

## Chemistry 222. Analytical Chemistry

**INSTRUCTOR:** Prof. Keith T. Kuwata, Olin-Rice 318, 696-6768, kuwata@macalester.edu.

Web page: [www.macalester.edu/~kuwata](http://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) **Two** composition books (5 x 5 Quad Ruled, 10" x 7<sup>7</sup>/<sub>8</sub>" (buy at the Highlander Store). These will serve as your lab notebooks. (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, structure and energetics) that is the foundation of your lab work and data analysis.

In Unit 1, we explore the basics: the analytical process (Chapter 0), key techniques for laboratory work and data analysis, especially statistics (Chapters 1, 3, and 4), a rigorous description of solution phase behavior (Chapter 8), and the classical method of gravimetric analysis (Chapter 27).

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 learn in detail about the construction of calibration and standard addition curves (Chapter 5) used to analyze spectroscopic data.

In Unit 3, we study in detail the classical method of volumetric analysis. We start by learning new, rigorous methods for describing chemical equilibria (Chapter 9). We then discuss the chemistry of polyprotic acid/base systems (Chapter 11). Finally, we treat in detail the titration of acids, bases, and metals by complex formation (Chapter 7, 12, and 13). For this unit, it is essential that you review the equilibrium concepts and acid/base chemistry you learned in general chemistry; mastery of Chapters 6 and 10 will be assumed.

We conclude by studying the theory and practice of chromatography (Chapters 23-25). We will bring to bear our understanding of molecular structure and energetics to understand this important instrumental technique. We will also learn about the use of internal standards to perform quantitative analysis on chromatographic data.

**LECTURES:** MWF from 9:40 to 10:40 a.m. in Olin-Rice 350. 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. 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.** You will work in pairs of your choosing throughout the semester; be paired up by the first day of lab (January 27) so that you can be assigned cabinets next to each other. **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 many 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 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 quantitative and qualitative problems, along with a few multiple-choice questions. Each test will run two hours. The first three tests will be administered during the laboratory time slot in Olin-Rice 350. This will provide you the time to answer in-depth problems. 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: Friday, May 6, 8:00 a.m. –10:00 a.m., in OR 350.

**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., Thursday 4:00-5:00 p.m., and Friday 11:00 a.m.-12:00 noon. 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. Other helpful people include the teaching assistants, Brinton Seashore-Ludlow (for lab questions) (bseashorelud@macalester.edu, x7320) and Johann Bergholz (for homework questions) (jbergholz@macalester.edu, 644-0326). We are all eager to help you do well in this course!

**GRADING: Homework: 15% Lab Work: 25% 1st 3 Tests: 45% 4th Test + Final : 15%**  
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 pair's lab data, 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)**

<b>Date</b>	<b>Day</b>	<b>What's Due?</b>	<b>Chap</b>	<b>Topics/Event</b>
1/24	M		0	Introduction
1/26	W		27	Gravimetric Analysis
1/27	Th		1	Concentration Units, Safety, Lab Check-in (Meet in OR 350)
1/28	F		27	(Gravimetric Analysis continued)
1/31	M	<b>PS 1</b>	4, 3	Statistics and Error Analysis
2/2	W		4, 3	(Statistics and Error Analysis continued)
2/3	Th			Exp 1: Gravimetric Determination of Fe—Part 1
2/4	F		4, 3	(Statistics and Error Analysis continued)
2/7	M	<b>PS 2</b>	8	Solubility and Activity (Review Chapter 6 on your own)
2/9	W		8	(Solubility and Activity continued)
2/10	Th			Exp 1: Gravimetric Determination of Fe—Part 2
2/11	F		8	(Solubility and Activity continued) <b>[Add/Drop Deadline]</b>
2/14	M	<b>PS 3</b>	5	Calibration
2/16	W		5	(Calibration continued)
2/17	Th			<b>TEST 1: Lectures thru 2/11; PS 1, 2, and 3 (in OR 350)</b>
2/18	F		18	Spectrophotometry: Concepts and Instrumentation
2/21	M	<b>Exp 1</b>	18	(Spectrophotometry: Concepts and Instrumentation continued)
2/23	W		18	(also skim Chapter 20)
2/24	Th			Exp 2: Spectrophotometric Determination of Fe
2/25	F		18	(Spectrophotometry: Concepts and Instrumentation continued)
2/28	M	<b>PS 4</b>	21	Atomic Spectroscopy
3/2	W		21	(Atomic Spectroscopy continued)
3/3	Th			Exp 3: Atomic Absorption Determination of Pb—Part 1
3/4	F		21	(Atomic Spectroscopy continued)
3/7	M	<b>Exp 2</b>	21	(Atomic Spectroscopy continued)
3/9	W		5	Standard Addition
3/10	Th			Exp 3: Atomic Absorption Determination of Pb—Part 2
3/11	F		9	Systematic Treatment of Equilibrium
3/14	M	<b>PS 5</b>	10	<b>Review</b> of Monoprotic Acids, Bases, and Buffers
3/16	W		11	Polyprotic Acids and Bases
3/17	Th			<b>TEST 2: Lectures thru 3/9; PS 4 and 5 (in OR 350)</b>
3/18	F		11	(Polyprotic Acids and Bases continued)
		<b>3/21 – 3/25</b>		<b>Spring Break (no classes)</b>
3/28	M		11	(Polyprotic Acids and Bases continued)
3/30	W		11	(Polyprotic Acids and Bases continued)
3/31	Th			Exp 4: Weak Acid/Strong Base Titration; Gran Plot
4/1	F	<b>PS 6</b>	12	Acid-Base Titrations <b>[Withdraw Deadline]</b>

<b>Date</b>	<b>Day</b>	<b>What's Due?</b>	<b>Chap</b>	<b>Topics/Event</b>
4/4	M	<b>Exp 3</b>	12	(Acid-Base Titrations continued)
4/6	W		12	(also read Chapter 7, Sections 1 and 2)
4/7	Th		12	(Acid-Base Titrations continued) (Meet in OR 350)
4/8	F		13	EDTA Titrations
4/11	M	<b>PS 7</b>	13	(EDTA Titrations continued)
4/13	W		13	(EDTA Titrations continued)
<b>4/14</b>	<b>Th</b>			<b>TEST 3: Lectures thru 4/7; PS 6 and 7 (in OR 350)</b>
4/15	F		13	(EDTA Titrations continued)
4/18	M	<b>PS 8</b>	23	Analytical Separations
4/20	W		23	(Analytical Separations continued)
4/21	Th			Exp 5: EDTA Titration
4/22	F		23	(Analytical Separations continued)
4/25	M	<b>Exp 4</b>	24	Gas Chromatography
4/27	W		24	(Gas Chromatography continued)
4/28	Th			Finish Exp 5 + Check-out
<b>4/29</b>	<b>F</b>		24	(Gas Chromatography continued)
<b>5/2</b>	<b>M</b>	<b>Exp 5</b>	25	High Performance Liquid Chromatography
5/4	W			NO CLASS
5/5	Th			NO CLASS
<b>5/6</b>	<b>F</b>			<b>TEST 4 + FINAL EXAM, 8:00-10:00 a.m., OR 350</b>
5/9	M	<b>GC Write-up</b>		