barriers to full participation, please feel free to speak with me so we can work together to find appropriate solutions. Queen’s University provides various resources to support equity, accessibility, and student well-being, and I encourage you to use them as needed.

**Classroom Community:** University is a place to share, question, and challenge ideas. Each student brings a different lived experience to draw upon. Please consider the following guidelines to help one another learn the most we can from this experience.

1. Commit to learning about, understanding, and supporting your peers.
2. Assume the best of others and expect the best of them.
3. Acknowledge the impact of oppression on other people’s lives and ensure that your writing is respectful and inclusive.
4. Recognize and value the experiences, abilities, and knowledge each person brings.
5. Pay close attention to what your peers write before you respond. Think through and re-read your writings before you post or send them to others.
6. It’s ok to disagree with ideas, but do not make personal attacks.
7. Be open to being challenged or confronted with your ideas and to challenge others to facilitate growth. Do not demean or embarrass others.
8. Please encourage others to develop and share their ideas.

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**Fostering Accessibility:** All of us have a shared responsibility for reducing barriers to learning and fostering accessibility and promoting meaningful inclusion of those with disabilities. The [Accessibility Hub](#) at Queen's University's Human Rights & Equity Office offer a host of [tutorials](#) that provide us all with practical tips for:

- creating accessible documents, e.g., to submit to your teaching team or share with peers in peer feedback activities/in a presentation,
- emails, e.g., while communicating with group members or your teaching team, and meeting practices (e.g., in tutorials/labs/seminars or virtual meetings).

**Academic Integrity:** Queen's University is dedicated to creating a scholarly community free to explore a range of ideas, to build and advance knowledge and to share the ideas and knowledge that emerge from a range of intellectual pursuits. Each core value of academic integrity, as defined in the [Senate Academic Integrity Policy](#), gives rise to and supports the next.

Honesty appears in presenting one's own academic work, whether in the context of an examination, written assignment, laboratory or seminar presentation. It is in researching one's own work for course assignments, acknowledging dependence on the ideas or words of another and in distinguishing one's own ideas and thoughts from other sources. It is also present in faithfully reporting laboratory results even when they do not conform to an original hypothesis. Further, honesty is present in truthfully communicating in written and/or oral exchanges with instructors, peers and other individuals (e.g. teaching assistants, proctors, university staff and/or university administrators).

Trust exists in an environment in which one's own ideas can be expressed without fear of ridicule or fear that someone else will take credit for them.

Fairness appears in the proper and full acknowledgement of the contributions of collaborators in group projects and in the full participation of partners in collaborative projects.

Respect, in a general sense, is part of an intellectual community that recognizes the participatory nature of the learning process and honours and respects a wide range of opinions and ideas. However, "respect" appears in a very particular sense when students attend class, pay attention, contribute to discussion and submit papers on time; instructors "show respect by taking students' ideas seriously, by recognizing them as individuals, helping them develop their ideas, providing full and honest feedback on their work, and valuing their perspectives and their goals" ("[The Fundamental Values of Academic Integrity](#)", 3rd Edition, p. 8).

Ultimately, responsibility is both personal and collective and engages students, administrators, faculty and staff in creating and maintaining a learning environment supported by and supporting academic integrity.

Courage differs from the preceding values by being more a quality or capacity of character – "the capacity to act in accordance with one's values despite fear" ("The Fundamental Values of

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Academic Integrity”, 3rd edition, p. 10). Courage is displayed by students who make choices and integrous decisions that are followed by action, even in the face of peer pressure to cheat, copy another's material, provide their own work to others to facilitate cheating, or otherwise represent themselves dishonestly. Students also display courage by acknowledging prior wrongdoing and taking proactive measures to rectify any associated negative impact.

All of these values are not merely abstract but are expressed in and reinforced by the University's policies and practices.

**Calculator Policy:** As noted in Academic Regulation 9.2, “Calculators acceptable for use during quizzes, tests and examinations are intended to support the basic calculating functions required by most Arts and Science courses. For this purpose, the **Casio 991 series calculator** is permitted and is the only approved calculator for Arts and Science students.”

**Technology:** Web Browsers – onQ performs best when using the most recent version of the web browsers, Chrome or Firefox. Safari and Edge are strongly discouraged as these web browsers are known to cause issues with onQ.

Internet Speed – While a wired internet connection is encouraged, we recognize that students may rely on a wireless connection. A minimum download speed of 10 Mbps and up to 20 Mbps for multimedia is recommended. To test your internet speed, <https://www.speedtest.net/>

For technology support ranging from setting up your device, issues with onQ to installing software, contact ITS Support Centre <https://www.queensu.ca/its/itsc>

**Copyright on Course Material:** This material is copyrighted and is for the sole use of students registered in CHEM/ENCH-212. This material includes class videos, handouts, emailed information and all documents and information provided on the course onQ site. This material shall **NOT** be distributed or disseminated to anyone other than students registered in this course. Failure to abide by these conditions is a breach of copyright and may also constitute a breach of academic integrity under the University Senate's Academic Integrity Policy Statement.

**Accommodations for Disabilities:** Queen's University is committed to working with students with disabilities to remove barriers to their academic goals. Queen's Student Accessibility Services (QSAS), students with disabilities, instructors, and faculty staff work together to provide and implement academic accommodations designed to allow students with disabilities equitable access to all course material (including in-class as well as exams). If you are a student currently experiencing barriers to your academics due to disability related reasons, and you would like to understand whether academic accommodations could support the removal of those barriers, please visit the [QSAS website](#) to learn more about academic accommodations or start the registration process with QSAS by clicking *Access Ventus* button at [Ventus | Accessibility Services | Queen's \(queensu.ca\)](#).

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VENTUS is an online portal that connects students, instructors, Queen's Student Accessibility Services, the Exam's Office and other support services in the process to request, assess, and implement academic accommodations.

To learn more, go to: <https://www.queensu.ca/ventus-support/students/visual-guide-ventus-students>

**Academic Considerations for Students in Extenuating Circumstances:** Academic Consideration is a process for the University community to provide a compassionate response to assist students experiencing unforeseen, short-term extenuating circumstances that may impact or impede a student's ability to complete their academics. This may include but is not limited to any extenuating circumstance (illness, bereavement, traumatic event, injury, family emergency, etc.) which is short-lived, begins within the term, and will not last longer than 12 weeks - see [Academic Consideration](https://www.queensu.ca/artsci/undergraduate/student-services/academic-consideration) webpage for details (<https://www.queensu.ca/artsci/undergraduate/student-services/academic-consideration>).

Each faculty has developed a protocol to provide a consistent and equitable approach to dealing with requests for academic consideration from students facing extenuating circumstances. For more information, undergraduate students in the Faculty of Arts and Sciences should consult the Faculty's webpage on [Academic Consideration in Extenuating Circumstances](#) and submit a request via the [Academic Consideration Request Portal](#). Students in other Faculties and Schools who are enrolled in this course should refer to the protocol for their home Faculty.

Students are encouraged to submit requests as soon as the need becomes apparent and to contact their instructor and/or course coordinator as soon as possible once academic consideration has been granted. Any delay in contact may limit the options available for academic consideration. While we encourage instructors to accommodate, each instructor has discretion in deciding whether or how to apply the Academic Consideration. For more information on the Academic Consideration process, what is and is not an extenuating circumstance, and to submit an Academic Consideration request, please see the Faculty of Arts and Science's [Academic Consideration website](#). ASO courses include links to information on **Academic Consideration** on your **Course Homepage** in onQ.

Please see the Teaching Team page for contact information for your instructor and TA(s), where relevant.

For more information, please see the [Senate Policy on Academic Consideration for Students in Extenuating Circumstances](#).