Chemistry 109-3 Honors (5 credits)
Advanced General Chemistry – Fall 2016

Instructor: Professor Randall Goldsmith
Lecture 3: MWF 8:50 to 9:40
Discussion: Thursday; various times
Lab: 3 hours per week; various times

Honors designation: All students earn honors credit. (!, HOP)
Prerequisites: Placement into Math 221 or higher; ACT Math ≥ 30; 2 years of high school chemistry, including AP Chem is required. At least one year of high school physics is recommended.

Chemistry 109 Honors (Lecture 3) 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 is important. Students should have credit for or be concurrently enrolled in first-semester calculus, Math 221.

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 topics planned for the course are:

- Thermodynamics
- Equilibrium and Free Energy
- Equilibrium in Solution
- Electrochemistry
- Quantum Mechanics, Light and the Structure of Atoms
- Molecular Structure and Bonding
- Photochemistry
- Chemical Kinetics
- Nuclear Chemistry

The course will move at a fast pace to cover these topics in one semester and the presentation assumes a good familiarity with the language of chemistry and chemical calculations. There will be resources for individual review, but the elementary topics are not part of the coverage in class or discussion. The course will use a preprint of a textbook titled *University Chemistry: in the Context of Global Energy and Climate Change* that is in the late stages of development by Professor James G Anderson of Harvard University.

The course begins with a discussion of energy and moves quickly 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 ion 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.

Students who are interested in enrolling in the honors section of Chemistry 109 will need special permission. If at SOAR, see the Chemistry Consultant. If not at SOAR, please send an email to Nora Burnham (nburnham@wisc.edu) that includes your full name and student ID number.

CHEM 109-H Schedule Goldsmith Fall 2016

Week 1

7 Sep - 9 Sep	Topic	Laboratory
Wed 7 Sep	**Energy Concepts and Demand (Chapter 1)**	Labs will not meet Week 1
Fri 9 Sep	1: Population growth, energy, and power	
	2: Energy scales and Newton's Laws	

Week 2

12 Sep - 16 Sep	Topic	Laboratory
Mon 12 Sep	3: Light and blackbody radiation	Orientation, Check-in
	Thermodynamics and the First Law (Chapter 3)	Online Safety Quiz
Wed 14 Sep	4: Radiative energy transfer	Academic Integrity Quiz
Fri 16 Sep	5: Heat, work, internal energy	

Week 3

19 Sep - 23 Sep	Topic	Laboratory
Mon 19 Sep	6: Enthalpy of reaction, enthalpy, calorimetry	Solution calorimetry
Wed 21 Sep	7: Isochoric, isobaric processes	
Fri 23 Sep	8: Isothermal, adiabatic processes	

Week 4

26 Sep - 30 Sep	Topic	Laboratory
Mon 26 Sep	9: Carnot cycle and engine efficiency	Synthesis of Biodiesel Fuel
	Energy, Spontaneity, Second Law (Chapter 4)	
Wed 28 Sep	10: Probability and entropy	
Thu 29 Sep	**Exam 1 - 7.15 pm - Room 1361 Chemistry**	
Fri 30 Sep	11: Spontaneous change and Second Law	

Week 5

3 Oct - 7 Oct	Topic	Laboratory
Mon 3 Oct	12: Gibbs free energy, Third Law	Heat and Light
	Equilibrium and Free Energy (Chapter 5)	
Wed 5 Oct	13: Equilibrium, Equilibrium constants	
Fri 7 Oct	14: Reaction quotient, LeChatelier's principle	

Week 6

10 Oct - 14 Oct	Topic	Laboratory
Mon 10 Oct	15: Gibbs free energy and equilibrium constants	Equilibrium and LeChatelier
	Solution Equilibrium (Chapter 6)	
Wed 12 Oct	16: Weak acids and bases	
Fri 14 Oct	17: Polyprotic acids, buffers	

Week 7

17 Oct - 21 Oct	Topic	Laboratory
	Electrochemistry (Chapter 7)	Thermodynamics of Ligand Substitution
Mon 17 Oct	18: Oxidation-Reduction, Half reactions	
Wed 19 Oct	19: Free energy, Cell potentials	
Fri 21 Oct	20: Nernst equation and equilbrium constants	

Week 8

24 Oct - 28 Oct	Topic	Laboratory
	Quantum Mechanics, One-Electron Atoms (Chapter 8)	Titrations
Mon 24 Oct	21: Blackbody radiation, Photoelectric effect	
Wed 26 Oct	22: Emission spectra, Bohr atom	
Thu 27 Oct	**Exam 2 - 7.15 pm - Room 1361 Chemistry**	
Fri 28 Oct	23: Wave mechanics	

Week 9

31 Oct - 4 Nov	Topic	Laboratory
Mon 31 Oct	24: Probability in quantum mechanics	Electrochemical cells
Wed 2 Nov	25: Particle-in-a-box, Schrödinger equation	
Fri 4 Nov	26: One-electron atoms	

Week 10

7 Nov - 11 Nov	Topic	Laboratory
	Multielectron Atoms (Chapter 9)	
Mon 7 Nov	27: Multielectron atoms	Emission spectroscopy
Wed 9 Nov	28: Aufbau, Periodic trends	
Fri 11 Nov	29: Electron sharing and polarity	

Week 11

14 Nov - 18 Nov	Topic	Laboratory
Mon 14 Nov	30: Molecular Shapes, VSEPR	Molecular Structures
	Quantum Description of Bonding (Chapter 10)	
Wed 16 Nov	31: Valence Bond Theory and Hybridization	
Fri 18 Nov	32: Molecular orbitals	

Week 12

21 Nov - 25 Nov	Topic	Laboratory
Mon 21 Nov	33. Orbital Energies, Bond Strengths	No lab
Wed 23 Nov	34: Electronic Excitation	
Fri 25 Nov	No class (Thanksgiving)	

Week 13

28 Nov - 2 Dec	Topic	Laboratory
Mon 28 Nov	35: Potential energy curves	Capturing Light
Wed 30 Nov	36: Vibrations, Infrared excitation	
Thu 1 Dec	**Exam 3 - 7.15 pm - Room 1361 Chemistry**	

Fri 2 Dec	**Kinetics (Chapter 12)** 37: Rates of reactions	

Week 14

5 Dec - 9 Dec	Topic	Laboratory
Mon 5 Dec Wed 7 Dec Fri 9 Dec	38: Rate expressions, Integrated expressions 39: Activation energy, Reaction profiles 40: Elementary reactions, Mechanisms	Kinetics of crystal violet

Week 15

12 Dec - 14 Dec	Topic	Laboratory
	Nuclear Chemistry (Chapter 13)	Neutron activation of silver
Mon 12 Dec	41: Binding energy, Fission	
Wed 14 Dec	42: Fusion, Radioactivity	

Week 16

19 Dec - 23 Dec	Topic	Laboratory
Friday 23 Dec	**Final Exam, 2:45 pm - 4:45 pm** Room TBA	