University of California Merced: Fall 2017 08/22/17
ENVE/ESS 100: Environmental Chemistry

Course Description: This course is an upper division survey of basic concepts, principles, and applications of environmental chemistry for students in Environmental Engineering, Earth Systems Science, Chemical and Biological Sciences, and related fields. The goal of the course is to examine the role of chemistry in environmental systems and to employ basic principles of thermodynamics, kinetics, chemical bonding, and mass transfer in solving chemical problems related to the Earth and its environment. We will survey a variety of topics involving inorganic and organic chemistry in the environment, including acid-base chemistry, carbonate equilibria, equilibrium aqueous speciation, liquid-gas-aqueous-mineral equilibria, oxidation-reduction, kinetics, and sorption. This course has a strong emphasis on *quantitative problem solving* and the practical application of fundamental physical chemical principles to environmental systems.

Instructor: Martha Conklin (mconklin@ucmerced.edu); office SE 220; tel. 228-4349
Office Hours: Wed 9 am -10 am, Th 11-12 am and by appointment

Laboratory Instructor: Ben Lash (blash@ucmerced.edu)

Class meetings:
Lecture: T Th 1:30-2:45 pm, CLSSRM Room 110
Laboratory: T 10:30-1:20 pm, SE2 Room 130

Course Format: Lecture meets twice weekly for 75 minute periods. Class time will be a combination of lecture, discussion, and in-class problem solving. There can be a short quiz. The laboratory period will be primarily chemistry laboratory exercises and a few field exercises. Problem sets and lab exercises will be assigned weekly.

Course Goals and Learning Outcomes: The ultimate goal in studying environmental chemistry is to understand the chemistry of natural water systems, their response to perturbations and the behavior of pollutants when they are released into these systems. To do so, I will use a multi-disciplinary approach. Our goal is for students to become proficient in:

1. the basic concepts of chemical equilibrium as applied to natural systems;
2. the behavior of organic pollutants in natural water systems, and
3. application of thermodynamic principles and mass balance to solve chemical systems.

Teaching philosophy: Learning without thought is labor lost. ~Confucius

In this course, students will read, attend lectures and laboratories, do in-class exercises, write laboratory reports and do homework. I expect students to come to class primed to discuss the material they have read in preparation for the class, and to come to lab prepared for the weekly exercise. Success in this course will depend on your level of active engagement with course activities and material.

Grading: Letter grade only & no late assignments accepted.
Exams: 50% = 4 total: 3 midterm exams (11%) and a final exam (17%)
Laboratory: 30%
Problem sets: 15%
Class participation: 5% (can include quizzes)

Required Texts:
1. Jensen, J.N. (2003) *Aquatic Chemistry*, John Wiley & Sons.
2. Course Reader for Environmental Chemistry: Available on course website
3. Lab Instructions: Available on course website

Supplemental Reading on Selected Topics: Specific chapters are available on-line
K&B: Krauskopf, K. B., and Bird, D. K. (1995) *Introduction to Geochemistry*, 3rd Ed., McGraw Hill.
Drever: Drever, J. A. (1997) *The Geochemistry of Natural Waters*, 3rd Ed., Prentice Hall.
McBride: McBride, M.B. (1994) *Environmental Chemistry of Soils*, Oxford University Press.
SGI: Schwarzenbach, R.P., Gschwend, P.M., and Imboden, D.M. (2003), *Environmental Organic Chemistry, 2nd Edition*, Wiley-Interscience (e-book)

MINEQL is available in SSM 152.

Accommodations for Students with Disabilities: The University of California Merced is committed to ensuring equal academic opportunities and inclusion for students with disabilities based on the principles of independent living, accessible universal design and diversity. I am available to discuss appropriate academic accommodations that may be required for student with disabilities. Make requests for academic accommodations during the first three weeks of the semester, except for unusual circumstances. Students are encouraged to register with Disability Services Center to verify their eligibility for appropriate accommodations.

Course Requirements:
Prerequisites: General chemistry (2 semesters); calculus (at least one semester).

Expectations: I expect students to have basic knowledge of introductory chemistry, calculus, and some computer literacy. Courses in environmental sciences and engineering, Earth sciences, and engineering principles are helpful but not necessary. Please see me if you have any questions about additional background material on topics in basic chemistry or environmental science and engineering that may be unfamiliar.

Course Policies:
Your attendance at lecture and lab, and your participation in class discussions and exercises, are an important part of this course. You are expected to attend class and to take your own notes, and/or to consult the material posted on the Catcourses site. All graded components (homework, tests, class participation (quizzes) and lab reports) are essential. You will not receive a passing grade in this course if you have not completed a component of the course. For example, let us assume Jane C. did not hand in any homework, but received a 'B' grade or better on tests and labs. Her final grade will be 'F' without any exceptions.

Cheating and plagiarism will be subject to disciplinary action according to University policies. *If you use reference materials (other than the course texts) to solve a problem, you must give a citation.* This includes material from the web. Not doing so is plagiarism (i.e., cheating).

UC Merced Academic dishonesty statement:
a. Each student in this course is expected to abide by the University of California, Merced's Academic Honesty Policy. Any work submitted by a student in this course for academic credit will be the student's own work.
b. You are encouraged to study together and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting" help to or receive "consulting" help from such students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else, in the form of an e mail, an e mail attachment file, a diskette, or a hard copy. Should copying occur, both the student who copied work from another student and the student who gave material to be copied will both automatically receive a zero for the assignment. Penalty for violation of this Policy can also be extended to include failure of the course and University disciplinary action.
c. During examinations, you must do your own work. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

Course Web Site: Course information, including the semester schedule for lectures, reading, handouts, and all assignments and their due dates, is available at the course web site, which you should be able to access through the Catcourses portal: https://catcourses.ucmerced.edu/.

LECTURE & LAB SCHEDULE: ENVIRONMENTAL CHEMISTRY, FALL 2017
Course Schedule Aug 21, 2017[1]

DATE	LECTURE	READING
Module 1: Basic aquatic chemistry, measurement of acid-base buffering capacity, Organic nomenclature		
Week 1:		
8/24	Review of Basic Concepts & Equilibrium Concepts	Ch 1-4
Week 2:		
8/29	Equilibrium Concepts & Thermodynamics	Ch 3-6
8/31	pC-pH diagrams & problem solving	Ch 7,8
LAB 1 Lab Safety/Practices & Statistics		
Week 3:		
9/5	Acid/Base & titrations	Ch 10,11
9/7	Buffering & alkalinity	Ch 12,13
10		
Week 4:		
9/12	Organic Nomenclature	BOC part 1 & Drever Ch 3
9/14	Vapor Pressure	BOC part 2.1
LAB R-1 Test review		
Week 5:		
9/19	Vapor Pressure	BOC part 2.1
9/21	**EXAM 1**	
LAB 3A Water Sampling: Water quality part 1		

Key concepts and learning outcomes for EXAM 1:
Basic concepts of equilibrium chemistry; problem solving using concepts; mass balance
Ability to solve acid/base problems
Ability to draw and interpret pC-pH diagrams
Concept of alkalinity; relationship to carbonate system; alkalinity problem solving
Organic nomenclature

Module 2: Phase partitioning (neutral molecules) & redox reactions		
Week 6:		
9/26	Solubility (liquid-aqueous)	BOC part 2.2
9/28	Solubility (liquid-aqueous) & Phase partitioning	BOC part 2.2-2.4
LAB 3B Water Sampling: Water quality part 2		
Week 7:		

[1] This course schedule may be updated as the semester progresses

10/3	Solubility& Air-Water partitioning	BOC part 2.2-2.4
10/5	Phase partitioning, inorganic	Ch 18

LAB 4 MINEQL (on lab computers)

Week 8:

10/10	Reduction & Oxidation	Ch 16
10/12	Reduction & Oxidation	Ch 16

LAB 5 Dissolved Oxygen

Week 9:

10/17	Environmental Solids	supp.: McBride Ch 2
10/19	Solid-liquid Equil	Ch 19

LAB R-2 Review

Week 10:

10/24	**Mon: EXAM II**	
10/26	Solid-liquid Equil; Non-ideality	Ch 19 & 21

LAB 6 Spectrophotometry: Organic Speciation and acid/base chemistry

Key concepts and learning outcomes for EXAM II -- Cumulative &

Organic Chemistry basics: general composition and structure of organic compounds & ability to name simple organic compounds
Basic concept of vapor pressure for organic liquids and solids; problem solving
Solubility of organic compounds in water; solubility calculations
Basic concepts of equilibrium thermodynamics; problem solving using concepts
Principles of oxidation-reduction reactions; electrochemical half-reactions
Henry's constant and aqueous-gas partitioning for organic compounds and inorganic species; problem solving and interpretation
Laboratory measurements and concepts

Module 3: Solid-liquid equilibrium, non-ideality & kinetics

Week 11:

10/31	Solvent-water partitioning & Natural Organic Matter	supp: Drever Ch 6 BOC parts 3 - 5
11/2	Natural Organic Matter	BOC parts 3 - 5

LAB 7 Spectroscopy: Analysis of Fe(II)

Week 12:

11/7	C-based Sorption	BOC parts 4 & 5
11/9	Sorption & mass fractions	BOC parts 4 & 5

LAB 7 Soil sampling

Week 13:

11/14	Sorption & mass fractions	BOC parts 4 & 5
11/16	Kinetics	Ch 22

LAB 9A Sorption on Activated Carbon

Week 14:

11/21	Kinetics	Ch 22
11/23	No Class (Thanksgiving)	

LAB 9B Sorption on Activated Carbon

Week 15:

11/28	Review
11/30	**EXAM III**

LAB 10 Kinetics: Pollutant Decomposition

Key concepts and learning outcomes for EXAM III: Cumulative &

Redox problems with the Nernst equation; construction and interpretation of Eh-pH diagrams
Familiarity with types of environmental solids
Principles of kinetic theory and application to environmental systems
Familiarity with non-ideality concepts: activity vs concentration
Observation and interpretation of solvent-water partitioning behavior for organic species (particularly octanol-water partitioning)
Solid-aqueous solubility concepts; problem solving of multi-phase equilibria (both organic and inorganic systems)
Familiarity with major types of natural organic matter and its behavior in the environment
Principles of surface sorption and carbon-based sorption; Langmuir and Freundlich isotherms
Understanding of mass fractions; ability to set-up and solve mass fraction sorption problems
Laboratory measurements and concepts

Week 16:

12/5	Bioaccumulation	Schwarzenbach, Ch 10
12/7	Bioaccumulation	
LAB R-3	Review	

12/15 FINAL EXAM: 11:30 – 2:30 pm

The final comprehensive exam will draw on concepts, principles, and problem-solving methods developed throughout the semester. It is important to review the first three exams for the final. Your understanding of non-ideal behavior and problem solving for complex, real-world systems will be tested. The following additional material since Exam III will be incorporated into the final: concepts of bioaccumulation; prediction and interpretation of bioaccumulation behavior.

CONCISE LECTURE & LAB SCHEDULE[2]

Week	Date	Topic	Reading	Lab
1	8/24	Equilibrium concepts	Ch 1-4	
2	8/29	Equilibrium & thermodynamics	Ch 3-6	1 Lab Safety/Practices & Statistics
	8/31	pC-pH diagrams	Ch 7,8	
3	9/5	Acid/Base titrations	Ch 10, 11	2 pH, Buffer Capacity **&** ALK
	9/7	Buffering & Alkalinity	Ch 12, 13	
4	9/12	Organic nomenclature	BOC P1 & Drever Ch 3	Exam 1 review
	9/14	Vapor pressure	BOC 2.1	
5	9/19	Vapor pressure	BOC 2.1	3A Water Sampling
	9/21	EXAM 1		
6	9/26	Solubility (liquid-aqueous)	BOC 2.2	3B Water Sampling
	9/28	Solubility (liquid-aqueous)	BOC 2.2	
7	10/3	Air-water partitioning, organic	BOC 2.4	4 MINEQL
	10/5	Air-water partitioning, inorganic	Ch 18	
8	10/10	Reduction & Oxidation	Ch 16	5 Dissolved Oxygen
	10/12	Reduction & Oxidation	Ch 16	
9	10/17	Environmental solids	McBride, Ch 2	Exam 2 review
	10/19	Solid-liquid equilibrium	Ch 19	
10	10/24	EXAM 2		6 Spectrophotometry: phenol
	10/26	Solid-liquid equil & non-ideality	Ch 19, 21	
11	10/31	Solvent –water partitioning & NOM	Drever Ch 6 & BOC 3-5	7 Spectroscopy: Fe
	11/2	Natural Organic Matter	BOC 3-5	
12	11/7	C-based sorption	BOC 4&5	8 Soil sampling
	11/9	Sorption & mass fractions	BOC 4&5	
13	11/14	Sorption & mass fractions	BOC 4&5	9A Sorption
	11/16	Kinetics	Ch 22	
14	11/21	Kinetics	Ch 22	9B Sorption
	11/23	Thanksgiving		
15	11/28	Review		10 Kinetics
	11/30	Exam 3		
16	12/5	Bioaccumulation	Schwarzenbach, Ch 10	Final exam review
	12/7	Bioaccumulation	Schwarzenbach, Ch 10	
17	12/15	**FINAL EXAM: 11:30 – 2:30 pm**		

[2] This course schedule may be updated as the semester progresses