Chemistry 111. General Chemistry I: Structure and Equilibrium

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

REQUIRED TEXT: Martin S. Silberberg, *Chemistry*: *The Molecular Nature of Matter and Change*, 3rd Edition, Boston: McGraw Hill, 2003.

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 7/8" (buy at the Highlander Store). These will serve as your lab notebooks. (3) A scientific calculator.

DESCRIPTION: This course, along with Chemistry 112 offered in the spring semester, lays the foundation for all subsequent study in chemistry. During this semester, we will focus on the key chemical themes of structure and equilibrium. In Unit 1, we introduce key concepts about light and quantum mechanics and use them to understand the properties of atoms and molecules (Chapters 7, 8, and 9). In Unit 2, we develop powerful models for understanding chemical bonding and the three-dimensional structures of inorganic and organic molecules (Chapters 10, 11, and 15). In Unit 3, we extrapolate from the properties of individual molecules to explore transition metal complexes and states of matter. We also begin our qualitative and quantitative treatment of chemical equilibrium (Chapters 12, 23, and 17). In Unit 4, we apply what we have learned about structure and equilibrium to the rich aqueous chemistry of acids, bases, and salts (Chapters 18 and 19).

Our lecture schedule does not include a formal treatment of the first five chapters of your textbook. These chapters cover topics such as basic chemical vocabulary, nomenclature, mass and mole relationships, balancing chemical equations, fundamental classes of chemical reactions, solution stoichiometry, and use of the ideal gas law. Much of what we will cover in Chemistry 111 and 112 assumes and builds on this foundational material. To help you review this elementary, but important, material, we will use the second and fourth weeks of lab as workshops on these topics. Also, you will be responsible for knowing all of the material on a nomenclature handout (see p. 5 of this syllabus).

LABORATORIES: Usually in OR 343. Attendance every week is mandatory. If special circumstances preclude your attendance at a session, you must notify your instructor beforehand and make arrangements to make that session up. Lab work starts on September 14. Please see p. 4 of this syllabus for a schedule of experiments. More details will be provided separately.

LECTURES: MWF from 8:30 a.m. to 9:30 a.m. in Olin-Rice 350. Attendance is not mandatory, but highly encouraged. It is your responsibility to read the assigned sections of Silberberg (see p. 3) before lectures on the material begin. Doing the reading will help you understand the lectures a lot more, and equip you to ask questions during class. Also, please bring a calculator for in-class exercises.

PROBLEM SETS: You will be required to turn in solutions to selected problems at the end of each chapter. Assignments will be handed out at least one week before they are due (see p. 3 for the due dates.) **No late homework will be accepted for any reason.** However, I will drop your lowest two homework scores in computing your course grade.

Doing the assigned homework is an essential part of learning the material and doing well on exams. You cannot learn chemistry without repeated problem solving. 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. You are encouraged to work with other people, but what you turn in must be your own work.

You should show in writing the process by which you have obtained your answers. Explanations should be clear and concise. In addition, final numerical answers must contain the correct number of significant figures (see pp. 27-30 of Silberberg for rules) and have the right physical units attached to receive full credit. I will hold you to the same standards when I grade your exams.

You should also make time to do additional problems as you study for this course. Answers to the end-of-chapter problems numbered in green can be found in Appendix E of your text, and the optional *Student Solutions Manual* (available for purchase in the bookstore) contains detailed solutions to the same problems. (Please feel free to ask me about any problem, assigned or unassigned.)

Note that Problem Sets 3, 6, and 9, which are due the class periods immediately before tests, may not be graded before the tests are administered. However, my solutions for these (and all other) problems sets will be posted on the course web page to help you study.

TESTS: There will be four examinations, corresponding to the four units described above, that will consist of math problems, short essay questions, and a few multiple-choice questions. The first three midterms will be held during the normal lecture time slot. The fourth midterm will occupy the first hour of your final exam time slot, **Saturday, December 18, 8:00-10:00 a.m. The final will not be administered at any other time--make your travel plans accordingly!** The second hour of your final will consist of a standardized multiple-choice exam from the American Chemical Society (ACS). (Note that Macalester chemistry students have an excellent track record on these standardized exams!)

You must talk with me before an exam if you have a legitimate reason (e.g. serious illness) for missing the scheduled times for the first three exams. If I grant you a postponement, you must make every effort to make up the test before the next class period (when I will hand the graded exams back).

GRADING: **Homework: 10% Lab Work: 20% 4 Midterms: 60% ACS Final: 10%**
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—but this is not guaranteed. Note that non-permanent midterm grades will be assigned based on the first two midterms only

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 4:00-5:00 p.m. If you cannot make one of these scheduled office hours, you can also make an appointment with me, or just come by—I'll usually be somewhere in Olin-Rice. Other helpful people include the chemistry major tutors in the department computer lab (OR 341, hours to be announced), the MAX Center tutors, your homework grader, Matt Patton '06 (x7001), and Prof. Kate Doan (OR 311, x6788). We are all eager to help you do well in this course!

ACADEMIC INTEGRITY: 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

Date	Day	What's Due?	Topics/Event—Silberberg reading assignments in ( )
9/8	W		Light, Quantum Mechanics, and the Atom (Ch. 7)
9/10	F		(Light, Quantum Mechanics, and the Atom continued)
9/13	M		(Light, Quantum Mechanics, and the Atom continued)
9/15	W		(Light, Quantum Mechanics, and the Atom continued)
9/17	F	**PS 1**	Multi-Electron Atoms; Periodic Table (Ch. 8) **[Validation Deadline]**
9/20	M		(Multi-Electron Atoms; Periodic Table continued)
9/22	W		(Multi-Electron Atoms; Periodic Table continued)
9/24	F	**PS 2**	Chemical Bonding (Ch. 9—skim 9.2 and 9.5; 10.1) **[Add/Drop Deadline]**
9/27	M		(Chemical Bonding continued)
9/29	W		(Chemical Bonding continued)
10/1	F	**PS 3**	Molecular Shape and VSEPR Theory (10.3-10.4)
10/4	**M**		**TEST 1: Lectures thru 9/29; PS 1, 2, and 3**
10/6	W		(Molecular Shape and VSEPR Theory continued)
10/8	F		(Molecular Shape and VSEPR Theory continued)
10/11	M	**PS 4**	Molecular Orbital and Hybridization Theories (Ch. 11)
10/13	W		(Molecular Orbital and Hybridization Theories continued)
10/15	F		(Molecular Orbital and Hybridization Theories continued)
10/18	M	**PS 5**	Bonding and Structure of Organic Molecules (15.1-15.2)
10/20	W		(Bonding and Structure of Organic Molecules continued)
10/22	F		(Bonding and Structure of Organic Molecules continued)
10/25	M	**PS 6**	Intermolecular Forces and States of Matter (12.1; 12.3; 12.5)
10/27	**W**		**TEST 2: Lectures thru 10/22; PS 4, 5, and 6 [Midterm Grades Due]**
10/28	Th		**Fall Break (no class)**
10/29	F		**Fall Break (no class)**
11/1	M		(Intermolecular Forces and States of Matter continued)
11/3	W	Baby Kuwata	Transition Metals and Coordination Compounds (23.1; 23.4; 23.5)
11/5	F	**PS 7**	(Coordination Compounds continued) **[Withdraw Deadline]**
11/8	M		(Coordination Compounds continued)
11/10	W		(Coordination Compounds continued)
11/12	F	**PS 8**	Chemical Equilibrium (Ch. 17)
11/15	M		(Chemical Equilibrium continued)
11/17	W		(Chemical Equilibrium continued)
11/19	F		(Chemical Equilibrium continued)
11/22	M	**PS 9**	Acid-Base Chemistry: Quantitative (18.1-18.5; 18.7)
11/24	**W**		**TEST 3: Lectures thru 10/19; PS 7, 8, and 9**
11/25	Th		**Thanksgiving Break (no class)**
11/26	F		**Thanksgiving Break (no class)**
11/29	M		(Acid-Base Chemistry: Quantitative continued)
12/1	W		(Acid-Base Chemistry: Quantitative continued)
12/3	F	**PS 10**	Acid-Base Buffers (19.1)
12/6	M		(Acid-Base Buffers continued)
12/8	W		Solubility Equilibrium and Polyprotic Species (19.3)
12/10	F		(Solubility Equilibrium and Polyprotic Species continued)
12/13	M	**PS 11**	Acid-Base Chemistry: Qualitative (18.6; 18.9)
12/15	W		(Acid-Base Chemistry: Qualitative continued) **[Last Day]**

TEST 4 + FINAL EXAMINATION: Saturday, December 18, 8:00—10:00 a.m., Olin-Rice 350

LAB SCHEDULE

Sept 6	7	8 Classes Begin	9	10
13	14 Exp 1: Using Excel	15	16 Exp 1: Using Excel	17
20	21 Workshop #1	22	23 Workshop #1	24
27	28 Exp 2: Periodic Trends	29	30 Exp 2: Periodic Trends	Oct 1
Oct 4	5 Workshop #2	6	7 Workshop #2	8
11	12 Exp 3: Molecular Shapes	13	14 Exp 3: Molecular Shapes	15
18	19 Exp 4: Visualizing Molecular Orbitals	20	21 Exp 4: Visualizing Molecular Orbitals	22
25	26 Exp 5: Al/Zn + HCl (THURSDAY LABS)	27	28 Midterm	29 Break
Nov 1	2 Exp 5: Al/Zn + HCl	3	4 Exp 6a: Cobalt Complex Synthesis	5
8	9 Exp 6a: Cobalt Complex Synthesis	10	11 Exp 6b: Cobalt Complex Analysis	12
15	16 Exp 6b: Cobalt Complex Analysis	17	18 Exp 7: Chemical Equilibrium	19
22	23 Exp 7: Chemical Equilibrium	24	25 Thanksgiving	26 Break
29	30 Exp 8: NaOH Standardization	Dec 1	2 Exp 8: NaOH Standardization	3
Dec 6	7 Exp 9: pH and Buffers	8	9 Exp 9: pH and Buffers	10
13	14 NO LAB	15	16	17

Chemical Formulas and Names to Memorize

Prefixes for Naming Compounds

mono-	1	penta-	5	nona-	9
di-	2	hexa-	6	deca-	10
tri-	3	hepta-	7	undeca-	11
tetra-	4	octa-	8	dodeca-	12

Common Cations Whose Charges/Oxidation States Do Not Vary

+1:	All Group 1 Elements	Silver (Ag^+)	Ammonium (NH_4^+)	Hydronium (H_3O^+)
+2:	All Group 2 Elements	Zinc (Zn^{2+})	Cadmium (Cd^{2+})	
+3:	Aluminum (Al^{3+})			

Important Cations Whose Charges/Oxidation States Vary

+1/+2:	Copper	Cu(I) and Cu(II)	Cu^+ and Cu^{2+}
	Mercury	Hg(I) and Hg(II)	Hg_2^{2+} (note: diatomic!) and Hg^{2+}
+2/+3:	Iron	Fe(II) and Fe(III)	Fe^{2+} and Fe^{3+}
+2/+4	Tin	Sn(II) and Sn(IV)	Sn^{2+} and Sn^{4+}

Common Anions

Group 17:	Fluoride (F^-)	Chloride (Cl^-)	Bromide (Br^-)	Iodide (I^-)
	Hypochlorite (ClO^-)	Chlorite (ClO_2^-)	Chlorate (ClO_3^-)	Perchlorate (ClO_4^-)
Group 16:	Oxide (O^{2-})	Peroxide (O_2^{2-})	Superoxide (O_2^-)	Hydroxide (OH^-)
	Sulfide (S^{2-})	Sulfite (SO_3^{2-})	Sulfate (SO_4^{2-})	Thiosulfate ($S_2O_3^{2-}$)
	Hydrogen Sulfide (HS^-)	Hydrogen Sulfite (HSO_3^-)	Hydrogen Sulfate (HSO_4^-)	
Group 15:	Nitrite (NO_2^-)	Nitrate (NO_3^-)		
	Phosphate (PO_4^{3-})	Hydrogen Phosphate (HPO_4^{2-})	Dihydrogen Phosphate ($H_2PO_4^-$)	
Group 14:	Cyanide (CN^-)	Cyanate (OCN^-)	Thiocyanate (SCN^-)	
	Carbonate (CO_3^{2-})	Hydrogen Carbonate (HCO_3^-)	Formate ($HCOO^-$)	Acetate (CH_3COO^-)
Others:	Hydride (H^-)	Permanganate (MnO_4^-)	Chromate (CrO_4^{2-})	Dichromate ($Cr_2O_7^{2-}$)

Important Acids

Group 17:	Hydrofluoric (HF)	Hydrochloric (HCl)	Hydrobromic (HBr)	Hydroiodic (HI)
	Hypochlorous (HOCl)	Chlorous ($HClO_2$)	Chloric ($HClO_3$)	Perchloric ($HClO_4$)
Group 16:	Hydrosulfuric (H_2S)	Sulfurous (H_2SO_3)	Sulfuric (H_2SO_4)	
Group 15:	Nitrous (HNO_2)	Nitric (HNO_3)	Phosphoric (H_3PO_4)	
Group 14:	Hydrocyanic (HCN)	Carbonic (H_2CO_3)	Formic (HCOOH)	Acetic (CH_3COOH)

Common Substances

Group 18:	Helium (He)	Neon (Ne)	Argon (Ar)	Krypton (Kr)	Xenon (Xe)
Group 17:	Fluorine (F_2)	Chlorine (Cl_2)	Bromine (Br_2)	Iodine (I_2)	
Others:	Hydrogen (H_2)	Nitrogen (N_2)	Oxygen (O_2)	Carbon Monoxide (CO)	
	Methane (CH_4)	Ammonia (NH_3)	Water (H_2O)	Nitric Oxide (NO)	