



Chemistry

UNIVERSITY OF TORONTO

CHM 222H: Introduction to Physical Chemistry

Course Syllabus Fall 2022

I TEACHING TEAM

INSTRUCTOR (weeks 1 to 6)



Name: Professor M. Cynthia GOh
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Online student hours: Monday 2pm to 3pm until Oct 25



INSTRUCTOR (weeks 7 to 12)

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Online student hours: starting Oct 26 Monday 2-3pm (tentative)
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TAs

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Name: Maxine Kirshenbaum
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Tutorial sessions will be held in LM157 during the scheduled period (either Tuesdays from 2 – 3 pm or Fridays from 1 – 2 pm) by the teaching assistant.

II COURSE OVERVIEW

COURSE DESCRIPTION:

This course provides an introduction to the physical principles that underlie, explain and predict the behaviour of atoms and molecules. Topics include thermodynamics; chemical equilibrium; introductory quantum mechanics and spectroscopy. The course will involve both theory and applications; problem sets will involve both

calculations and concepts. While lectures will review some mathematics used in the course, a degree of mathematical proficiency will be assumed.

STUDENT LEARNING OUTCOMES:

By the end of this course, students will be able to:

- Discuss the laws of thermodynamics and how they can be used for chemical systems.
- Apply the laws of thermodynamics to compute changes in observable physical properties for specific processes, and to qualitatively discuss changes in observables.
- Express concepts in mathematical terms and interpret mathematical equations in terms of concepts and applications.
- Understand that at the atomic level, a quantum or wave description of matter is needed
- Predict molecular structure based on quantum mechanical principles
- Learn the quantum origins of the various molecular and intermolecular forces
- See the connection in how chemistry scales in complexity to biological systems

What students can expect to know and be able to do by the end of the course. For guidance in constructing these, see: <https://teaching.utoronto.ca/teaching-support/course-design/developing-learning-outcomes/what-are-learning-outcomes/>

PREREQUISITE COURSE(S):

Course pre-requisites: CHM 135H, 136H)/151Y, MAT (135H, 136H)/137Y/157Y, PHY (131H, 132H)/(151H, 152H).

Co-requisites: MAT 235Y or MAT 237Y.

It will be assumed that you have a basic understanding of elementary differential and integral calculus, elementary physics and introductory chemistry (CHM135, 136).

BOOKS:

For the thermodynamics section (weeks 1 to 7), we will follow the McQuarrie and Simon Physical Chemistry book from LibreText, which you can download from

[https://chem.libretexts.org/Bookshelves/Physical and Theoretical Chemistry Textbook Maps/Physical Chemistry \(LibreTexts\)](https://chem.libretexts.org/Bookshelves/Physical%20and%20Theoretical%20Chemistry/Textbook%20Maps/Physical%20Chemistry%20(LibreTexts))

Thermodynamics is covered in Chapters 19 to 23. Note that this book is quite concise, and you may wish to use other books for reference. The suggested reference book is: Engel and Reid, Physical Chemistry: Thermodynamics, Statistical Thermodynamics and Kinetics but you are welcome to use as reference any book on

introductory physical chemistry or introductory thermodynamics, such as Physical Chemistry for Life Sciences by Chang, Physical Chemistry by Atkins, Physical Chemistry by McQuarrie and Simon, and others, which can be found in the libraries. Thermodynamics is an old subject, so any edition will cover the material we will discuss. There may be discrepancies in notation, in which case the lecture will prevail.

For the Quantum Mechanics portion of the course (weeks 8-12), there will be extensive notes provided as part of Prof. Miller's initiative to write a companion book on this topic for LibreText, specifically geared to this course. This textbook will be provided at the beginning of the quantum section of the course. Suggested references are: Physical Chemistry for Life Sciences by Chang Physical Chemistry for the Chemical and Biological Sciences by Raymond Chang EISBN13: 9781891389948. More thorough treatments and additional insight into the quantum mechanics that rules the atomic world can be found in the first several chapters of the McQuarrie & Simon mentioned above.

The reference books mentioned are useful resources that can help you understand the course materials, as well as provide examples and problems that you can try to solve for a deeper understanding.

Supplemental:

III COURSE ORGANIZATION

This course is organized into two parts, covering the two main topics, Thermodynamics and Quantum Mechanics. The schedule is as follows.

COURSE SCHEDULE & RELEVANT SESSIONAL DATES:

DATES	UNIT/WEEK	TOPICS
Sept. 12 – Sept. 16	1	Introduction, review and definitions. Temperature and the zeroth law
Sept. 19 – Sept. 23	2*	Energy, work, heat; real gases; 1 st law <i>Tutorials start this week.</i>
Sept 26 to Sept 30	3*	Enthalpy; state functions; second derivatives – heat capacity, thermal expansion, compressibility QUIZ #1 (on lectures 1 to 4) during tutorials on Sept 27 and 30
Oct 3 to Oct 7	4	Entropy and spontaneity; 2 nd law.
Oct 10 to Oct 14	5*	Oct 10 – Thanksgiving day The 3 rd law. Free Energy. Maxwell relations; non-ideality.

		QUIZ #2 (on lectures 5 to 8) during tutorials on Oct 11 and 14
Oct 17 to Oct 21	6*	Calculation of changes in S, G, H. Connection to applications.
Oct 24 to Oct 28	7	Oct 25 – Term Test 1 , 6 to 8pm; location TBA No tutorials this week. Oct 26 – Prof Miller starts; Chemical Equilibrium
Oct 31 to Nov 4	8*	Equilibrium; chemical equilibrium
Nov 7 to Nov 11		READING WEEK – no classes
Nov 14 to Nov 18	9	Quantum Mechanics and Atomic structure. The “What is life?” question at the quantum level. How did chemistry scale in complexity from quantum origins to living systems <i>Nov 16 – last day to drop courses</i>
Nov 21 to Nov 25	10	Focus on Intermolecular forces – Levinthal’s paradox re: protein structure and function QUIZ #3 on Lectures 13 to 17 during tutorials on Nov 22 and 25
Nov 28 to Dec 2	11*	Spectroscopy: Direct observation of the quantization of electronic/vibrational levels/spin (biodiagnostics and observation of structure-function relationships) QUIZ #4 on lectures 18 to 21 during tutorials on Dec 2 and 6
Dec 5 to Dec 8	12	Dec 8 (make up for Thanksgiving) Photobiology and Primary Processes of Life
Exam period		Term test 2, location and date/time TBA

TUTORIAL OBJECTIVES:

Tutorials begin the week of September 19, held in person at LM157. While we will not check attendance, it is highly recommended that you be present. This is your opportunity to ask questions that can clarify your thoughts and assist in your

understanding. It is your chance to be in a smaller group, wherein you can discuss and clarify issues. Quizzes are administered during tutorials.

The tutor will show how to solve certain problems. You should come to the tutorials prepared by working on the suggested examples on your own. In this way, you can more clearly articulate where you may have gotten stuck.

IV EVALUATION/GRADING SCHEME

OVERVIEW:

Two different marking schemes will be used:

Quizzes (x4) held during tutorials:	40%	or	30%
Homework (x 10):	10%		20%
Term Tests (x2) 2 hours, 25% each:	50%		50%
TOTAL	100%		100%

ASSESSMENT DATES & MARK BREAKDOWN:

1. Quiz 1 (10% or 7.5%): 30 minutes, to be written during tutorials on week of Sept 26.
3. Quiz 2 (10% or 7.5%): 30 minutes, to be written during tutorials on week of Oct 10.
3. Quiz 3 (10%): 30 minutes, to be written during tutorials on week of Nov 21.
4. Quiz 4 (10%): 30 minutes, to be written during tutorials on week of Dec 5.
5. Term Test 1 (25%,): 2 hours. Tuesday 25th October, 6pm to 8 pm – NOT DURING CLASS. Location to be announced.
6. Term Test 2 (25%): 2 hours. During Final Exam schedule; date and time to be announced.
5. Homework (total of 10% or 20%): to be submitted at the designated dates.

The marks will be calculated according to both marking schemes given above, and whichever yield the higher value will be taken.

For students missing **one** quiz or term test **for a valid reason**, the missed grade will be calculated based on performance on the other term tests and quizzes, weighted by the class average. **For students missing two tests for valid reasons the mark for the missing tests will be replaced by a cumulative, two-hour assessment to be**

written during the April final assessment period. This assessment will cover all aspects of the course.

IMPORTANT: if an unexpected technical issue occurs with a university system (e.g., Quercus services, network outage) that affects availability or functionality, it may be necessary to revise the timing or weighting of the quizzes/term tests.

V COURSE POLICIES

- Each member of this course is expected to maintain a:
 - (i) professional and respectful attitude during all course activities, including classes, tutorials and online activity.
 - (ii) personal calendar/schedule/organizer to ensure that all course activities are completed, and due dates are met.
 - (iii) collection of notes recorded independently based on concepts covered in course activities (students registered with Accessibility Services requiring a class note-taker will have access to this accommodation)
 - (iv) familiarity with the university policy on Academic Integrity (overleaf)
- The University of Toronto is committed to equity, human rights and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each other, and respect one another's differences. As a Course Instructor, I will neither condone nor tolerate behaviour that undermines the dignity or self-esteem of any individual in this course and wish to be alerted to any attempt to create an intimidating or hostile environment. It is our collective responsibility to create a space that is inclusive and welcomes discussion. Discrimination, harassment and hate speech will not be tolerated. If you have any questions, comments, or concerns, we encourage you to reach out to the staff in our Equity Offices.
- Communication with instructor: I will respond to reasonable email queries within 24 hrs. on weekdays.
- Privacy language and appropriate use of course materials:
<https://teaching.utoronto.ca/ed-tech/audio-video/sample-statements/>
- Policy for late assignment submissions: 5% will be deducted daily.
- Policy for reweighting due to missed pieces of academic work.
- Submission methods (e.g., use Quercus only).

- Process for requesting re-grading of course work: Any request for re-grading of term tests should be submitted in writing with a clear explanation of why it is appropriate. Any work submitted for a re-grade will be fully re-evaluated (i.e., all parts, not just the requested part). Quizzes will not be subject to regrading.
- Process for signaling course absences and requesting make-up tests or exams, if applicable: There are no make-up tests.

VI TECHNOLOGY REQUIREMENTS

- Specific guidance from the U of T Vice-Provost, Students regarding student technology requirements is available here:
<https://www.vicprovoststudents.utoronto.ca/covid-19/tech-requirements-online-learning/>
- Advice for students more broadly regarding online learning is available here:
<https://onlinelearning.utoronto.ca/getting-ready-for-online/>
- This course requires the use of computers, and technical issues are possible. When working on a piece of academic work, students are responsible for scheduling enough time to allow for reasonable delays due to technical difficulties to be overcome, so such issues will not be acceptable grounds for deadline extension. Particularly, maintaining an up-to-date independent backup copy of your work is strongly recommended to guard against hard-drive failures, corrupted files, lost computers, etc.

VII INSTITUTIONAL POLICIES & SUPPORT

ACADEMIC INTEGRITY

Academic integrity is essential to the pursuit of learning and scholarship in a university, and to ensuring that a degree from the University of Toronto is a strong signal of each student's individual academic achievement. As a result, the University treats cases of cheating and plagiarism very seriously. The University of Toronto's Code of Behaviour on Academic Matters (governingcouncil.utoronto.ca/secretariat/policies/code-behaviour-academic-matters-july-1-2019) outlines the behaviours that constitute academic dishonesty and the processes for addressing academic offences. Potential offences include, but are not limited to:

On quizzes and term tests:

1. Using or possessing unauthorized aids. **Please note that the use of websites (such as Chegg.com or the course discussion board) to post quiz/term test questions or to post/access answers to questions is an academic offence under the University of Toronto's Code of Behaviour on**

Academic Matters. Alleged instances of this nature are forwarded to the Faculty of Arts & Science Student Academic Integrity office.

2. Looking at someone else's answers or collaborating/discussing answers during a quiz or term test.
3. Misrepresenting your identity.

In general academic work:

1. Falsifying institutional documents or grades.
2. Falsifying or altering any documentation required by the University.

All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters. If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, you are expected to seek out additional information on academic integrity from your instructor or from other institutional resources (see www.academicintegrity.utoronto.ca/).

Plagiarism Detection

Ouriginal (<https://q.utoronto.ca/courses/46670/pages/integration-plagiarism-detection-tool>) is a very highly recommended tool directly integrated into Quercus that will assist in detecting textual similarities between compared works. Students must be informed at the start of the course that the instructor will be using Ouriginal. If you plan to use this tool, the course syllabus must include the following statement (as is):

Normally, students will be required to submit their course essays to the University's plagiarism detection tool for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the tool's reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of this tool are described on the Centre for Teaching Support & Innovation web site (<https://uoft.me/pdt-faq>).

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sample statements for instructor recording of online courses are available here: <https://teaching.utoronto.ca/ed-tech/audio-video/sample-statements/>

If a student wishes to copy or reproduce class presentations, course notes or other similar materials provided by instructors, he or she must obtain the instructor's written consent beforehand. Otherwise, all such reproduction is an infringement of copyright and is absolutely prohibited. More information regarding this is available here: <https://teaching.utoronto.ca/ed-tech/audio-video/copyright-considerations/>

ACCESSIBILITY NEEDS

Students with diverse learning styles and needs are welcome in this course. The University of Toronto is committed to accessibility: if you require accommodations for a disability, or have any other accessibility concerns about the course, please contact [Accessibility Services](#) as soon as possible.

ACCOMMODATIONS FOR RELIGIOUS OBSERVANCES

Following the University's policies, reasonable accommodations will be made for students who observe religious holy days that coincide with the due date/time of an assignment, tutorial, class or laboratory session. Students must inform the instructor **before** the session/assignment date to arrange accommodations.

ADDITIONAL SERVICES & SUPPORT

The following are some important links to help you with academic and/or technical service and support:

- General student services and resources at [Student Life](#)
- Full library service through [University of Toronto Libraries](#)
- Resources on conducting online research through [University Libraries Research](#)
- Resources on academic support from the [Academic Success Centre](#)
- Learner support at the [Writing Centre](#)
- Information for [Technical Support/Quercus Support](#)

ACKNOWLEDGEMENT OF TRADITIONAL LANDS

We wish to acknowledge this land on which the University of Toronto operates. For thousands of years, it has been the traditional land of the Huron-Wendat, the Seneca and, most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.