CHEM/ENCH 222 - Methods of Structural Determination
Winter Term 2020

LECTURES: Tuesdays 11:30 am – 12:30 pm
       Wednesdays 1:30 – 2:30 pm
       Fridays 12:30 – 1:30 pm

Dupuis Hall Auditorium

Instructor: Prof. Gang Wu
Office: Chernoff 408

Instructor Contact Information: Phone: 613-533-2644 (32644 from on-campus)
                             E-mail: gang.wu@chem.queensu.ca

Office Hours: No fixed office hours. Drop by at any time or contact me by e-mail to make an
             appointment at a specific time.

Tutorials

Section 002  Monday  11:30 am – 1:00 pm  Chernoff 117
Section 003  Friday  8:30 – 10:00 am  Chernoff 117
Section 004  Monday  2:30 – 4:00 pm  Chernoff 117
Section 005  Monday  4:00 – 5:30 pm  Chernoff 117

Tutorial TAs:

Jiahui Shen  Sections 002 and 003
             Chernoff 4385
             613-533-6000 ext. 75018
             jiahui.shen@queensu.ca

Graham Beaton  Sections 004 and 005
               Chernoff 430
               613-533-6000 ext. 74394
               g.beaton@queensu.ca

Tutorial Schedule

There are a total of 10 tutorial sessions, with the 5th (week 5) and 10th (week 13) tutorials being
review sessions for the midterm and final exams, respectively. There are no tutorials in the weeks
of Feb. 10-14 (midterm exam) and Feb. 18-21 (reading week). The remaining tutorials will be based
on end-of-chapter questions from the textbook (they will be posted on onQ in the Tutorial section).
The tutorials in weeks 3, 4, 5, 9, 10, 11 and 12 will have also have a short quiz, comprised of
multiple choice, matching, or short answer questions. The quiz questions will be based on the
material covered in the previous week’s tutorial and associated lecture material (details for each quiz, and a practice quiz, will be posted on onQ)

<table>
<thead>
<tr>
<th>Week (Tutorial Dates)</th>
<th>Tutorial</th>
<th>Quiz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Jan. 6 and 10)</td>
<td>No tutorial</td>
<td>No quiz</td>
</tr>
<tr>
<td>2 (Jan. 13 and 17)</td>
<td>Tutorial 1</td>
<td>No quiz</td>
</tr>
<tr>
<td>3 (Jan. 20 and 24)</td>
<td>Tutorial 2</td>
<td>Quiz 1</td>
</tr>
<tr>
<td>4 (Jan. 27 and 31)</td>
<td>Tutorial 3</td>
<td>Quiz 2</td>
</tr>
<tr>
<td>5 (Feb. 3 and 7)</td>
<td>Tutorial 4 - Review</td>
<td>Quiz 3</td>
</tr>
<tr>
<td>6 Midterm exam (Feb. 12, 2020)</td>
<td>No tutorial</td>
<td>No quiz</td>
</tr>
<tr>
<td>7 Reading Week</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 (Feb. 24 and 28)</td>
<td>Tutorial 5</td>
<td>No quiz</td>
</tr>
<tr>
<td>9 (Mar. 2 and 6)</td>
<td>Tutorial 6</td>
<td>Quiz 4</td>
</tr>
<tr>
<td>10 (Mar. 9 and 13)</td>
<td>Tutorial 7</td>
<td>Quiz 5</td>
</tr>
<tr>
<td>11 (Mar. 16 and 20)</td>
<td>Tutorial 8</td>
<td>Quiz 6</td>
</tr>
<tr>
<td>12 (Mar. 23 and 27)</td>
<td>Tutorial 9</td>
<td>Quiz 7</td>
</tr>
<tr>
<td>13 (Mar. 30 and Apr. 3)</td>
<td>Tutorial 10 - Review</td>
<td>No quiz</td>
</tr>
</tbody>
</table>

**Intended Student Learning Outcomes**

At the end of CHEM 222, students will be able to...

- Understand the basic elemental composition of organic compounds
- Define basic spectroscopic properties of organic compounds
- Discuss trends in spectroscopic properties in organic functional groups
- Analyze IR, NMR (\(^1\)H, \(^1\)C and 2D), Mass and UV-vis spectra of organic compounds
- Combine all spectroscopic data given to determine the molecular structure of an unknown organic compound
- Apply software to process experimental NMR data

**onQ site**

Students registered in the course can access the course onQ site at [https://onq.queensu.ca/d2l/home/377710](https://onq.queensu.ca/d2l/home/377710)

The site includes the lecture notes, reserve books and e-books, tutorial problems and practice quizzes, assignments and solutions, your grades, the formula and data sheets for the midterm and exam, old exams with solutions, and other materials.

**Textbook, Reserve Books, E-books**

The textbook for the course is "Introduction to Spectroscopy", 5th edition by Pavia, Lampman, Kriz, and Vyvyan (available in the Campus Bookstore). The 3rd, 4th, and 5th editions are very similar, except for the order of chapters. A copy of the 3rd edition is available on reserve in the Library (see below, 24 hour load period). Copies of these editions are also available on Amazon (new and used).

Books on reserve for CHEM/ENCH 222 – Winter Term 2020
Course Outline (Textbook chapters)

First Half (Weeks 1-6)

Chapter 1: Molecular formulas and what can be learned from them
- Elemental analysis and calculations
- Determination of molecular mass
- Molecular formulae
- Index of hydrogen deficiency
- The rule of thirteen
Chapter 2: Infrared spectroscopy
- Molecular vibrations
- Bond properties and modes of vibration
- IR signatures of organic functional groups
- How to examine IR spectra
- General strategy in extracting structural information from IR spectra

Chapter 10: Ultraviolet spectroscopy
- Nature of electronic transition
- Organic chromophores
- Effect of conjugation
- The Beer-Lambert law
- Presentation of UV-vis spectra
- Color of organic compounds

Chapter 3: Mass spectrometry (basics)
- The mass spectrometer
- Ionization methods (EI, CI, MALDI, ESI)
- Mass analysis
- High resolution MS
- Isotope patterns

Chapter 4: Mass spectrometry (Part II)
- The Initial ionization process
- Fragmentation processes
- MS signatures of organic functional groups

Second Half (Weeks 8-13)

Chapter 5: Nuclear magnetic resonance (Part 1)
- Nuclear spin states
- Nuclear magnetic moment
- Chemical shifts
- J-couplings
- Signal integrations

Chapter 6: Nuclear magnetic resonance (Part 2)
- $^{13}$C NMR
- Proton decoupling
- General trends in $^{13}$C chemical shifts
- Heteronuclear J-couplings
- DEPT experiments

Chapter 7: Nuclear magnetic resonance (Part 3)
- General trends in J-couplings
- Chemical and magnetic equivalency
- Strong couplings
- Spectra of diastereomers
Chapter 8: Nuclear magnetic resonance (Part 4)
- Chemical exchange processes
- $^1$H-$^{14}$N J-couplings
- The quadrupole effect
- Paramagnetic shift reagents and chiral resolving agents

Chapter 9: Nuclear magnetic resonance (Part 5)
- 2D NMR

Chapter 11: Combined Structure Problems
- Solving structures with a combination of various spectroscopic methods

Grading Scheme

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 assignments:</td>
<td>4 x 5%</td>
<td>20%</td>
</tr>
<tr>
<td>7 tutorial quizzes:</td>
<td>6 x 1.67%</td>
<td>10%</td>
</tr>
<tr>
<td>1 midterm exam:</td>
<td>1 x 20%</td>
<td>20%</td>
</tr>
<tr>
<td>1 final exam:</td>
<td>1 x 50%</td>
<td>50%</td>
</tr>
</tbody>
</table>

Grading Method
All components of this course will receive numerical percentage marks. 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:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Numerical Course Average (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+</td>
<td>90-100</td>
</tr>
<tr>
<td>A</td>
<td>85-89</td>
</tr>
<tr>
<td>A-</td>
<td>80-84</td>
</tr>
<tr>
<td>B+</td>
<td>77-79</td>
</tr>
<tr>
<td>B</td>
<td>73-76</td>
</tr>
<tr>
<td>B-</td>
<td>70-72</td>
</tr>
<tr>
<td>C+</td>
<td>67-69</td>
</tr>
<tr>
<td>C</td>
<td>63-66</td>
</tr>
<tr>
<td>C-</td>
<td>60-62</td>
</tr>
<tr>
<td>D+</td>
<td>57-59</td>
</tr>
<tr>
<td>D</td>
<td>53-56</td>
</tr>
<tr>
<td>D-</td>
<td>50-52</td>
</tr>
<tr>
<td>F</td>
<td>49 and below</td>
</tr>
</tbody>
</table>

Late Policy
If you require additional time to complete an assignment, please contact me as soon as possible. See below for the Chemistry Department policy on missed quizzes, tests, midterms, presentations, and assignments.
**Department of Chemistry Policy on Missed Quizzes, Tests, Midterms, Presentations, and Assignments**

The Chemistry Department requires that students submit a ‘declaration of extenuating circumstances’ form before being considered for accommodation. The form, and related information, is available at [http://www.chem.queensu.ca/undergraduate/undergraduate-resources/missed-exam-policy](http://www.chem.queensu.ca/undergraduate/undergraduate-resources/missed-exam-policy). Note that this departmental policy does NOT apply to final exams.

**Calculator Policy**

Calculators are not needed, nor allowed, during the midterm or final exams, or the tutorial quizzes. You are welcome to use calculators for the assignments or tutorial problems.

**Academic Integrity**

Academic Integrity is constituted by the six core fundamental values of honesty, trust, fairness, respect, responsibility and courage (see [www.academicintegrity.org](http://www.academicintegrity.org)). These values are central to the building, nurturing and sustaining of an academic community in which all members of the community will thrive. Adherence to the values expressed through academic integrity forms a foundation for the “freedom of inquiry and exchange of ideas” essential to the intellectual life of the University (see the Senate Report on Principles and Priorities [http://www.queensu.ca/secretariat/policies/senate/report-principles-and-priorities](http://www.queensu.ca/secretariat/policies/senate/report-principles-and-priorities)).

Students are responsible for familiarizing themselves with the regulations concerning academic integrity and for ensuring that their assignments conform to the principles of academic integrity. Information on academic integrity is available in the Arts and Science Calendar (see Academic Regulation 1 [http://www.queensu.ca/artsci/academic-calendars/regulations/academic-regulations/regulation-1](http://www.queensu.ca/artsci/academic-calendars/regulations/academic-regulations/regulation-1)), on the Arts and Science website (see [http://www.queensu.ca/artsci/academics/undergraduate/academic-integrity](http://www.queensu.ca/artsci/academics/undergraduate/academic-integrity)), and from the instructor of this course. Departures from academic integrity include plagiarism, use of unauthorized materials, facilitation, forgery and falsification, and are antithetical to the development of an academic community at Queen's. Given the seriousness of these matters, actions which contravene the regulation on academic integrity carry sanctions that can range from a warning or the loss of grades on an assignment to the failure of a course to a requirement to withdraw from the university.

**Copyright of Course Materials**

All materials associated with this course are copyrighted. This includes in-class handouts, E-mailed information, and all documents and information provided on the course onQ site. These course materials are for the sole use of students registered in the course. These materials 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.**

**Accessibility Statement**

Queen’s is committed to an inclusive campus community with accessible goods, services, and facilities that respect the dignity and independence of persons with disabilities. Course materials are available in an accessible format or with appropriate communication supports upon request.

Please contact **Meredith Richards in the Department of Chemistry** in one of the following ways:

- Email: ugadm@chem.queensu.ca
- Phone: 613-533-6000 extension 75518
- In person: Chernoff 200
Accommodations for Disabilities
Queen's University is committed to achieving full accessibility for people with disabilities. Part of this commitment includes arranging academic accommodations for students with disabilities to ensure they have an equitable opportunity to participate in all of their academic activities. The Senate Policy for Accommodations for Students with Disabilities was approved at Senate in November 2016 (see https://www.queensu.ca/secretariat/sites/webpublish.queensu.ca.uslwww/files/files/policies/senateandtrustees/ACADACCOMMPOLICY2016.pdf). If you are a student with a disability and think you may need academic accommodations, you are strongly encouraged to contact the Queen's Student Accessibility Services (QSAS) and register as early as possible. For more information, including important deadlines, please visit the QSAS website at: http://www.queensu.ca/studentwellness/accessibility-services/

Academic Considerations for Students in Extenuating Circumstances
Queen’s University is committed to providing academic consideration to students experiencing extenuating circumstances that are beyond their control and are interfering with their ability to complete academic requirements related to a course for a short period of time, not to exceed three months. Students receiving academic consideration must meet all essential requirements of a course. The Senate Policy on Academic Consideration for Students in Extenuating Circumstances was approved at Senate in April, 2017 (see http://www.queensu.ca/secretariat/sites/webpublish.queensu.ca.uslwww/files/files/policies/senateandtrustees/Academic%20Considerations%20for%20Extenuating%20Circumstances%20Policy%20Final.pdf) Each Faculty has developed a protocol to provide a consistent and equitable approach in dealing with requests for academic consideration for students facing extenuating circumstances. Arts and Science undergraduate students can find the Faculty of Arts and Science protocol and the portal where a request can be submitted at: http://www.queensu.ca/artsci/accommodations. Students in other Faculties and Schools who are enrolled in this course should refer to the protocol for their home Faculty.

If you need to request academic consideration for this course, you will be required to provide the name and email address of the instructor/coordinator. Please use the following:

Instructor/Coordinator Name: Gang Wu
Instructor/Coordinator email address: gang.wu@chem.queensu.ca

Statement of the Location and Timing of Final Examinations
The exam dates for each Term are listed on the Faculty of Arts and Science webpage under “Important Dates.” Student exam schedules for the Fall Term are posted via SOLUS immediately prior to the Thanksgiving holiday; for the Winter Term they are posted on the Friday before Reading Week, and for the Summer Term they are individually noted on the Arts and Science Online syllabi. 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. Also, as indicated in Academic Regulation 8.3, students must write all final examination in all on-campus courses on the Kingston campus.