CHM 217H1 Curriculum 2005/6
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 it be blood testing, 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 princples 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. 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:

- 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 closely-integrated lectures, tutorial exercises and laboratory experiments. By the end of the course, students will be expected to demonstrate the following core competencies:

- correct calculation of absolute and relative errors, and significant figures
- identification of random and systematic error; uncertainty calculations
- correct presentation of results; tests for precision and accuracy
- ability to prepare and use standard solutions and appropriate calibration methods
- correct understanding and use of regression coefficients and the method of "least squares"
- use of computer software (i.e. spreadsheets, statistical packages) to perform scientific calculations and produce graphs
- familiarity with the principles and use of volumetric glassware, pH and ion-selective electrodes, uv/visible and infrared spectrometers, flame atomic spectrometers, and ion chromatographs
- general GLP procedures and the development of standard operating procedures (SOPs)

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 listing 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 relevant material in the course text, suggested review problems, background readings, 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.

Labs and Tutorials

Labs commence in the second, and tutorials the third, 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 4 hrs, 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 weekly 1 hr alternating exercises and help sessions; some will relate directly to the laboratory experiments. These are

Approximate lecture 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
	2.2	determining purity - general methodologies
4	2.3	volumetric analysis – titrations
5	3	"All Charged Up!" – electroanalytical chemistry
	3.1	electrochemistry review; Nernst equation
	3.2	potentiometry
6	3.3	membrane electrodes – pH and ISEs
7	3.4	potentiometric titrations
8	4	"Making Light Work" – molecular spectroscopy
	4.1	overview and review of electromagnetic radiation
	4.2	electronic transitions in atoms and molecules
9	4.3	uv/visible spectrophotometry – Beer-Lambert Law
	4.4	uv/visible instrumentation
10	4.5	rovibrational transitions in molecules – infrared
	4.6	basic IR and FTIR instrumentation
11	5	"A Bright Spark!" – atomic emission and absorption
	5.1	atomic line spectra; spin multiplicity
	5.2	Maxwell-Boltzmann equation in AS
12	5.3	atom sources, sample introduction, flame processes
	5.4	flame atomic absorption spectrometry
	5.5	interference effects, calibration, standards addition
13	6	"Degrees of Separation" – introductory chromatography
	6.1	mechanisms and definitions; retention and resolution
	6.2	gas and liquid chromatographic instrumentation
	6.3	phenomalogical evolution of chromatograms

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.

Expectations, Evaluation, and Marking Scheme

Given the scope of the material and integration of lectures, practicals, 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 within 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. If you will be late or absent from the lab. for any reason, as a matter of courtesy you are expected to notify the laboratory instructor and your partner(s) as soon as possible.

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 problem-solving ability (~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 15%
- term test 15%
- laboratory 30%
- final exam (3 hours) 40%

Important Dates for the Fall 2005 Session:

- Lab. enrolment: Departmental enrolment via the course web site is compulsory for ***all*** students taking CHM 217
  – starts Tuesday, August 2nd, 2005
  – ends Tuesday, September 6th, 2005

- First lecture
  – Tuesday, September 12th, 2005 at 4 pm; location to be announced

- First tutorial
  – the week commencing September 19th, 2005; see web site for details

- First lab.
  – the week commencing September 19th, 2005; see web site for details

- Term Test
  – Thursday, October 27th, 2005; location and time to be announced

- Final Exam
  – during the University examinations period, December 12th–21st 2005

List of Experiments for 2005/6:

A Introduction
1. Solution Handling

B Water Analysis
2. Spot Tests for Water Quality
3. Acidity and Alkalinity
4. Chloride by Potentiometric Titration
5. Fluoride & Ammonia by Ion Selective Electrode
6. Anions by Ion Chromatography

C. Nutrition, Food and Drink, Pharmaceuticals
7. Zinc by Flame AAS
8. Calcium & Magnesium by EDTA Titration
9. Organic Compounds by FTIR Analysis
10. Iron by Complexometric Analysis

D. Group-Collaborative Project
11. Sodium in Beverages