Chem. 0330, Spring 2015: Equilibrium, Rate, and Structure

Content: Electronic structure of atoms and molecules, thermodynamics, solution equilibrium, electrochemistry, chemical kinetics, and reaction mechanisms. Three hours of lecture and five hours of pre-laboratory and laboratory per week.

Professor: Christoph Rose-Petruck, GeoChem 245, Christoph_Rose-Petruck@brown.edu

C. Rose-Petruck's office hours: Tue, 1:00 PM- 2:00 PM; W 1:00 PM- 2:00 PM, Geochem 245

Textbook used: "Chemical Principles", S. S. Zumdahl, Books/Cole, 6th edition or later

Lecture hours: Tue, Th 10:30-11:50, McMillan 117

1st Midterm: Friday, March 5, 10:30AM, 2015, MacMillan 117

2nd Midterm: Monday, April 7, 10:30AM, 2015, MacMillan 117

Final: December: Friday, May 14, 2PM – 5PM**For all exams:**

Students should bring calculators to each exam We will supply periodic tables, the values of any necessary constants, and a formula sheet.

The final grade will be assigned based on a weighted sum of the points from the hour exams, the final, the homework, and the laboratory:

1st Midterm	20 %
2nd Midterm	20 %
Final exam	30 %
Homework	10 %
Laboratory	20 %

On-line homework assignment: One problem set every 1 week. All homework assignments are completed and submitted on-line in Sapling Learning. Here are the sign-up instructions for students:

1. Go to http://saplinglearning.com and click on your country at the top right.

2a. If you already have a Sapling Learning account, log in and skip to step 3.

2b. If you have a Facebook account, you can use it to quickly create a Sapling Learning account. Click "Create an Account", then "Create my account through Facebook". You will be prompted to log into Facebook if you aren't already. Choose a username and password, and then click "Link Account". You can then skip to step 3.

2c. Otherwise, click "Create an Account". Supply the requested information and click "Create My Account". Check your email (and spam filter) for a message from Sapling Learning and click on the link provided in that email.

3. Find your course in the list (you may need to expand the subject and term categories) and click the link.

4. Select a payment option and following the remaining instructions.

Once you have registered and enrolled, you can log in at any time to complete or review your homework assignments. During sign up or throughout the term, if you have any technical problems or grading issues, send an email to support@saplinglearning.com explaining the issue. The Sapling Learning support team is almost always faster and better able to resolve issues than your instructor.

A Canvas-website exists for this class. It is used to publish helpful information as well as all lecture grades. Students who have registered for this course will automatically find a link to this site on Canvas.

Chem. 0330, Fall 2015

	Subject	Chapters in Textbook, 6th edition	Learning goals Major learning goals, understand the listed topics and be proficient using the concepts, i.e. apply the concepts to problems and practice, practice, practice, ….	Lecture dates Dates may shift slightly	Problem sets: Set # On-line	Problem sets: Due date Submit until 5PM.
	Lecture					
1	**Introduction**		Get to know the course			
1.1	Stoichiometry	Chapter 3	Mole; Atomic and molecular mass, Balancing of chemical equations, Limiting reagents, Calculate mass of reactants and products; chem. equations and chem. equilibrium	22-Jan		
1.2	Solution, strong and weak electrolytes	Sections 4.1 - 4.8	Structure of aqueous solutions; Solvation of ions in water; Identifying all ions and their approx. concentrations in solution; Precipitation of reaction products	27-Jan	1	3-Feb
		Section 4.9	Basic definition of acids and bases; Identification of all ions and their approx. concentrations; Molecular structure of acids and bases			
2	**Thermodynamics, the foundation of chemistry**					
2.1	The first law of thermodynamics	Chapter 9	What is energy; System and surroundings; Internal energy U (or E); State of a system; Definition and measurements of heat capacities, Enthalpy H; Difference between U and H; Bond energies and bond enthalpies; A simple but useful example system: The ideal gas	29-Jan		
			When to use U when H; Hess law; Standard states and standard enthalpy; read section 9.7 because its interesting			
2.2	The second law of thermodynamics	Sections 10.1 - 10.7	Definition of entropy S, Relation of S to heat flow, order/disorder, and probability of finding system in a specific state; Volume, pressure, and temperature dependence of S	3-Feb	2	10-Feb
			What "drives" a process: energy changes or disorder increase of the universe?; 3rd-law entropies; C hanges during chemical reactions; Standard reaction entropies, Gibbs Free energy G; Is ΔG (change of G) of a system equivalent to the entropy change of the universe?; Reversible and irreversible processes			
2.3	Thermodynamics in chemistry	Sections 10.8 - 10.14	ΔG for chemical reactions and phase transitions; G of formation and ΔG of reaction	5-Feb		
			Effects of temperature and pressure conditions and changes on ΔG; why is G called "free energy"?; isothermal and adiabatic processes			
3	**Chemical reactions and equilibria**					
3.1	Chemical equilibrium, equilibrium constants	Chapter 6	ΔG and equilibrium constants K; Standard state G and activities; Equilibrium constants and chemical composition; Reaction quotient Q; Calculations of chemical compositions (concentrations) for reactions in equilibrium	10-Feb	3	17-Feb
3.2	Solubility equilibrium and complex-ion equilibria	Sections 8.8 - 8.10	Precipitation and solubility products; Common ion effect - measurement of the ion concentration of a sample solution by precipitation; Ion extraction from solutions; Complex-ions, Formation constants;			
3.3	Acids and Bases	Sections 7.1 - 7.6, 7.8, 7.11	Strength of acids and bases; Equilibrium constants K_a for acid dissociation; Autodissociation of water and K_w; pH, pOH, pK_a pK_b scales;	12-Feb	4	24-Feb
			Strong and weak acidic and basic solutions; Identification of the dominant ions in solution; Calculation of pH of weak acidic solutions;	19-Feb		
			Calculation of weak basic solutions; When do we consider the contributions of water ions to the acidity or alkalinity of the solutions?	24-Feb	5	3-Mar
			Calculation of pH and pOH of salt solutions;			
			~~Which ions are present in a buffer solutions?; Calculation of the pH for a buffer; Buffer capacity;~~	26-Feb		
3.4	Titrations and Buffers	Sections 8.1 - 8.6	Titration curves for strong and weak acids - how do they differ?; Typical ion concentrations at the equivalence point, halfway point, end points, and in the buffer region; Determination of ion concentrations in samples from titration curves; Determination of K_a or K_b for unknown substances;	3-Mar		
	1st Midterm, March 5, our usual time and lecture room MacMillan 117					
3.5	Polyprotic acids, bases, and their buffers	Sections 7.7, 8.7	Identification of all ions in solution; Which ions are important?; Calculation of pH of acidic solutions;	10-Mar	6	17-Mar
			Theoretical calculations of titration curves - which are the dominant ions at various stages?			
3.6	Redox reactions	Sections 4.10 - 4.12, 11.1 - 11.6	Determinations of K_a values;	12-Mar		
			Assignment of oxidation numbers; Identification of the oxidized and reduced species; Balancing redox reactions by half-reaction method;			
			Galvanic cells; Standard reduction potential; Calculation of the voltage of a battery	17-Mar	7	31-Mar
			Nernst equation; Concentration cells; How does a pH-meter work? Measure a voltage and calculate K			
4	**Chemical kinetics**					
4.1	Rate laws	Chapter 15	Measurements of reaction rates; Differential rate laws;	19-Mar		
			Integrated rate laws; Graphical methods for determination of rate laws;	31-Mar	8	6-Apr
4.2	Transition state theory		Steady-state approximation; Transition state theory and catalysis			
5	**Quantum Mechanics**					
5.1	Principles of quantum mechanics	Chapter 12	Particle-wave dualism; Probability density; Heisenberg uncertainty principle; de Broigle wavelength	2-Apr		
	2nd Midterm, April 7, our usual time and lecture room MacMillan 117					
5.1	Structure of atoms and atomic orbitals		Quantum numbers; ψ_i^2 = i-th orbital - where is the i-th electrons in the atom? Rhydberg formula and the spectroscopy of hydrogen; Ground state and its energy; Excited states; Ionization energy; Shapes of orbitals	9-Apr	9	16-Apr
5.2	The Periodic Table, and atomic orbital		Energetic order of atomic orbitals; "Aufbau" (construction) principle, Pauli exclusion principle, Hund's rule; electron configuration of atoms;	14-Apr		
6	**Chemical bonding, structure of molecules**					
6.1	General concepts of bonding	Sections 13.1 - 13.8	Interatomic forces; Electrostatic forces; Electronegativities, Bond polarity, and ionic bonds; Bonding described by quantum mechanics - covalent bonds; A2	16-Apr	10	23-Apr
6.2	Structure of molecules	Sections 13.9 - 13.13	Lewis structures; VESPER-model; Steric numbers; Resonance structures; Octet rule and exceptions;	21-Apr		
6.2	Molecular orbitals	Sections 14.1 - 14.6	Hybridization: sp, sp^2, sp^3, dsp^3, d^2sp^3; Molecular orbitals as superposition of atomic orbitals and hybrid orbitals	23-Apr		
6.3			σ, σ*, π, π* -bonds; Shape and spatial orientation or molecular orbitals; Predicting molecular structure from molecular orbitals;	Time permitting		
7	**Reading Period**					
	I will answer whichever question you might have. This session is entirely voluntary. I will be in the lecture hall but if you have no questions, there is no need to come.			28-Apr		
				30-Apr		
	May 14, 2 PM, Room: TBA					

Chem. 0330 Laboratory

Instructor: Professor Li-Qiong Wang
Email: Li_Qiong_Wang@brown.edu
Office: GeoChem 337

Pre-lab: M, Tu, 12:00-12:50 pm
MacMillan 115
The first Pre-lab: Feb. 2 or 3
(You can attend any one of the prelabs (also called conferences) on or before your lab day and don't need to change your registration on banner*). The prelab is given to help you to do the experiment in the same week)*

Labs: M W (1:00 -4:50 pm; 2:00 – 5:50 pm)

Tu Th (1:00 – 4:50 pm; 2:30 -6:20 pm)
MacMillan 201, 205
(*Lab Room Assignments will be posted on the window outside the MacMillan 205)*

Lab Manual: Online manual are posted on Canvas "CHEM0330L Spring15 Equilibrium, Rate, and Structure Lab" *(You are responsible for printing out the lab procedures for you to bring to the lab)*

Lab Report: Lab reports are posted on Canvas "CHEM0330L Spring 15 Equilibrium, Rate, and Structure Lab" (You can either type or write by hand your answers in your report. Please keep the original written questions in your report)

Rescheduling labs: Please email Ms. Keenan at kim_keenan@brown.edu for permission. In order for the request to be considered, in the email you need to write the reason for the rescheduled laboratory, your original lab section, TA's name and your preferred lab section for the rescheduling. Please understand that rescheduling to study for exams, write papers, or because you are unprepared for lab are not acceptable reasons.

All students must have the following items:
I-clicker (**register your i-clicker on canvas)**; Safety goggles (Brown book Store); Plastic apron (Brown book Store); Print-outs of the online lab procedures (double sided printing to save paper); 1 Laboratory notebook (must produce copies); USB flash drive; Black permanent marker

Notes: The i-clicker participation in prelab lectures will count 3% of the lab grade. Please attend to your assigned lab section from the banner. Unfortunately, we don't give any overrides for the lab sections since all available lab spots are given through the online registration. If you don't have the right lab section before the lab starts, please continue to attend the lectures and monitor the banner. In most cases, the right lab section will be available for you.

Chem. 0330 Laboratory Schedule

Dates	✓ ***Lab manuals are posted on Canvas*** **"CHEM0330L Spring13 Equilibrium, Rate, and Structure Lab."** ***Weekly assignments are available before every Thursday 5:00 pm.***	***Pre-lab Lecture*** *M,Tu*	***Assignment Due***
February 2-5	Read the *Introduction and Lab Safety* on Canvas	yes	------
February 9-12	Check-in, Experiment 1 *How can eleven colorless solutions be chemically identified?*	yes	Pre-laboratory Questions for Expt. 1
February 16-19	Break	No	Break
February 23 –26	Experiment 2 *How is Acid Rain Neutralized in Nature?*	yes	Experiment 1 Report
March 2-5	Experiment 3 *How Can Thermodynamic Values be Determined from Solubility of a Salt?*	yes	Experiment 2 Report
March 9-12	Experiment 4 *What are the Factors Controlling the Equilibrium of Cobalt Complex Ions*	yes	Experiment 3 Report
March 16-19	Experiment 5 *What Chemical Species Control the pH of Solutions?*	yes	Experiment 4 Report
March 23-26	Spring Break	No	Spring Break
March 30-April 2	Experiment 6 *How Can We Use a Hydrogen Fuel Cell to Generate Clean Energy and Connect Chemistry to the Real World?*	yes	Experiment 5 Report
April 6-10	No prelab/lab (2^{nd} Mid-term)	No	None
April 13-16	Experiment 7 *How Do Certain Factors Affect the Rate of a Chemical Reaction?*	Yes	Experiment 6 Report
April 21 Only	Make-Up Lab (only for students who miss one of the regular labs with legitimate reasons)	April 20 Only	Experiment 7 Reports
April 27-30	Experiment 8: Lab Activity (3D Modeling of Molecular Structures) Lab Notebook Evaluation, Work-Station Cleaning & Check-out	No	No regular labs, *Only make-up prelab/lab (12:00-4:50 pm in MacMillan 205)*

Chem. 0330 Problem-Solving Sessions

Dr. Suzanne Rudnicki (email: suzanne_rudnicki@brown.edu) Office: GeoChem 329

Dr. Rudnicki will be available to students in Prof. Rose-Petruck section who are seeking extra help in problem solving or in understanding the lecture materials. It is suggested (and beneficial for students) to begin seeking extra help BEFORE the first exam.

She will be holding Open Office Hours: Wednesday 1:00pm – 3:00pm, Tuesday and Thursday 2:30pm – 4:00pm.

Students who are unable to meet during Open Office Hours may also schedule an appointment throughout the week. Dr. Rudnicki is also available to meet in the mornings before class. Students who wish to meet in the mornings may schedule an appointment Monday through Friday from 8:00am – 9:30am. In addition, as the semester progresses (and based on student need and interest) weekend review sessions will be scheduled.

This semester there will also be weekly Problem-Solving Sessions beginning on Monday, February 2, 2015. These Problem-Solving Sessions will take the form of small group problem solving whereby students will work on problems cooperatively with the aid of facilitators. The problems will reinforce the concepts covered in lecture.

There will be three Problem-Solving Sessions offered at the following times:

11:30am-1:00pm
2:30pm-4:00pm
4:00pm-5:30pm

Students who are interested in signing up for a review session are encouraged to do so as soon as possible as space is limited and it is expected that spaces will fill up quickly. Sign-ups for the Problem-Solving Session will begin after the first week of classes.