CHM 217H1 Curriculum 2011-12
Introduction to Analytical Chemistry

CHM 217H1, "Introduction to Analytical Chemistry", 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.

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)

General Requirements & 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 in this course. All students are expected to read ahead for both lectures and labs, and to complete all required preparation for the latter. Please read the information and instructions presented in the laboratory manual completely and carefully, answering any pre-lab questions. You will often find yourself working with one or more partners in your demonstrator group; all students are expected to do their fair share of the work (including cleaning up), to take turns using the instruments, and to share all experimental data before leaving the laboratory. You are also expected to be familiar and comply with all relevant safety procedures and policies – these are set out in the lab manual, and 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 partner(s) as soon as possible should you be late or absent from the lab for *any* reason.

Evaluation and Marking Scheme

The overall marking scheme for the course is set out 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 factual knowledge and operational skills in the early stages of the course. Both the term test and final exam will be cumulative. You will not be expected to memorise details from specific experiments (*e.g.* concentrations, instrument settings, *etc.*), but you *should* be familiar with the general principles, operation, calibration practices, and applications for the techniques used in the laboratory course.

- Tutorials, quizzes, and assigned coursework 14%
- Term tests 14%
- Laboratory 32%
- Final exam (3 hours) 40%

Lecture Topics and Approximate Schedule

The material for this course is divided into six broad sections. These are listed below, together with a more detailed description of the lecture content and approximate schedule. There are two 1 hr lectures a week. To aid students during the lectures, handouts will be provided in advance of each section via the course web site; these will include page references to reading material in the course text, suggested review problems, background material, essential diagrams and equations from the lecture slides, and additional material not included in the course text. Please note that these handouts are structured to provide a framework for your own notes. They are *not* intended to be a substitute for your own reading, note taking, or attendance at lectures.

Course Text

D. C. Harris, Quantitative Chemical Analysis, 7th or 8th ed., Freeman

Please note that the 8th edition will also be available electronically as a subscription-based web resource (*i.e.* available for a time-limited period on-line.)

Please see http://www.coursesmart.com/9781429269117 for further information and pricing.

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 two-week group collaborative 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 1 hr sessions, roughly 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.

Important Course Policies

Students are expected to be aware of, and comply with, all applicable rules, regulations, and policies established by the Faculty of Arts and Science and the Chemistry Department. Of particular importance is the departmental policy on plagiarism, http://www.chem.utoronto.ca/undergraduate/plagiarism.htm. 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 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 *in writing* as soon as possible
- Any course work submitted past the stated deadline *without* the prior permission of the instructor will be subject o a penalty of 5% of the maximum possible mark per working day past the deadline
- The late penalty *may* be waived by the course instructor under extenuating circumstances (such as sudden illness); contact the course instructor *in writing* as soon as possible
- 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 *or* the end of the December examinations period, whichever comes sooner
- Term work written in pencil will *not* be accepted for remarking
- Students who receive a failing grade on a lab report *may* be allowed to resubmit that report, at the discretion of the course instructor; a resubmitted report *must* be accompanied by the original report

Lateness to the Laboratory:

- Students are reminded that the laboratory classes are compulsory
- Labs start at 9:00 am, *not* 9:10; a progressive lateness penalty 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 Quizzes, Term Tests, and Labs:

- Students who miss a quiz, term test, or lab session *for a valid reason* (such as a medical emergency) should contact the course instructor *in writing* as

soon as possible; students may be offered either an opportunity to make up the missed work or consideration for the lost marks, depending on circumstances

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