CHM 217H1 Curriculum Fall 2015
Introduction to Analytical Chemistry

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. Throughout this course, there will be a strong emphasis on good laboratory practice (GLP), error analysis and the correct use of statistics, and problem-solving skills. As such, it will provide an excellent practical foundation for students interested in research opportunities, regardless of the specific area of interest or program of study.

General Expectations

Given the scope of the material and integration of lectures, labs, and tutorials, it is essential that you employ good study habits from the outset. All students should read ahead for both lectures and labs, and complete all required preparation for the latter. Please read the information and instructions in the laboratory manual completely and carefully. You will find yourself working with one or more partners in your demonstrator group; all students must do their fair share of the work (including cleaning up), take turns using the instruments, and share all experimental data before leaving the laboratory. You are must be familiar – and comply – with all relevant safety procedures and policies: these are set out in the lab manual, while further information is available from the Department of Chemistry web site. As a matter of courtesy, you are expected to notify the laboratory instructor and your lab partner(s) as soon as possible should you be late or absent from the lab for *any* reason.

Aims and Objectives

The overall goals of this course are to:

- Describe the practice of analytical chemistry
- Teach the proper use and importance of measurement statistics
- Teach proper solution handling and standards preparation
- Reinforce the principles of good laboratory practice

- Provide a basic understanding of common analytical techniques
- Provide guidance on the appropriate choice of technique for a given size and type of sample

This will be achieved through a mixture of highly integrated lectures, tutorials, and laboratory experiments. 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)

Evaluation

The course evaluation scheme is outlined below. More specific details regarding the laboratory evaluation can be found in the lab manual. In *general* terms, tests, quizzes, and exams will evaluate your factual knowledge (~33%), operational skills (~33%), and conceptual understanding (~33%). Note that the actual distribution of questions between these categories will vary, with a greater emphasis on conceptual understanding in the latter part of the course.

- Tutorials, quizzes, *etc*. 10%
- Term tests (two, each 45 minutes and equally weighted) 20%
- Laboratory 35%
- Final exam (3 hours; cumulative) 35%

Tutorial component:
Tutorials will include a variety of in-class and post-class activities and assignments. There will be a total of three graded activities throughout the term, with the best two out of three counting for 5% each to your final grade.

Term tests:
Term tests will be based on lecture material from the weeks prior to each test, and will be partially cumulative; specific content coverage will be posted on the portal course site prior to each test. Past term test questions will be taken up in the tutorial immediately prior to each test. Since tests will take place during a scheduled lecture time slot, there will be no provision for an early or late test session. Students are reminded that they are responsible to ensure they do not have timetable conflicts between courses.

Laboratory component:
A complete marking scheme is provided in the lab manual. Generally, marks will be divided between student preparation, in-lab performance, results and calculations, short report forms, and one formal report towards the end of the semester. Approximately 33% of the marks are awarded for preparation and performance; the balance is based on results and understanding of the lab material. Lab material is not directly evaluated on term tests, but is relevant to the final exam.

Final exam:
The final exam is cumulative across all lecture material, and will take place during the December examinations period. For the final exam, you should also be familiar with the *general* operating principles, calibration practices, and applications for the experiments used in the laboratory course: treat these as examples that you can use when describing the techniques covered in the lectures. You will not be expected to memorise specific details (such as reagent concentrations) but should be able to outline how an analysis using one of the lab techniques would be performed. Students are reminded that past exams are available through the university library web site.

Course Policies & Procedures

Students are expected to be aware of, and comply with, all applicable rules, regulations, and policies established by the University, the Faculty of Arts and Science, and the Department of Chemistry. Of particular importance are the **Faculty guidelines on academic integrity** and the departmental **policy on plagiarism.** Please see:

http://www.artsci.utoronto.ca/osai/students
https://www.chem.utoronto.ca/undergrad/plagiarism.php

Students are encouraged to form study groups, and discuss procedures and data obtained during lab experiments; however all calculations, and answers to specific lab, tutorial, or assignment questions *must* be your own work. Specific course policies are outlined below; if you have any questions about these, please contact the instructor.

Submission of Lab Reports and Assignments:

- All pre-labs, lab reports and tutorial assignments should be submitted by the deadline specified within the lab manual or on the course work
- If you believe that you will be unable to submit *any* item of course work by the stated deadline, you should contact the course instructor *by email before* the deadline to request an extension
- Any course work submitted past the stated deadline *without* an extension or valid explanation will be subject to a penalty of 5% of the maximum possible mark per business day past the deadline

- In the case of illness, you will need to see a doctor *at the time of illness* and have them complete the appropriate form; see the entry on missed tests and labs below
- Plagiarism will not be tolerated. See the departmental policy on plagiarism for information
- Other students' lab reports, tests, assignments, and pre-labs are considered as unauthorized study aids, and ***may not be used***

Remarking of Returned Term Work:

- If you find an error in marks addition on any item of returned term work, you should bring it to the attention of the course instructor within two weeks from the date it was made available for collection
- Term work written in pencil will *not* be accepted for remarking
- Students who receive a failing grade on a lab report *may* ask the course instructor for permission to resubmit that report; a resubmitted report *must* be accompanied by the original report

Conduct in the Laboratory:

- Students are expected to conduct themselves at all times in a safe and professional manner, in keeping with the requirements set out in both the lab manual and the university's code of conduct. You should consider the laboratory to be a place of employment
- Where experiments involve group work, *all* students are expected to perform their fair share of the work, to cooperate with their peers, and to provide necessary data to their partners in a timely fashion

Lateness to the Laboratory:

- Students are reminded that the laboratory classes are compulsory
- Students should be at the lab by 9:00 am sharp to ensure that all experiments start on time; a progressive penalty for unreasonable lateness applies as described in the lab manual
- Students who are more than 30 minutes late for a regularly scheduled laboratory class *without* good reason will *not* be allowed to perform that experiment, and will *not* be allowed to submit their pre-lab questions or a report for grading (*i.e*. will receive a zero mark for the entire experiment)
- Students who are habitually late (*i.e*. more than twice consecutively, or more than three times during the semester) *without* good reason will similarly be refused permission to perform experiments or submit pre-lab questions and reports

Missed Exams and Labs:

- Students who miss a quiz, term test, or lab session *for a valid reason* should contact the course instructor *by email* as soon as possible; students may be offered either an opportunity to make up the missed work or given consideration for the lost marks, depending on circumstances.
- In the case of personal illness or other medical emergency, university policy requires you to submit a "Verification of student illness" form, completed by the medical professional you consulted at the time of illness. Contact your college registrar's office for assistance if you need to submit this form for multiple courses. See http://www.illnessverification.utoronto.ca/
- In the case of a missed final exam, you will need to petition through your college registrar's office and *not* your course instructor. Please note that this should be done *as soon as possible*

Lecture Topics and Approximate Schedule

The material for this course is divided into six broad sections, as listed below. There are two weekly and one biweekly 1 hour lectures. Hand outs will be available through the portal course site ahead of time, while lecture recordings will become available the following week. For more information and study tips, please consult:

http://www.chem.utoronto.ca/coursenotes/CHM217/lectures.html

Students should read ahead in the course text, as well as use the assigned problems listed in the hand outs to test their understanding of the course material.

Course Text

Skoog, West, Holler, and Crouch, "\Fundamentals of Analytical Chemistry", 9th ed., Brooks/Cole Puhlishing.

In addition, students are strongly recommended to obtain the following:

Student solutions manual for the course text
D. Brynn Hibbert & J. J. Gooding, Data Analysis for Chemistry, OUP

Labs and Tutorials

Labs and tutorials commence in the second week of term. Full schedules can be found at **http://www.chem.utoronto.ca/coursenotes/CHM217**. Topics will *generally* be introduced in the same order as lectures, although it is not possible to synchronize them completely. This means that you may use some techniques in the lab ahead of the lectures. Labs take place once a week for four hours, over an eleven-week period, and include a one-week group project.

The lab manual includes brief overviews of the techniques and provides page references for the course text, as well as standard operating procedures (SOPs) for each experiment. Tutorials will consist of five hour-long sessions, every other week; some will relate directly to the laboratory experiments. These are designed to give you practice in performing calculations and analysing data, as well as reviewing the factual content of the course. Towards the end of the course, there will be an increased emphasis on applying what has been learnt to new situations and problem-solving skills. Some tutorials require advance preparation, which will be graded; please check the tutorial schedule regularly for information and updates.

Course Outline and Approximate Timetable:

Week	Section	Title/Topics
1	1	"What's in a Number?" – introduction to measurement
	1.1	the nature and scope of analytical chemistry
	1.2	measurement terminology; errors in measurement
2	1.3	error estimates; the Gaussian (Normal) distribution
	1.4	significance tests; calibration; regression analysis
3	2	"How Pure is Pure?" – standards and calibration
	2.1	standards and reference materials
4	2.2	determining purity - general methodologies
	2.3	volumetric analysis – titrations, complexometry, and
5	3	"All Charged Up!" – electroanalytical chemistry
	3.1	electrochemistry review; Nernst equation
	3.2	potentiometry, reference electrodes
6	3.3	membrane electrodes – pH and ISEs
	3.4	potentiometric titrations
7	4	"Making Light Work" – molecular spectroscopy
	4.1	overview and review of electromagnetic radiation
	4.2	electronic transitions in atoms and molecules
8	4.3	UV/visible spectrophotometry – Beer's Law
	4.4	UV/visible instrumentation
	4.5	molecular rovibrational transitions – IR
9	4.6	basic IR and FTIR instrumentation
	5	"A Bright Spark!" – atomic emission and absorption
10	5.1	atomic line spectra; spin multiplicity
	5.2	Maxwell-Boltzmann equation in AS
	5.3	atom sources, sample introduction, flame processes
11	5.4	flame atomic absorption spectrometry
	5.5	interference effects, calibration, standards addition
	6	"Degrees of Separation" – introductory chromatography
12	6.1	description and mechanisms of separation
	6.2	definitions – retention and resolution
	6.3	gas and liquid chromatography instruments
	6.4	optimization, resolution, method selection

List of Laboratory Experiments (Fall 2015):

1. Pipette Calibration & Solution Handling
2. Spot Tests for Water Quality
3. Acidity and Alkalinity by pH Titration
4. Chloride by Potentiometric Titration
5. Fluoride by Ion Selective Electrode
6. Anions by Ion Chromatography
7. Zinc by Flame AAS and Microwave Digestion
8. Metals by EDTA Photometric Titration
9. FTIR Qualitative Analysis of Organics
10. Iron Speciation by UV-visible Absorption