

Chemistry 112. General Chemistry II—Energetics and Reactivity

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Web page: www.macalester.edu/~kuwata (for class handouts, class overheads, and answer keys)

REQUIRED TEXTS: (1) Robert M. Hanson and Susan M. E. Green, *Introduction to Molecular Thermodynamics* ("IMT"), Northfield, Minnesota: Integrated Graphics, 2005. (2) Martin S. Silberberg, *Chemistry: The Molecular Nature of Matter and Change* ("S"), 4th Edition, Boston: McGraw Hill, 2006. (This is the same text used in Chemistry 111 last semester.) (3) *Chemistry 112 Laboratory Manual*.

OTHER REQUIRED MATERIALS: (1) A pair of safety goggles (or safety glasses with side shields) (buy at the Lampert Building Bookstore). State law requires that you wear safety eyewear during all lab 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. Please continue using your lab notebooks from Chemistry 111 last semester.

DESCRIPTION: This first half of this course provides a unique treatment of thermodynamics—the effect of energy on physical processes and chemical reactions—in terms of chemical structure and basic concepts of probability. We will closely follow a text written by chemistry faculty at St. Olaf College.

In Unit 1, we discuss how probability governs the distribution of isotopes between molecules (Chapter 1) and the distribution of energy within molecules (Chapter 2). We also consider in detail, building on concepts learned in Chemistry 111, how atoms and molecules store energy (Chapter 3).

In Unit 2, we discuss in detail how the internal energy of a system (a collection of atoms and molecules) can be changed by physical processes or chemical reactions (Chapters 4 and 5). We then consider how the ability of a system to disperse energy within itself affects its position of equilibrium (Chapter 6), and learn how to quantify this dispersal of energy, known as entropy (Chapters 7 and 8).

In Unit 3, we introduce the concepts of enthalpy (Chapter 9) and free energy (Chapter 10). These quantities, in conjunction with the second law of thermodynamics, allow us to predict equilibrium constants for physical and chemical changes, and understand quantitatively how temperature affects equilibrium (Chapters 11 and 12).

In Unit 4, we focus on the important area of electron-transfer reactions (electrochemistry). We will combine Silberberg's treatment of the fundamentals (Chapters 4 and 21) and the molecular thermodynamic treatment of the energy involved in electron transfer (IMT Chapter 13).

We close the semester by studying the rates of chemical reactions, or kinetics. We will learn both how to mathematically model reaction rates, and to think about how changes in chemical structure determine reaction rates. We will focus on Chapter 16 in Silberberg, but will also build on the molecular thermodynamics concepts learned in the first half of the semester.

LECTURES: MWF from 8:30 to 9:30 a.m. in Olin-Rice 350. It is your responsibility to do the assigned reading before lectures on the material begin. See p. 3 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: Usually in Olin-Rice 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 no later than one week after the original lab session. Please see p. 4 for the schedule of experiments. More details will be provided separately by your lab instructor.

PROBLEM SETS: You will be required to turn in solutions to selected problems about once a week (see p. 3 for the due dates). Assignments will be handed out at least one week before they are due. Each assignment will be weighted equally in determining the homework portion of your overall grade. Homework will be due by 5 p.m., and **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 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 in Silberberg numbered in blue can be found in Appendix E. *Introduction to Molecular Thermodynamics* has no answers in back, but you can ask me or a tutor for the answer to any question. Please feel free to ask me about any problem, assigned or unassigned.

EXAMINATIONS: There will be four unit tests consisting of calculations, short essay questions, and a few multiple-choice and true-false questions. I will give you from 8:00 to 9:30 a.m. to work on each exam. **You must take each exam when it is scheduled**. The only exceptions are (1) if you have another major event at the same time, you must then take the exam before the scheduled time; (2) if you are seriously ill the day before an exam, I may grant you a postponement if you contact me before the exam.

The final exam will have a section on chemical kinetics and a comprehensive section covering all of the major topics of the semester. This must be taken at the time set by the Registrar's Office: **Monday, May 8, 8:00 a.m. –10:15 a.m., in Olin-Rice 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., 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 during the day. Chemistry tutors will be staffing the department computer lab (Olin-Rice 341) Sundays from 1:00-10:00 p.m., and Mondays – Thursdays from 7:00 – 10:00 p.m.

GRADING: Homework: 10% Lab Work: 20% 1st 4 Tests: 50% 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		IMT-1	Probability
1/25	W		IMT-1	(Probability continued)
1/27	F		IMT-2	Distributing Energy
1/30	M	PS 1	IMT-2	(Distributing Energy continued)
2/1	W		IMT-3	Energy Levels in Matter
2/3	F		IMT-3	(Energy Levels in Matter continued)
2/6	M		IMT-3	(Energy Levels in Matter continued)
2/8	W	PS 2	IMT-4	Internal Energy
2/10	F		IMT-4	(Internal Energy continued)
2/13	M	TEST 1: Lectures thru 2/6; PS 1 and 2		
2/15	W		IMT-5	Chemical Bonding and Internal Energy
2/17	F		IMT-6	Temperature and Equilibrium
2/20	M	PS 3	IMT-7	Entropy
2/22	W		IMT-7	(Entropy continued)
2/24	F		IMT-8	Entropy Under Non-Standard Conditions
2/27	M	PS 4	IMT-9	Enthalpy
3/1	W	TEST 2: Lectures thru 2/24; PS 3 and 4		
3/3	F		IMT-10	Free Energy
3/6	M		IMT-10	(Free Energy continued)
3/8	W	PS 5	IMT-11	Equilibrium Constants
3/10	F		IMT-11	(Equilibrium Constants continued)
3/13 – 3/17	Spring Break (no classes)			
3/20	M		IMT-12	Free Energy and Phase Changes
3/22	W		IMT-12	(Free Energy and Phase Changes continued)
3/24	F	PS 6	S-21	Electrochemistry
3/27	M	TEST 3: Lectures thru 3/22; PS 5 and 6		
3/29	W		S-21	(also read Silberberg sections 4.5 and 4.6)
3/31	F		IMT-13	Thermodynamics and Electrochemistry
4/3	M	PS 7	IMT-13	(Thermodynamics and Electrochemistry continued)
4/5	W		IMT-13	(Thermodynamics and Electrochemistry continued)
4/7	F		IMT-13	(Thermodynamics and Electrochemistry continued)
4/10	M		IMT-13	(Thermodynamics and Electrochemistry continued)
4/12	W	PS 8	S-16	Chemical Kinetics
4/14	F	Good Friday (no class)		
4/17	M		S-16	(Chemical Kinetics continued)
4/19	W	TEST 4: Lectures thru 4/10; PS 7 and 8		
4/21	F		S-16	(Chemical Kinetics continued)
4/24	M		S-16	(Chemical Kinetics continued)
4/26	W	PS 9	S-16	(Chemical Kinetics continued)
4/28	F		S-16	(Chemical Kinetics continued)
5/1	M		S-16	(Chemical Kinetics continued)
5/8	M	FINAL EXAM, 8:00 a.m.-10:15 a.m., OR 350		

LAB SCHEDULE

Monday	Tuesday	W	Thursday	Friday
Jan 23	24 Probability and Equilibrium	25	26 Probability and Equilibrium	27
30#	31 Synthesis and Spectroscopy	Feb 1	2 Synthesis and Spectroscopy	3
6#	7 Molecular Vibrations and Spectroscopy (OR341)	8	9 Molecular Vibrations and Spectroscopy (OR341)	10
13#	14 Calorimetry: Quantification of ΔU	15	16 Calorimetry: Quantification of ΔU	17
20#	21 Probability and Entropy (Humanities 302)	22	23 Probability and Entropy (Humanities 302)	24
27	28 No Lab	M1	2 No Lab	3
6#	7 Vapor Pressure and Enthalpy of Vaporization	8	9 Vapor Pressure and Enthalpy of Vaporization	10
13 Spring	14 Midterm	15	16 Break	17
20#	21 Molar Mass Determination by Freezing Point Depression	22	23 Molar Mass Determination by Freezing Point Depression	24
27#	28 Determination of Iron by Reactions with $[\text{MnO}_4^-]$	29	30 Determination of Iron by Reactions with $[\text{MnO}_4^-]$	31
April 3#	4 Determination of an Equivalent Mass by Electrolysis	5	6 Determination of an Equivalent Mass by Electrolysis	7
10#	11 Voltaic Cells	12	13 Voltaic Cells	14 Good Friday
17#	18 Rates of Chemical Reactions (Clock Reaction)	19	20 Rates of Chemical Reactions (Clock Reaction)	21
24#	25 Radioactivity: A Rate Study	26	27 Radioactivity: A Rate Study	28
May 1	2 Classes End	5	6 Finals Begin	7

#The Advance Study Assignments for the upcoming lab experiment are due for all laboratory sections on Monday by 6:00 PM. Turn in your ASA to the appropriately labeled mailbox outside of OR310.