



**CHM 220H: Physical Chemistry for the Life Sciences**  
**Course Syllabus: Fall 2022**

**I CONTACTS**

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**INSTRUCTORS**



Name: Prof. Andrew Woolley  
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Student hours: Fridays 1-2 or by appointment



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**Course Administrator:**



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**TAs**

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## II COURSE OVERVIEW

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### COURSE DESCRIPTION:

A central theme of CHM 220H is that, starting from a few basic physical principles, it is possible to understand phenomena ranging from the small-scale behavior of single molecules to complex biological processes. One of the goals of the course is to give you an introduction to this remarkable relationship between physical chemistry concepts and observations. CHM 220H will cover key concepts in modern physical chemistry and biophysics. It will prepare you for 300-level life science classes or will serve as an introductory course for physical chemistry. Problems will involve calculations and some mathematical concepts, as well as qualitative topics. It is important both to understand the ideas presented from a conceptual point of view, and to be able to use them to solve quantitative problems.

### STUDENT LEARNING OUTCOMES:

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

- **apply central concepts** in physical chemistry (e.g. entropy, Gibbs energy) to the description of biochemical systems
- **formulate** scientific questions about biochemical systems in quantitative terms
- **plan** ways to calculate answers to questions you formulate
- **calculate** and **interpret** answers to the questions
- **communicate** results, and conclusions using appropriate SI units, language, and formats.

Physical chemistry is a problem-solving discipline: therefore, you must be able to apply concepts taught in classes to solve new problems. Note that tutorials will provide very useful examples of problems that you should be able to solve on quizzes and tests and provide an excellent opportunity to ask questions. It is, therefore, highly recommended that you take advantage of this resource.

### PREREQUISITE KNOWLEDGE:

This course requires that you have a fundamental understanding of introductory chemistry (CHM 135H, CHM 136H). In addition, you are required to have taken a course in differential and integral calculus (MAT 135H, 136H)/137Y/157Y). MAT 235Y/237Y is a recommended co-requisite course. CHM 220H is itself a prerequisite course (with a minimum B grade) for CHM 223H (Physical Chemistry: The Molecular Viewpoint). This course covers topics in quantum mechanics and spectroscopy as well as an introduction to reaction kinetics.

**TEXTBOOKS:**

**For the Thermodynamics section** (weeks 0-7), we will use The Molecules of Life, by Kuriyan, Konforti, & Wemmer (**TMOL**). This is available from the U of T Bookstore

Or kindle Ed: <https://www.amazon.ca/Molecules-Life-John-Kuriyan/dp/0815341881>

**For the Quantum Mechanics section** (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.

**Please note:** the textbooks provide a useful resource to better understand class material and to provide more sample problems. Note, however, that you are **not responsible for material in the textbooks that is not covered in classes.**

### III HOW THE COURSE IS ORGANIZED

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Over the course of each week, you are expected to attend classes, read the corresponding sections of the textbooks, attend tutorials and do the assigned problems according to the schedule outlined below. **Classes will be starting in-person on Friday Sept. 9<sup>th</sup>, 2022.**

- **Mondays 13:00 — 14:00**
  - **Wednesdays 13:00 — 14:00**
  - **Fridays 12:00 — 13:00**
- [MC 102](#)
  - [MC 102](#)
  - [ES 1050](#)

**COURSE SCHEDULE (tentative):**

| DATES               | WEEK                      | TOPICS   |
|---------------------|---------------------------|--|
| Sept. 9             | 0                         | Introduction to Course   |
| Sept. 12 – Sept. 16 | 1                         | TMOL Chapter 6 – Energy and Intermolecular Forces: Thermodynamics of heat transfer, Heat capacities and introduction to the Boltzmann distribution, Basic definitions; The 1st Law of Thermodynamics |
| Sept. 19 – Sept. 23 | 2 – tutorial A and quiz A | TMOL Chapter 7 - Entropy: Counting statistics and multiplicity, entropy, statistical and thermodynamic descriptions  |
| Sept. 26 – Sept. 20 | 3 - tutorial B and quiz B | TMOL Chapter 8 – Linking Energy and Entropy: energy distributions  |

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|--|---|--|
|  | <b>Test 1 Sept. 30</b>                  | and entropy, the Boltzmann distribution, entropy, and temperature  |
| Oct. 3 – Oct. 7                                  | 4 - tutorial C and quiz C               | TMOL Chapter 9 - Gibbs Free Energies: free energy, standard free energies, free energy, and work   |
| Oct. 10 – Oct. 14                                | 5- tutorial D and quiz D                | TMOL Chapter 10 Chemical Potential and the Drive to Equilibrium: chemical potential, equilibrium constants, acid/base, protein folding                                   |
| Oct. 17 – Oct. 21                                | 6<br><b>Test 2 Oct. 21</b>              | TMOL Chapter 11 (part) – Voltages and Free Energy: Basic definitions; ionic mobility; thermodynamics of ions in solution; biological membranes and transport             |
| Oct. 24 – Oct. 28                                | 7- tutorial E and quiz E                | TMOL Chapter 12 (part) – Molecular Recognition: The thermodynamics of Binding: thermodynamics of molecular interactions, drug binding to proteins                        |
| Oct. 31 - Nov. 4                                 | 8<br><b>Test 3 Nov. 4 (Thermo)</b>      | 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? |
| Nov. 7-11  | <i>Reading week</i>                     |  |
| Nov. 14-18                                       | 9 - tutorial F and quiz F               | Quantum Mechanics of the chemical bond and intermolecular forces – driving forces for molecular self-assembly  |
| Nov. 21-25                                       | 10 -<br><b>Test 4 Nov. 25 (Quantum)</b> | Focus on Intermolecular forces – Levinthal’s paradox re: protein structure and function  |
| Nov. 28 – Dec. 2                                 | 11- tutorial G and quiz G               | Spectroscopy: Direct observation of the quantization of electronic/vibrational levels/spin (biodiagnostics and observation of structure-function relationships)          |
| Dec. 5 - 9                                       | 12- tutorial H and quiz H               | Photobiology and Origins of Life   |
| December Examination Period<br>Dec. 10 – Dec. 20 | <b>Test 5 Date TBA (Quantum)</b>        |  |

## TUTORIALS:

**Tutorials begin the week of September 19** and will be held **in-person** (rooms will be announced when known). Attendance is highly encouraged.

Mondays 11:00 – 12:00; Wednesdays 14:00 – 15:00; Thursdays 16:00 – 17:00

### Tutorial Objectives & Quizzes:

Tutorials are designed to give you practice at applying concepts learned during that week to the description of biochemical systems to solve quantitative problems. Problem sets for the tutorials will be posted ahead of time. You should try to solve the problems before coming to the tutorial. At the tutorial, the tutor will show how to work the problems and provide further reinforcement of concepts learned. Tutorial quizzes will be based on problem sets and will be available **online** from 5-10 pm on the day of your tutorial. These are designed to assess whether you have achieved the learning objectives for that week.

## IV EVALUATION/GRADING SCHEME

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- Tutorial Quizzes (best 7 of 8) worth 20% total (**online only**)
- Tests (5) 90 min, 16% each (see dates on schedule). These will be held **in-person only** on Fridays from **6:30 – 8 pm**. (The 5<sup>th</sup> test will be held during the December final examination period). Locations will be posted on Quercus.

### **Notes:**

- If a network disruption occurs at your end during a quiz, please stay calm and don't panic! Contact the course administrator, Alex Fernandes (alex.fernandes@utoronto.ca) with details of the situation - how long you had been writing the quiz for and at what time the disruption occurred. Please note that you will not receive a response until after your quiz window closes.
- 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 assessments.

## V COURSE POLICIES

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- Each member of this course is expected to maintain a:
  - (i) professional and respectful attitude during all course activities, including classes, laboratories, 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.
  
- The course website (on Quercus) will serve as a primary source for the information upon which you need to remain up to date. Information concerning classes, tutorials, assignments, quiz and test information and other course material will be posted frequently on the website as the course progresses. Visit the course website on a regular basis!
  
- Online live sessions (when necessary) and tutorial quizzes will use links within the course website.
  
- CHM 220H email policy: Please note that your email to the CHM 220H teaching team will only be accepted if:
  1. You send it from your utoronto.ca account.
  2. You identify yourself as a student in CHM 220H and include your name and student i.d. number.
  3. No attachments or screenshots are sent.

4. You are aware that chemistry can be discussed during office hours much more effectively than by email. Please use email for administrative issues and for making appointments with instructors - detailed course material questions will not be answered. Scheduled instructor office hours are posted on the web page - alternative hours are available by arrangement.
- This course, including your participation, may be recorded on video and will be available to students in the course for viewing remotely and after each session. Course videos and materials belong to your instructor, the University, and/or other source depending on the specific facts of each situation and are protected by copyright. In this course, you are permitted to download session videos and materials for your own academic use, but you should not copy, share, or use them for any other purpose without the explicit permission of the instructor. For questions about recording and use of videos in which you appear please contact your instructor.

#### **ABSENCE:**

You will need to record any absence from class or a piece of academic work through the Absence Declaration tool on [ACORN](#). The tool can be found in the ACORN Profile and Settings menu. You should record each day of your absence as soon as it begins, up until the day before you return to classes or other academic activities. The University will use this information to provide academic accommodation and to monitor overall absences. **In order to receive consideration for any work missed for an illness or related reason, the Course Administrator must additionally be contacted within one week of the date of absence. Only serious illness (or equivalent reasons) will be accepted as justification for absence.**

- There will be no make-up tests. For students missing one test for a valid reason, the other four will be used (worth 20% of the course final grade each). For students missing two tests for a valid reason, the missed test mark will be calculated based on your performance on the other tests and the class average. For students missing three or more tests for valid reasons, the mark for the missing tests will be replaced by a cumulative oral assessment.

## **VI TECHNOLOGY REQUIREMENTS**

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Guidance from the U of T Vice-Provost, Students regarding student technology requirements is available here:

<https://www.viceprovoststudents.utoronto.ca/covid-19/tech-requirements-online-learning/>

General advice regarding online learning is available here:  
<https://onlinelearning.utoronto.ca/getting-ready-for-online/>

This course requires the use of computers, and of course sometimes things can go wrong when using them. You are responsible for ensuring that you have a stable internet connection, maintaining regular backup copies of your files, using antivirus software (if using your own computer), and scheduling enough time when completing an assignment to allow for delays due to technical difficulties. Computer viruses, crashed hard drives, lost or corrupted files, incompatible file formats, and similar mishaps are common issues when using technology, and are **not acceptable grounds** for a deadline extension. Further, please note that Quercus is known to have some specific issues that you need to be aware of. The browsers that work best so far and are not known to cause issues are **Chrome and Firefox**, (the most up-to-date versions). The **Safari browser does NOT work well on Quercus**. If you are using Apple devices, download and use one of the other browsers, particularly when you are doing your quizzes.

## VII INSTITUTIONAL POLICIES AND SUPPORT

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### 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 (<https://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 online quizzes:

1. Using or possessing unauthorized aids. **Please note that the use of websites (such as Chegg.com or a course discussion board) to post quiz 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.
3. Misrepresenting your identity.

In 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 instructors or from other institutional resources (see <https://www.academicintegrity.utoronto.ca/>).

### **COPYRIGHT**

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://archive.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 and 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.