# CHM 217H1F: Introduction to Analytical Chemistry

Note: Due to the exceptional circumstances associated with the Fall 2020 semester, this syllabus will differ slightly from previous years versions as posted on the public course web site. Students should consider this version as authoritative for Fall 2020.

## I CONTACTS

**INSTRUCTOR/COORDINATOR**
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**CO-INSTRUCTOR**
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## II COURSE OVERVIEW

**COURSE DESCRIPTION:**
CHM 217H1 is the first in a series of courses designed to introduce students to the topic of chemical detection and measurement. As well as being a varied and interesting discipline in its own right, analytical chemistry plays an essential role in many other important subjects such as biochemistry, clinical chemistry, environmental science, food and nutrition, forensic science, organic chemistry and spectroscopy, medicinal and pharmaceutical chemistry, pharmacology, and toxicology. Whether performing blood tests, verifying the safety of our food and drinking water, determining the cause of a fire, or identifying genetic disease markers, analytical chemistry touches every aspect of our daily lives.

This course provides an introduction to the fundamental principles of chemical measurement used in medical diagnosis, quality assurance and control, and research studies. It will teach you how to correctly handle and interpret experimental measurements, compare results and procedures, and calibrate analytical instrumentation. You will also learn how to perform many analytical procedures including volumetric analysis, potentiometry, UV/visible and infrared spectrophotometry, flame atomic spectrometry, and chromatography.

**STUDENT LEARNING OUTCOMES:**
By the end of the course, students will be expected to demonstrate the following core competencies:

- Correctly identify absolute and relative errors, and use significant figures
- Identify random and systematic errors, and calculate uncertainties and confidence intervals

- Present results correctly, and test for precision and accuracy
- Correctly prepare standard solutions and use appropriate calibration methods
- Correctly understand and use regression coefficients and the method of "least squares"
- Use appropriate software to perform scientific calculations and produce graphs
- Be familiar with the correct use of volumetric glassware to prepare solutions and perform titrations
- Be familiar with the correct use and operation of pH and ion-selective electrodes
- Be familiar with the correct use and operation of spectrometers, including UV/visible, FTIR, and flame atomic absorption/emission
- Be familiar with basic chromatographic theory, and the operation of ion chromatographs for water analysis
- Be familiar with good laboratory practice (GLP) and the development of standard operating procedures (SOPs)

**PREREQUISITE COURSE(S):**
This course assumes you have a basic understanding of the following topics from high school chemistry and the prerequisite courses CHM135H & CHM136H (or equivalent), or CHM151Y (or equivalent):

- Significant figures, decimal places, and rounding in calculations
- Fundamental SI units and common unit prefixes; unit conversion
- Common chemical units and their conversion to/from SI units
- Interpretation of simple chemical names and formulae
- Calculation of molecular and formula masses
- Concentration calculations (molar, molal, mass, mole fraction, density)
- Balancing equations; stoichiometry & limiting reagent calculations
- Identification and balancing of acid-base, precipitation and redox reactions
- Formal oxidation numbers; identification of oxidant and reductant
- Definition of the equilibrium constant; relations between $K$, $Q$, and $\Delta G$
- Basic principles of equilibrium calculations; combination of equilibria
- Acids and bases (Arrhenius, Brønsted-Lowry, and Lewis); acid & base strength
- Calculation of pH, $K_a$, $K_b$, and equivalence point in acid-base titrations
- Identification of buffers, calculation of buffer composition & pH
- Solubility, precipitation, $K_{sp}$, and solubility calculations
- Standard reduction potentials, electrodes and cells; the Nernst equation
- Chemical bonds (covalent, ionic, coordinate); atomic & molecular orbitals
- Naming, identity, structure, and properties of common functional groups (alkane, alkene, alkyne, alkyl halide, alcohol, aldehyde, ketone, carboxylic acid, ester, ether, phenyl, *etc.*)
- Molecular orbital description of $\sigma$ and $\pi$ bonds
- Definition & origin of bonding, non-bonding & anti-bonding MOs
- Delocalization and aromaticity (phenyl group, conjugated alkenes and enones)

This course is a prerequisite for the following course(s): CHM 317H1, CHM 410H1, CHM 414H1, and CHM 416H1.

**READINGS:**
Required: Readings and recommended problems from the course text will be provided in the lecture notes handouts throughout the course.

## III HOW THE COURSE IS ORGANIZED

This course is organized by units, the first half of which will be taught by Professor Stone and the second half by Professor Peng.

- Lectures will be delivered as in-person section(s) with synchronous on-line section(s) via Quercus using Bb Collaborate. These sessions will also be recorded for students unable to access Quercus at the time of the lecture.
- Laboratories and Tutorials will be delivered via on-line sections **only.**

Please note that in-person classes require full compliance with all conditions imposed by the Ontario Ministry of Health, Toronto Public Health, and the University of Toronto (St. George campus) at all times. Section sizes for in-person activities have been adjusted to allow for social distancing within the assigned classroom. As a result, **only** those students registered for in-person sections should show up to the lecture and tutorial classrooms.

**COURSE SCHEDULE & RELEVANT SESSIONAL DATES:**

| DATES* | UNIT/WEEK | TOPICS |
|---|---|---|
| Sept. 10 | 0 | Course introduction and basic concepts |
| Sept. 11 – | 1 | Analytical measurement, errors, and statistics |
| Sept. 29 – | 2 | Stoichiometric methods of analysis |
| Oct. 15 – | 3 | Potentiometric analysis (pH, ion-selective electrodes) |
| Oct. 29 – | 4 | Molecular spectrophotometry (UV/visible and FTIR) |
| Nov. 24 – | 5 | Atomic absorption and emission spectrophotometry |
| Dec. 3 – | 6 | Introduction to chromatography |

** Provisional dates subject to confirmation; please check for updates on Quercus*

**TUTORIAL OBJECTIVES:**
Tutorials, which will be scheduled roughly every two weeks, will focus on building a deeper conceptual and operational understanding of the course materials through problem-solving group activities. Preparation, in-class, and follow-up assignments will be drawn from both assigned problems and prior years' term tests and final exams. The emphasis will be on understanding how to read analytical methods and select appropriate methods for performing calculations and drawing conclusions.

**LABORATORY OBJECTIVES:**
Analytical chemistry is a highly practical subject. The **mandatory** laboratory sessions reflect the topics addressed in lectures, and are intended to provide students with the opportunity to develop the technical skills necessary to perform a variety of common analytical procedures.

Arrangements will be different in Fall 2020 compared to previous years as, due to space limitations, it will not be possible to offer in-person labs. All lab sections will be on-line virtual labs. Students will be graded on preparatory quizzes and individual lab reports. Full details are being finalized, and will be made available before the start of labs.

## IV EVALUATION/GRADING SCHEME

- Term tests (two in total, on Oct. 16th & Nov. 20th) worth 15% each
- Tutorial assignments (five in total: one every other week) worth 15%
- Laboratory assignments (seven in total, spread over 10 weeks) worth 25%
- Final assessment (end of course) worth 30%

**Note 1:** For Fall 2020, the Faculty of Arts and Science have adopted a policy of no in-person tests or exams. Both term tests and the final assessment will be delivered on-line.

**Note 2:** 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.

**Note 3:** an alternate grading scheme for the two term tests will be offered to all students, in which the test with the higher grade will be weighted more than the one with the lower grade.

## V COURSE POLICIES

- Communication with the instructors: students should email from their U of T email account. Please allow 24 hours for a response on **weekdays**; generally, instructors will not respond on weekends.
- All online interactions are expected to conform with the University statement regarding a positive learning environment: "*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. U of T does not condone discrimination or harassment against any persons or communities*."
- Privacy and appropriate use of course materials: Lectures and tutorials will be recorded, and the recordings made available for a limited time through Quercus. These recordings should be considered private and for the use of students registered

in the course **only**. They may not be shared or reposted in any way. Students may not make their own recordings, either for personal use or distribution. Students with accessibility requirements should contact the course instructor to make appropriate arrangements.

- Late policy for all term work submissions: a penalty of 5% of the maximum mark per will be deducted daily for term work submitted past the deadline unless:
    - An extension had been agreed to by the instructor prior to the deadline
    - An emergency arose and any notification/documentation was completed in accordance with the Rules and Regulations as posted in the Faculty of Arts & Science Calendar
- Submission methods and deadlines: students are responsible for checking the time, date, and submission process for each item of term work. Generally, submissions will be made through Quercus.
- Students are responsible for notifying the course instructor of any absences; accommodation for missed term work, tests, labs, or exams will be considered on a case-by-case basis.

## VI TECHNOLOGY REQUIREMENTS

Specific 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/

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 of course sometimes things can go wrong when using them. You are responsible for ensuring that you maintain regular backup copies of your files, use antivirus software (if using your own computer), and schedule enough time when completing an assignment to allow for delays due to technical difficulties. Computer viruses, crashed hard drives, broken printers, 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.

## VII INSTITUTIONAL POLICIES AND 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 (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:

In papers and assignments:

1. Using someone else's ideas or words without appropriate acknowledgement.
2. Submitting your own work in more than one course without the permission of the instructor.
3. Making up sources or facts.
4. Obtaining or providing unauthorized assistance on any assignment, including (but not limited to) other students' work and prior assignments.

On tests and exams:

1. Using or possessing unauthorized aids, including (but not limited to) unauthorized copies of prior tests and exams.
2. Looking at someone else's answers during an exam or test.
3. Misrepresenting your identity.
4. Obtaining or providing unauthorized assistance during an on-line exam or test

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 instructor or from other institutional resources (see https://www.academicintegrity.utoronto.ca/).

**TURNITIN:**
Normally, students will be required to submit their course essays to Turnitin.com 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 Turnitin.com reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of the Turnitin.com service are described on the Turnitin.com web site.

**COPYRIGHT**
If a student wishes to copy or reproduce lecture 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.

**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