QUANTITATIVE CHEMICAL ANALYSIS: CHEM 2AA3

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Textbook: Quantitative Chemical Analysis by Daniel C. Harris, Freeman Inc. - 9th Edition

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What is analytical chemistry?

• A process of understanding complex natural phenomena through analysis: taking things apart to identify, separate, and measure (quantify) specific chemical substances (analytes). This course teaches how biological, clinical and environmental relevant properties and quantities are obtained by measurements of analytes. The principles of ion equilibrium, solubility, complexation, redox and acid-base systems are presented in the context of relevant case studies that impact society. Explanations emphasize dynamic chemical equilibria processes in free solution with introduction to modern instrumental methods based on optical spectroscopy, fluorescence and chromatography.

How is it important and relevant to you?

• The techniques and tools of analytical chemistry play a vital role in many areas of science and “modern” life including biology, medicine, environmental science, forensics, toxicology, pharma etc.

Goals of this course: Why are you here?

• This is an introductory analytical course aimed at providing students with a deeper understanding of the principles of chemical equilibria using traditional volumetric “wet” methods and modern instrumental methods based on optical spectroscopy, mass spectrometry and chromatography.

• By the end of the course students should be able to:
  1. Describe, calculate, and understand fundamental chemical equilibria processes (e.g., acid-base, redox etc.) used in volumetric and instrumental methods used to measure specific analytes in complex sample matrices.
  2. Appreciate the process and limitations (errors/interferences) involved in obtaining analytical results and relate its role in society through case studies and research articles.
  3. Develop excellent technical & problem-solving skills while performing rigorous data analysis/interpretation using statistical tests/regression analysis (*in context of CHEM 2LA3).

Course strategy: Hints on how to succeed in this course

• If you attend every class on time and conscientiously do the reading and assignments.
• Reading a chapter beforehand will make the lecture much more rewarding. Not all topics in the textbook will be addressed in lecture due to time constraints.
• During the course, compile a concise set of notes (1 page) from lecture and text material that includes basic principles and equations of chemical analysis (review for final exam).
Repeated practice of problems explained in class leads to deeper understanding.
Actively participate in class with questions and discussions.
Relate knowledge gained in class which can be applied to “real-world” problems.
If you have any questions or doubts about the material being taught (before an exam!), feel free to ask questions in class, drop-by for a visit in my office or send an e-mail message.
Keep an update on any changes in schedule announced in class or on Avenue to Learn.
But most important of all, keep a balanced body and mind (relax) and have fun!

Course Outline: The Big Picture!

• Selected parts of the following chapters will be covered (see table), most likely presented in the order shown. The text covers a great deal of material and not every chapter can be discussed fully. In addition, case studies, scientific articles (as handouts) and invited speaker(s) will be introduced in order to stimulate deeper appreciation of the important role of analytical chemistry in society.

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<th>Week (Fall 2015)</th>
<th>Exploring Chemical Analysis</th>
<th>Chapters (in Text)</th>
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<td>Week 1-2</td>
<td>Introduction: Analytical Process/Case Study, Error, Basic Statistics, Method Validation, Quality Control</td>
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<td>Week 3</td>
<td>Chemical Equilibrium/Activity/Solution Chemistry</td>
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<td>Week 4</td>
<td>Acid-Base Equilibria &amp; Buffers</td>
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<td>Week 5</td>
<td>Titrations, Mono-/Polyprotic Acid-Base</td>
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<td>Week 6</td>
<td>Complexation/EDTA Titration</td>
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<td>Week 7</td>
<td>Electrochemistry/Electrode Measurements</td>
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<td>Week 8</td>
<td>Redox Titrations &amp; Instrumental Electrochemistry</td>
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<td>Week 9</td>
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<td>Week 10</td>
<td>Optical Emission/Fluorescence</td>
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<td>Week 11-12</td>
<td>Chromatography and Mass Spectrometry</td>
<td>21-23</td>
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<td><strong>Final Exam</strong></td>
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<td><strong>Final Exam</strong></td>
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First day of class is Tues. Sept. 8, 2015; Last day of class is Tues. Dec. 8, 2014; Last date to drop class/without failure: Sept. 16/Nov. 13, 2015; Mid-term Break: Mon. Oct 12-Fri. Oct. 16

Grading procedure

• Your final grade in this course will be based on following assessment. Dates are tentative only and are subject to change with due notice. Students who fail to complete a mid-term test will have their final mark added to the weighting of the final exam. For example, missing one mid-term will result in a final exam weighting of 55% to your final mark. Also, if a student does not regularly attend classes nor participates in class discussions or group projects/presentations, they will receive a zero grade.

There will no make-up tests and no assignment accepted late.
1. Participation 10% Participation/attendance/discussions/quizzes in class

2. Inquiry Projects (Group presentation) 2 x 10% Oct. 22/29, 2015; Nov. 26/Dec. 3, 2015 * tentative dates/groups of 4/10 min oral presentation

3. Mid-term Exam In-class (TBA) 2 x 15% Oct. 8, 2015; Nov. 12, 2015 (Textbook chapters, handouts, notes/quizzes, articles) * tentative dates

4. Final Exam Assigned class (TBA) 40% Dec. 9-23, 2015: Comprehensive; Date to be announced. Final exam must be completed to pass course!

Total 100%

* Full course notes (slides), articles and answers to mid-terms will be posted on Avenue to Learn
  * No classes during mid-term reading break (Mon. Oct 12-Fri. Oct. 16)

**Academic Dishonesty**

- Academic dishonesty consists of misrepresentation by deception or by other fraudulent means in an academic setting. This principle is particularly important in analytical chemistry since fraudulent data can have major impacts on human health and well-being. Plagiarism, improper collaboration in groups and copying or using unauthorized tests/exams can result in a grade of **zero, loss of credit, or suspension** from university. Although working in groups is encouraged, **plagiarism** is not! Please refer to the Academic Integrity Policy (Appendix 3) for further details: [http://www.mcmaster.ca/senate/academic/ac_integrity.htm](http://www.mcmaster.ca/senate/academic/ac_integrity.htm)

**Student Absence due to Illness & McMaster Student Absence Form**

- If you are absent from the university for a minor medical reason, lasting fewer than 5 days, you may report the absence, without documentation, using the McMaster Student Absence Form (MSAF). Absences for a longer duration or for other reasons must be reported to your Faculty/Program office with proper documentation, and relief from term work may not be necessarily granted. When using MASF, report your absence to your course instructor by e-mail or telephone. Note that students who fail to hand in an assignment or who miss the mid-term test will have their final mark added to the weighting of the final exam. Student who are absent are expected to keep up with the course by regularly checking course material and announcements posted on Avenue to Learn ([http://avenue.mcmaster.ca/](http://avenue.mcmaster.ca/))

**Copyright Policy**

- In this course you will have access to material that is subject to copyright laws. This includes (but is not limited to) the textbook, solutions manual and all resources developed by the instructors such as lab manuals, demonstration videos, quizzes, assignments, tests, class notes and class slides. You are not allowed under any circumstance to share or redistribute this material in any printed or electronic form without the explicit written consent of the copyright holder. This includes posting any course material on Internet bulletin boards, course repositories, social networks, etc.
Course Outline:
This is an introductory course in analytical chemistry that aims to provide students with a deeper understanding of common methods used for performing quantitative chemical measurements in modern laboratories. The course emphasizes basic principles of chemical equilibria using traditional volumetric methods, as well as modern instrumental techniques based on optical spectroscopy, mass spectrometry and chromatography. Students will learn and apply fundamental principles as related to solubility, complexation, redox and acid-base solution chemistry as a way to measure specific "analytes" in complex "real-world" samples that is relevant to environmental toxicology, clinical diagnostics, forensic studies and food safety/pharmaceutical analysis. An introduction to statistical analyses and method validation are included to help students in the interpretation of experimental data that is critical to reliable decision-making. The course combines engaging lectures, case studies, and guest speakers in order to encourage students to appreciate the many important roles that analytical chemistry plays in modern society.

Interesting or Practical Questions?
What is the difference between the accuracy and precision of a method?
How do I determine statistically whether there has been a significant increase in human exposure to radioactive iodine following Fukushima?
Why was melamine adulteration of infant formulations not identified by traditional methods used for food screening in China?
How does one develop a method and then evaluate its performance to conduct reliable measurements in a certified laboratory environment?
What are limitations to classical volumetric methods used for analytical testing of analytes?
What is chromatography and how does one select the appropriate conditions for separating complex mixtures?
How does one unambiguously identify and quantify an unknown chemical substance of clinical relevance to a diagnosis using mass spectrometry?
How do governmental laboratories monitor drug safety and water quality to ensure public safety?
How to detect bias in a method or protocol that can lead to flawed data resulting in major repercussions in society (i.e., death/injury, wrongful incarceration)?

Where does the course lead?
CHEM 2AA3 is arguably one of the most interesting and practical courses in the second year chemistry program that integrates elements of physical, organic and inorganic chemistry in the context of quantitative chemical measurements. The course teaches you a process towards understanding and interpreting complex natural phenomena through rigorous analysis: taking things apart to identify, separate, and measure specific chemical substances (i.e., analytes) with confidence in various samples of interest (e.g., blood, soil, hair etc.). The course content is also directly related to analytical experiments incorporated into our second year laboratory course (CHEM 2LA3). Expertise in analytical chemistry is used in nearly
all academic disciplines, private companies, hospitals and governmental agencies that rely on laboratory measurements for decision-making with diverse career options, including environmental monitoring, forensic studies, (bio)pharmaceutical industry, cosmetics/food testing, clinical/toxicological investigations and petrochemical refining.

**Student Testimonials:**
- I learnt about new techniques and procured skills to think analytically. Overall, course was pretty good.
- Lots of great information. Great guest speakers
- Course related well to lab course
- Explain the mechanism and principle behind many lab techniques that I actually do in the lab. Therefore, it helps me understand why I do something instead of just following the procedure given in the lab manual
- Enjoyed the biology/medical applications Guest speakers applied the lecture material to real world applications
- The assignments are very helpful and they are based on what is taught in lectures.
- I really enjoyed how this course was structured and how it showed the relationship between chemistry and the other scientific disciplines. It was nice to hear how analytical chemistry can be applied to biology, pharmacology and even environmental science.
- The notes were much better than staring at a screen full of words the diagrams helped a lot as well as the fact that the notes aligned closely with the textbook.
- The statistics part of the course was useful and will be used in the future
- Two aspects of this course that were particularly effective are the weekly quizzes and also the assignments.

**Sample Lecture Material:**
1. Basic Statistical Tests used in Chemical Measurements
2. Volumetric Analysis using Acid-Base Equilibria for Chemical Analyses
4. Redox Chemistry and Electrochemical Measurements
5. Chromatography and Mass Spectrometry for Complex Mixtures
6. Quality Control and Quality Assurance Practices in Certified Laboratory Testing
7. Case Studies and Guest Speakers in Environmental Monitoring and Clinical Diagnostic Testing
8. Method Development, Optimization and Validation of Assays