Chemistry 222. Analytical Chemistry

INSTRUCTOR: Prof. Keith T. Kuwata, Olin-Rice 318, 696-6768, kuwata@macalester.edu.
Web page: www.macalester.edu/~kuwata (for class handouts, class overheads, and answer keys)

REQUIRED TEXT: Daniel C. Harris, *Quantitative Chemical Analysis*, 6th ed., W. H. Freeman, New York, 2003. (Lab instructions will be found in handouts.)

OTHER REQUIRED MATERIALS: (1) A pair of safety goggles (buy at the Lampert Building Bookstore). Macalester College and the State of Minnesota both require that you wear goggles during all laboratory sessions. **You will not be allowed to work in lab if you do not bring your own pair of goggles.** (2) A composition book (5 x 5 Quad Ruled, 10" x 7 7/8", buy at the Highlander Store). This will serve as your lab notebook. (3) A fine-point Sharpie marker for lab. You are also required to bring your own scientific calculator for use in lab, in class, and on tests.

DESCRIPTION: In this course, we will focus on the following goals: (1) Making accurate and precise measurements of chemical abundances using both classical and instrumental methods of analysis; (2) Obtaining reliable quantitative results from these measurements; (3) Understanding the chemistry (that is, the structure and energetics) underlying your lab work and data analysis. Lecture and lab work will be integrated as much as possible.

In Unit 1, we tackle the fundamentals of analytical chemistry: the analytical process (Chapter 0), key techniques for laboratory work and data analysis, especially statistics (Chapters 1, 3, and 4) and calibration (Chapter 5), and the classical method of gravimetric analysis (Chapter 27). Test 1 (on February 16) covers Unit 1.

In Unit 2, we focus on one of the most important and widely used instrumental methods today: spectrophotometry. We will explore the concepts and techniques for studying molecules (Chapters 18 and 20) and atoms (Chapter 21) by the absorption and emission of light. We will also build on the foundation of statistics and calibration laid in Unit 1. Test 2 (on March 9) covers Unit 2.

In Unit 3, we study in detail the classical method of volumetric analysis. We start by learning how to describe solution phase chemistry rigorously using the concept of activity (Chapter 8) and how to use mathematically general methods for describing chemical equilibria (Chapter 9). We then discuss the chemistry of polyprotic acid/base systems (Chapter 11). (This takes us up to Test 3 on April 6.) Finally, we treat in detail the titration of monoprotic and polyprotic species (Chapters 7 and 12). For this unit, it is essential that you review the equilibrium problem-solving techniques and acid/base chemistry you learned in general chemistry; mastery of Chapters 6 and 10 will be assumed.

In Unit 4, we consider the theory and practice of chromatography (Chapter 23, with highlights from Chapters 24 and 25). We will bring to bear our understanding of statistics, calibration, molecular structure and energetics to understand this instrumental technique, which is second only to spectrophotometry (Unit 2) in its importance and breadth of use.

LECTURES: MWF from 10:50 to 11:50 a.m. in Olin-Rice 301. It is your responsibility to do the assigned reading before lectures on the material begin. See pp. 3-4 of this syllabus for the approximate lecture schedule. Doing the reading will help you understand the lectures a lot more, prepare you to ask questions during class, and equip you to benefit from in-class problem solving activities we will do periodically. Also, please bring your calculator to class.

LABORATORIES: Thursdays from 8:00 to 11:40 a.m. in Olin-Rice 380. Due to limited resources (*e.g.* we have only one atomic absorption spectrometer), you will need to do some work outside the "official" lab time. I will give you card access to the appropriate instrumental laboratories. **However, note that you must never work alone in any lab**. There will be ten lab teams total; each of you will work in a group of two or three of your choosing throughout the semester. **There will be a 20% per day penalty for late lab reports.** More details will be provided separately.

PROBLEM SETS: Assignments (usually problems from your text) will be handed out a week before they are due (see pp. 3-4 for due dates). **There will be a 20% per day penalty for late homework, and will not be accepted after the test on that material.** Unless otherwise noted, each of the problems sets will be weighted equally in determining this percentage of your cumulative score. Note that the final answers for most problems are in the back of the book. However, your answers must be justified to receive credit. My solutions to the homework will be posted on the course web page to help you study.

Doing the assigned homework is essential for you to learn the material and do well on exams. However, do not expect the specific problems I assign to be a targeted rehearsal for, or preview of, test questions. The goal is for you to master concepts and principles on which you will be tested. Please come talk with me or the tutor if you have any questions on the homework. You are also encouraged to work with other people, but what you turn in must be your own work. I also highly recommend you make time to do additional problems as you study for this course.

EXAMINATIONS: There will be four unit tests consisting largely of calculations and essay questions. I will give your two hours to work on each exam. This will provide you the time to answer in-depth problems. The first three tests will be administered during the laboratory time slot in Olin-Rice 150. The last test will be combined with a comprehensive final exam consisting of standardized multiple-choice questions written by the American Chemical Society. This must be taken at the time set by the Registrar's Office: Thursday, May 4, 10:30 a.m. –12:30 p.m., in OR 301.

GETTING HELP: I will be available in my office Monday 1:30-2:30 p.m., Tuesday 9:00-10:00 a.m., Wednesday 2:30-3:30 p.m., and Thursday 1:30-2:30 p.m. If you can't make one of these office hours, please make an appointment with me, or just come by—I'll usually be somewhere in Olin-Rice. Senior chemistry major Anne Blair (ablair@macalester.edu) will also be available the night before each lab report and problem set is due. We are eager to help you do well in this course!

GRADING: **Homework: 15% Lab Work: 25% 1st 3 Tests: 40% 4th Test + Final : 20%**
Grades will be assigned using a curve based on your cumulative percentage of points. However, everyone who earns at least 90% is guaranteed an A or an A-. Typically, if your cumulative score is close to the class average, you will receive a B. Note that non-permanent midterm grades will be assigned based on the first two midterms only—homework and lab scores will not be included.

ACADEMIC INTEGRITY: Fabricating experimental data, copying another lab group's data without my permission, copying another person's lab report or homework (from this or past years), obtaining copies of tests prior to their administration, using unauthorized materials during tests, sharing or stealing information during an exam, and alteration of a graded exam and then requesting a re-grade all constitute cheating and are forbidden. As per the Macalester Student Handbook, I will report any clear violation of academic integrity standards to Ellen Guyer, the Dean of Academic Programs.

COURSE SCHEDULE (timing of lecture topics may vary)

Date	Day	What's Due?	Chap	Topics/Event
1/23	M		0	Introduction
1/25	W		27	Gravimetric Analysis
1/26	Th		1	Concentration Units, Safety, Lab Check-in (Meet in OR 350)
1/27	F		27	(Gravimetric Analysis continued)
1/30	M	**PS 1**	4, 3	Statistics and Error Analysis
2/1	W		4, 3	(Statistics and Error Analysis continued)
2/2	Th			Exp 1: Gravimetric Determination of Fe—Part 1
2/3	F		4, 3	(Statistics and Error Analysis continued)
2/6	M	**PS 2**	5	Calibration
2/8	W		5	(Calibration continued)
2/9	Th			Exp 1: Gravimetric Determination of Fe—Part 2
2/10	F		5	(Calibration continued)
2/13	M	**PS 3**	18	Spectrophotometry: Concepts and Instrumentation
2/15	W		18	(Spectrophotometry: Concepts and Instrumentation cont.)
2/16	**Th**	**TEST 1: Lectures thru 2/10; PS 1, 2, and 3 (in OR 150)**		
2/17	F		18	(also skim Chapter 20)
2/20	M	**Exp 1**	18	(Spectrophotometry: Concepts and Instrumentation cont.)
2/22	W		18	(Spectrophotometry: Concepts and Instrumentation cont.)
2/23	Th			Exp 2: Spectrophotometric Determination of Fe
2/24	F	**PS 4**	21	Atomic Spectroscopy
2/27	M		21	(Atomic Spectroscopy continued)
3/1	W		21	(Atomic Spectroscopy continued)
3/2	Th			Exp 3: Elemental Analysis by Atomic Absorption—Part 1
3/3	F	**Exp 2**	21	(Atomic Spectroscopy continued)
3/6	M	**PS 5**	8	Solubility and Activity (Review Chapter 6 on your own)
3/8	W		8	(Solubility and Activity continued)
3/9	**Th**	**TEST 2: Lectures thru 3/3; PS 4 and 5 (in OR 150)**		
3/10	F		8	(Solubility and Activity continued)
3/13 – 3/17		**Spring Break (no classes)**		
3/20	M		9	Systematic Treatment of Equilibrium
3/22	W		10	**Review** of Monoprotic Acids, Bases, and Buffers
3/23	Th			Exp 3: Elemental Analysis by Atomic Absorption—Part 2
3/24	F	**PS 6**	11	Polyprotic Acids and Bases
3/27	M		11	(Polyprotic Acids and Bases continued)
3/29	W		11	(Polyprotic Acids and Bases continued)
3/30	Th			Exp 4: Weak Acid/Strong Base Titration; Gran Plot
3/31	F	**Exp 3**	11	(Polyprotic Acids and Bases continued)

Date	Day	What's Due?	Chap	Topics/Event
4/3	M	**PS 7**	12	Acid-Base Titrations
4/5	W		12	(Acid-Base Titrations continued)
4/6	**Th**	**TEST 3: Lectures thru 3/31; PS 6 and 7 (in OR 150)**		
4/7	F		12	(also read Chapter 7, Sections 1 and 2)
4/10	M		12	(Acid-Base Titrations continued)
4/12	W	**PS 8**	23	Extractions
4/13	Th			Exp 5: Gas Chromatography on Whiskey—Part 1
4/14	F	**Good Friday (no class)**		
4/17	M	**Exp 4**	23	Chromatography Fundamentals
4/19	W		23	(Chromatography Fundamentals continued)
4/20	Th			Exp 5: Gas Chromatography on Whiskey—Part 2
4/21	F		23	(Chromatography Fundamentals continued)
4/24	M	**PS 9**	23	Resolution in Chromatography
4/26	W		23	(Resolution in Chromatography continued)
4/27	Th			Lab Check-Out
4/28	F		23	(Resolution in Chromatography continued)
5/1	M	**Exp 5**		Chromatography Applications
5/3	W	**Study Day (no class)**		
5/4	**Th**	**TEST 4 + FINAL EXAM, 10:30 a.m.-12:30 p.m., OR 301**		