WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Chemistry 109H – Advanced General Chemistry
Fall, 2018

Official course description: A modern introduction to chemical principles that draws on current research themes. For students with good chemistry and mathematics background preparation who desire a one-semester coverage of general chemistry. Recommended for students intending majors in chemistry or allied fields. Lecture, lab, and discussion.

Official requisites: MATH 113, 114, or 171; not open to students who have taken CHEM 104 or CHEM 115. (See information on next page regarding the use of calculus in the course.)

Course designations and attributes: Elementary level; physical science breadth; counts as L&S credit; satisfies General Education Quantitative Reasoning Part B; accelerated honors

Instructional mode: face-to-face

Credit information: This is a 5-credit class that meets three times weekly for 50-minutes, plus students participate in a lab section (3 hours per week) and a discussion section (50 minutes per week). Over the course of the semester, students are expected to engage in at least 225 hours of learning activities which include class attendance, reading, studying, preparation, problem sets, and other learning activities.

Course learning outcomes – By completing this course, you will learn how to:

1. Describe fundamental chemical concepts and principles, including structure and properties of atoms, models for bonding and molecular geometry, kinetics and reaction mechanisms, equilibria and thermodynamics, acid-base chemistry, and electrochemistry.
2. Invoke models of atoms, molecules, and their interactions to qualitatively explain observed macroscopic phenomena, including: the organization of the periodic table, the rates of chemical reactions, equilibrium concentrations, and electrical currents generated by electrochemical cells.
3. Apply quantitative chemical models to predict thermodynamics, equilibrium concentrations, rates of reaction, and voltages of electrochemical cells.
4. Design, conduct and analyze experiments pertaining to the covered chemical concepts while developing fundamental skills in safe laboratory practices, accurate chemical measurements, sample isolation and analysis techniques.
5. Demonstrate abilities as reflective, self-directed learners who can assess their work, identify their misconceptions, and critically evaluate information from a variety of sources.
6. Articulate the rationale behind experimental observations and the answers to conceptual problems using clear, concise, and scientifically appropriate language.
7. Solve a wide variety of integrative chemistry problems that connect ideas across the covered concepts and their applications to real world situations.
8. Understand the role of chemistry in assessing world energy requirements and climate change.

Class meeting	8:50 am MWF, 204 Educ Sci
Instructor	Professor Randall Goldsmith 3309 Chemistry Chem109HProf@chem.wisc.edu
Teaching Assistants	Ryan Allen Office Hours in 1201 Chemistry rtallen@wisc.edu Amanda Spiewak Office Hours in 1201 Chemistry aspiewak@wisc.edu
Office Hours	Randall: Mon 10-11am, Tue 5-6pm, and by appointment. Ryan: Thur 6-7pm, and by appointment. Amanda: Wed 6-7pm, and by appointment.
Course Website	Go to canvas.wisc.edu and select Chemistry 109 003 (login with your UW NetID if prompted)

Chemistry 109H is the honors version of Chemistry 109, a modern introduction to chemical principles that draws on current research themes. The honors section is for students with particularly strong backgrounds in chemistry and good preparation in physics and mathematics. Although the course involves only small amounts of formal calculus, familiarity with calculus and at least concurrent enrollment in calculus is important. Students who have NOT taken AND are NOT currently enrolled in calculus have done well in the class, but it is more difficult. Please contact Professor Goldsmith if you are in this category.

The plan for the course is to develop the organizing principles of chemistry and apply them to questions of energy and global climate change. The unifying theme in the course is using fundamental concepts to think critically about energy production and consumption as well as their impact on the environment.

The course begins with a discussion of energy and moves to a rigorous description of thermodynamics, a topic that sits at the heart of energy production and use. After developing the concepts of entropy and free energy, the next step is applying them to spontaneous change and equilibrium, in both gases and solution. The combination of solution equilibrium and free energy leads into electrochemistry, a topic central to solar energy conversion and storage. All of these concepts turn on the interaction of molecules with light, and the course moves on to examine light, atoms, and molecules. Combining these ideas makes it possible to discuss atmospheric photochemistry. Because understanding the rates of processes is important to both energy production and reactions in the atmosphere, the course develops and applies ideas of chemical kinetics. Nuclear reactions and their connection to energy production are the final topics in the course.

The course will move at a fast pace, and the presentation assumes a good familiarity with the language of chemistry, chemical calculations, and introductory physics. (There will be resources for individual review, but the elementary topics are not part of the coverage in class or discussion.)

Materials

Text *University Chemistry: In the Context of Energy at the Global and Molecular Level* by James G. Anderson. This book is a preprint of a new text. The book will be sold in 1375 for $~75 (WISCARD only). It comes in two volumes. We will also make PDF files of the text available on the website. Purchase of a physical copy of the textbook is recommended but not required. Since we are using an unfinished textbook, we're going to offer extra credit points for finding errors in the book. One extra point will be awarded for each identification, up to a maximum of five extra credit points. We will keep a running list of identified errors. Errors can be reported by clicking on the Textbook Errors link on the course website.

Lab Manual *Laboratory Manual for Chemistry 109H, 2018* (sold in room 1375, pay by WISCARD only). It will be $20.

Top Hat We will be using the Top Hat app for in-class discussions and questions. Our course ID is 870984.

Notebook Carbonless laboratory notebook with duplicate pages. Available at local bookstores or from Alpha Chi Sigma (a bit cheaper, cash only).

Safety Goggles *You are required to wear safety goggles when in the laboratory.* We cannot admit you to the laboratory without goggles (safety glasses are not good enough!). Alpha Chi Sigma (a bit cheaper, cash only) and local bookstores sell safety goggles that will fit over regular glasses.

Calculator A scientific calculator. Graphing calculators are acceptable for use in the course.

Procedures and Policies

Website The website for the course (which uses the Canvas course management system) is the place for you to obtain current information about the course, to find links to the material presented in the course, to find reference materials and resources, and to take online quizzes, and to check your grades.

The website lists all assignments, and it is important that you use it to see when quizzes and problems sets are due. You can navigate to the website from the URL http://canvas.wisc.edu/ by selecting the link to Chemistry109: Advanced General Chemistry (003). You may need to login with you UW NetID.

Email Your UW email address is our primary means of contacting you during the semester. We will send messages to the entire class and to individuals using those addresses. Please be sure to check that account or have it forwarded to an account you see regularly. All emails to Professor Goldsmith should be sent to Chem109HProf@chem.wisc.edu

Class Meetings Your attending class is important. The class meeting will expand on material in the text, point to the most important aspects of the material, and, if things go well, stimulate discussion. I will post copies of the notes I use in class, including the Top Hat questions and answers, on the course website (as a pdf file you can view and print) shortly after the lecture. These notes are detailed enough for you to revisit points you missed in class, but they are not a substitute for the text or for your own notes.

Quizzes There will be an online quiz most weeks on the material that we will cover in roughly the following three class meetings. You will need to read the assigned chapter in the text and complete the online quiz at the website. The quiz deadline will be 8 am on either a Monday or a Wednesday. You must check the assignment for the coming week to learn the due date. I strongly urge you to complete the quiz prior to the absolute deadline. Two attempts will be allowed for each quiz. NO EXCEPTIONS will be made for late quizzes. You will be allowed to drop one quiz grade (because everyone has a bad day).

Problem Sets There will be eleven problem sets during the semester that we will post on the website (usually on Fridays). Your solutions are due at the *end of class* the following week, NO EXCEPTIONS. You will be allowed to drop one homework grade (because everyone has a bad day).

The teaching assistants will grade your solutions of selected problems and will post copies of the solutions. You will receive partial credit for attempting all of the problems. *We encourage you to discuss the problems with each other and work together.* (See the information below on *Tutorials*.) *You must generate, hand-in, and take responsibility for your own solutions. Do not copy another student's work. Any consultation of previous years' solutions sets is explicitly forbidden and will result in severe consequences.*

Top Hat You will use a personal response system operating on your phone to answer clicker questions posed in class. You must download the Top Hat App and register. Students who do not intend to use a smartphone should contact Professor Goldsmith.

You will receive up to 45 points for responding (not necessarily getting them right!) to the clicker questions. Responding to more than 75% of all the questions during the semester earns you the maximum. Responding to between 50% and 75% of the questions earns you 20 points. Responding to fewer than 50% earns you no points. The threshold is set at 75% to allow for the times you forget your phone, are ill or absent for any other reason, or just don't push the button. These are easy points to get!

Examinations There are four examinations during the semester and NO final examination. The exam dates are listed in the course outline. The first three examinations will be at *7:15 pm on Thursdays, September 27, October 25, and November 29.* These first there examinations will last one and one-half hours. The fourth exam will be on *Wednesday December 12* and will be *in class (50 min in length).*

I will announce and post the location of the exams prior to their dates. Please inform me *during the first week of class* if you have a conflict with any of the examination times.

Discussion You will meet with your teaching assistant for a discussion period each Thursday. Your teaching assistant will answer questions, discuss the material, and guide you through assignments that expand on the material discussed in the class meeting.

Tutorials There will be two-hour tutorial sessions for this course in Room 1371 on Wednesday and Thursday evenings from 7.00 to 9.00 PM. One of the teaching assistants will be available to help with problem sets and other questions you have from 8-9 PM. We encourage you to come to a tutorial to work with others in the class as well, particularly for the first hour, and get help from a teaching assistant. Additional review sessions and extra office hours will be announced prior to exams.

Laboratories The teaching assistants supervise the laboratories and direct your work. They will discuss related material, demonstrate unfamiliar techniques, and answer questions. The goal of the laboratory is to provide experience with a variety of techniques and to illustrate the principles we are discussing in lecture. We especially want you to learn to generate quantitative results and to interpret them critically.

You must come to laboratory prepared. Before coming to the laboratory, you must read and understand the procedure and complete the preparations described by your teaching assistant. Your teaching assistants will give you more detailed instructions for the pre-laboratory assignments. Lab write-ups will be due 24 hours after the lab ends.

Conflicts If a religious observance or an official University activity conflicts with any scheduled activity in this course, please notify me at the beginning of the semester. We will schedule a makeup date or otherwise accommodate you.

Illness If you are ill or have another unexpected reason that you are unable to attend an exam or laboratory please inform your teaching assistant and Professor Goldsmith as soon as possible. Sending an email message is the best means of informing us of the problem.

Grading We grade the exams on a numerical scale and provide letter grade guidelines for each exam. Problem sets, quizzes, and laboratory reports also receive numerical grades. The aggregate of the points you accumulate on these assignments determines your grade. The points for the various components are

Exams (3@100, 1@55)	355
Problem sets, 1 dropped (10-1=9@15)	135
Quizzes, 1 dropped (10-1=9@10)	90
Clicker participation	45
Laboratory	195
Total Points	**720**

You must complete the laboratory to pass the course. There is no set quota of any particular grade. You can see the distribution of grades from the last several years under the *Exams* link on the website. I will assign final course grades, in consultation with your teaching assistants, taking into account participation in discussion and laboratory activities along with your numerical score.

ACADEMIC INTEGRITY

By enrolling in this course, each student assumes the responsibilities of an active participant in UW-Madison's community of scholars in which everyone's academic work and behavior are held to the highest academic integrity standards. Academic misconduct compromises the integrity of the university. Cheating, fabrication, plagiarism, unauthorized collaboration, and helping others commit these acts are examples of academic misconduct, which can result in disciplinary action. This includes but is not limited to failure on the assignment/course, disciplinary probation, or suspension. Substantial or repeated cases of misconduct will be forwarded to the Office of Student Conduct & Community Standards for additional review. For more information, refer to studentconduct.wiscweb.wisc.edu/academic-integrity/.

ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES

McBurney Disability Resource Center syllabus statement: "The University of Wisconsin-Madison supports the right of all enrolled students to a full and equal educational opportunity. The Americans with Disabilities Act (ADA), Wisconsin State Statute (36.12), and UW-Madison policy (Faculty Document 1071) require that students with disabilities be reasonably accommodated in instruction and campus life. Reasonable accommodations for students with disabilities is a shared faculty and student responsibility. Students are expected to inform faculty [me] of their need for instructional accommodations by the end of the third week of the semester, or as soon as possible after a disability has been incurred or recognized. Faculty [I], will work either directly with the student [you] or in coordination with the McBurney Center to identify and provide reasonable instructional accommodations. Disability information, including instructional accommodations as part of a student's educational record, is confidential and protected under FERPA." http://mcburney.wisc.edu/facstaffother/faculty/syllabus.php

DIVERSITY & INCLUSION

Institutional statement on diversity: "Diversity is a source of strength, creativity, and innovation for UW-Madison. We value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals.

The University of Wisconsin-Madison fulfills its public mission by creating a welcoming and inclusive community for people from every background – people who as students, faculty, and staff serve Wisconsin and the world." https://diversity.wisc.edu/

CHEM 109-3 Honors Course Schedule Fall 2018

Week 1	3 Sep - 9 Sep	Topic	Laboratory	Assignments
		Energy Concepts and Demand (Chapter 1)	Labs will not meet Week 1	Read Chapter 1 (1.1 - 1.30)
	Wed 5 Sep	1. Population growth, energy, and power		Register Top Hat
	Fri 7 Sep	2: Energy scales and Newton's Laws		Practice Quiz (to test your computer - no points)
Week 2	**10 Sep - 16 Sep**	**Topic**	**Laboratory**	**Assignments**
	Mon 10 Sep	3: Light and blackbody radiation	Orientation, Check-in	Read Chapter 1 (1.30-1.62)
		Thermodynamics and the First Law (Chapter 3)	Online Safety Quiz	Review Chapter 2 (as needed)
	Wed 12 Sep	4: Radiative energy transfer		**Quiz Week 2** (Chapter 1, due 8 am, Monday 10 Sep)
	Fri 14 Sep	5: Heat, work, internal energy	Academic Integrity Quiz	**Problem Set 1** (due end of class, Friday, 14 Sep)
Week 3	**17 Sep - 23 Sep**	**Topic**	**Laboratory**	**Assignments**
	Mon 17 Sep	6. Enthalpy of reaction, enthalpy, calorimetry	Solution Calorimetry	Read Chapter 3
	Wed 19 Sep	7: Isochoric, isobaric processes		**Quiz Week 3** (Chapter 3, due 8 am Monday, 17 Sep)
	Fri 21 Sep	8: Isothermal, adiabatic processes		**Problem Set 2** (due end of class, Friday 21 Sep)

Week 4	24 Sep - 30 Sep	Topic	Laboratory	Assignments
	Mon 24 Sep	9: Carnot cycle and engine efficiency	Heat and Light	Read Chapter 4
		Energy, Spontaneity, Second Law (Chapter 4)		No quiz
	Wed 26 Sep	10: Probability and entropy		No problem set
	Thu 27 Sep	**Exam 1 - 7:15 pm**		
	Fri 28 Sep	11: Spontaneous change and Second Law		
Week 5	**1 Oct - 7 Oct**	**Topic**	**Laboratory**	**Assignments**
	Mon 1 Oct	12: Gibbs free energy, Third Law	Capturing Light	Read Chapter 5
		Equilibrium and Free Energy (Chapter 5)		**Quiz Week 5** (Chapter 4, due 8 am, Monday, 1 Oct)
	Wed 3 Oct	13: Equilibrium, equilibrium constants		
	Fri 5 Oct	14: Reaction quotient, Le Chatelier's principle		**Problem Set 3** (due end of class, Friday, 5 Oct)
Week 6	**8 Oct - 14 Oct**	**Topic**	**Laboratory**	**Assignments**
	Mon 8 Oct	15: Gibbs free energy and equilibrium contants	Equilibrium and Le Chatelier	Read Chapter 6
		Solution Equilibrium (Chapter 6)		**Quiz Week 6** (Chapters 5 & 6, due 8 am, Monday 8 Oct)
	Wed 10 Oct	16: Weak acids and bases		
	Fri 12 Oct	17: Polyprotic acids, buffers		**Problem Set 4** (due end of class, Friday, 12 Oct)
Week 7	**15 Oct - 21 Oct**	**Topic**	**Laboratory**	**Assignments**

		Electrochemistry (Chapter 7)	Thermodynamics of Ligand Substitution	Read Chapter 7
	Mon 15 Oct	18: Oxidation-reduction , half reactions		**Quiz Week 7** (Chapter 7, due 8 am, Monday, 15 Oct)
	Wed 17 Oct	19: Free energy, cell potentials		
	Fri 19 Oct	20: Nernst equation and equilibrium constants		**Problem Set 5** (due end of class, Friday, 19 Oct)
Week 8	**22 Oct - 28 Oct**	**Topic**	**Laboratory**	**Assignments**
		Quantum Mechanics, One-electron Atoms (Chapter 8)	Titrations	Read Chapter 8
	Mon 22 Oct	21: Blackbody radiation, photoelectric effect		No quiz
	Wed 24 Oct	22: Emission spectra, Bohr atom		No problem set
	Thu 25 Oct	**Exam 2 - 7:15 pm**		
	Fri 26 Oct	23: Wave mechanics		
Week 9	**29 Oct - 4 Nov**	**Topic**	**Laboratory**	**Assignments**
	Mon 29 Oct	24: Probability in quantum mechanics	Electrochemical Cells	Read Chapter 9
	Wed 31 Oct	25: Particle-in-a-box, Schrödinger equation		**Quiz Week 9** (Chapter 9, due 8 am, Monday, 29 Oct)
	Fri 2 Nov	26: One-electron atoms		**Problem Set 6** (due end of class, Friday, 2 Nov)
Week 10	**5 Nov - 11 Nov**	**Topic**	**Laboratory**	**Assignments**
		Multielectron Atoms (Chapter 9)	Emission Spectroscopy	Read Chapter 10
	Mon 5 Nov	27: Multielectron atoms		

	Wed 7 Nov	28: Aufbau principle, periodic trends		**Quiz Week 10** (Chapter 10, due 8 am, Monday, 5 Nov)
	Fri 9 Nov	29: Electron sharing and polarity		**Problem Set 7** (due end of class, Friday, 9 Nov)
Week 11	**12 Nov - 18 Nov**	**Topic**	**Laboratory**	**Assignments**
	Mon 12 Nov	30: Molecular shapes, VSEPR	Molecular Structures	Read Chapter 11
		Quantum Descriptions of Bonding (Chapter 10)		**Quiz Week 11** (Chapter 11 pt 1, due 8 am, Monday, 12 Nov)
	Wed 14 Nov	31: Valence Bond Theory and Hybridization		
	Fri 16 Nov	32: Molecular orbitals		**Problem Set 8** (due end of class, Fri, 16 Nov)
Week 12	**19 Nov - 25 Nov**	**Topic**	**Laboratory**	**Assignments**
	Mon 19 Nov	33: Orbital energies, bond strengths	No lab	**Quiz Week 12** (Chapter 11 pt 2, due 8 am, Monday, 19 Nov)
	Wed 21 Nov	34: Electronic excitation		
	Fri 23 Nov	No class (Thanksgiving)		**Problem Set 9** **(due end of class, Wed, 21 Nov)**
Week 13	**26 Nov - 2 Dec**	**Topic**	**Laboratory**	**Assignments**
	Mon 26 Nov	35: Potential energy curves	Kinetics of Crystal Violet	Read Chapter 12
	Wed 28 Nov	36: Vibrations, infrared excitation		No quiz
	Thu 29 Nov	**Exam 3 - 7:15 pm**		No problem set
		Kinetics (Chapter 12)		
	Fri 30 Nov	37: Rates of reactions		

Week 14	3 Dec - 9 Dec	Topic	Laboratory	Assignments
	Mon 3 Dec	38: Rate expressions, integrated expressions	Neutron Activation of Silver	**Quiz Week 14** (Chapter 12, due 8 am, Monday, 3 Dec)
	Wed 5 Dec	39: Activation energy, reaction profiles		
	Fri 7 Dec	40: Elementary reactions, mechanisms		**Problem Set 10** (due end of class, Friday, 7 Dec)
Week 15	**10 Dec - 14 Dec**	**Topic**	**Laboratory**	**Assignments**
		Nuclear Chemistry (Chapter 13)	No lab	No quiz
	Mon 10 Dec	41: Binding energy, fission		No problem set
	Wed 12 Dec	42: Exam 4 (In Class)		