CEE461L Chemical Principles in Environmental Engineering
CEE561L/ENV542L Environmental Aquatic Chemistry **Fall 2018**

Instructor:
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Office hours: Mondays 2:40-4:45 or by prior arrangement

Teaching Assistant:
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Office hours: Tuesdays 9:30-10:30 or by prior arrangement

Lecture time: Mon and Wed 1:25 – 2:40 pm Location: 216 Hudson Hall

Lab: Section 1 Mondays 3:05-4:20 pm
Section 2 Mondays 4:40 – 5:55pm Location: 024C Hudson Hall

Prerequisites: CHEM 11, 18, 19, 21L, 23L, or 31L, or equivalent university-level general chemistry.

Course description: Fundamentals of chemical equilibria as applied in environmental engineering processes. Chemistry topics include acid-base equilibrium, the carbonate system, metal-ligand coordination, mineral surface interactions, redox reactions, and surface/colloid chemistry. Applied environmental systems include water quality and treatment, soil remediation, and outdoor air pollution.

Learning Objectives:
- Students will learn fundamental principles of aquatic chemistry including acid/base, metal complexation, mineral solubility, oxidation-reduction reactions, and surface chemistry.
- Students will learn to solve chemical equilibria problems in the context of processes in natural and engineered waters
- Students will learn applications of aquatic chemistry principles such as water treatment, nutrient cycling, and pollutant fate in air, water, and soil.
- Students will learn to perform laboratory experiments, collect data, and analyze data.

Course website on Sakai: http://sakai.duke.edu
Solutions for homework problems and exams will be posted here. Electronic copies of class handouts and other items will also be made available here.

Textbook: *one* of the following is recommended
Benjamin, M. Water Chemistry. 1st or 2nd edition. Waveland Press.

Brezonik P.L. and Arnold W.A. Water Chemistry: An Introduction to the Chemistry of Natural and Engineered Aquatic Systems. Oxford. 2011.

Stumm W. and Morgan J.J., Aquatic Chemistry; Chemical equilibria and rates in natural waters. Wiley and Sons, Inc. 1996. (359.9 S934, A656, 1996)

Homework Assignments:

Weekly homework assignments will include quantitative chemistry-related problems and questions related to the week's lab session.

The homework questions will be assigned one week in advance. They should be submitted during the lecture period on the due date. We anticipate that the homework due dates will be Wednesdays (although this may change depending on how the semester progresses).

*** You may discuss the general approach to the problems with classmates, but please work independently on the actual solutions. (See Course Policies for more details)

*** Homework must be **neat** and presented on paper (either hand-written or typed). The problem statement need not be copied. However, your work should be clearly shown. For example, the problem number (e.g., 1a, 1b, 2a, etc.) should be provided with each answer, final answers should be outlined with a box, and graphs should include labels and units on the axes. You must show all your work to receive credit, including all formulas used in excel calculations. Illegible answers will be given zero credit.

*** Late homework can be submitted for up to 50% credit until the answer key has been posted on Sakai. Exceptions to this policy will be made if a prior conflict is known (e.g. if you cannot attend class on the due date) and approval has been received from Dr. Hsu-Kim at least 1 week prior to the homework due date. Extensions will typically be no more than 24 hours.

Exams: Three closed book exams during class on September 26, October 31, and December 5. One sheet of notes will be allowed. These notes will be submitted with your answers after the exam.

Labs: Field and experimental measurements are critical for understanding chemical processes that occur in environmental systems. The laboratory exercises are intended to provide practical and hands-on insights on the chemistry concepts discussed in lecture and homework sets. Ideally the experience in conducting laboratory analyses will help you appreciate the importance and limits of water quality data in your environmental engineering career.

We will have an Introductory lab session and 2 experimental lab sessions that will help you familiarize yourself with water quality concepts of pH buffering and alkalinity. A 4th session will entail computer-based modeling.

Grading: 25% Assignments
25% Exam 1
25% Exam 2
25% Exam 3

(CEE461 and CEE561/ENV542 will have separate grading scales)

Weekly Outline

	Topic	**Reading Assignments**	
		Benjamin[1]	B&A[2]
Aug 27, 29	Introduction; Thermodynamics	Ch. 1, 2, 4	*Ch. 1,2, 3*
Sept. 3, 5	Thermodynamics, Acid/base, **Lab Intro**	Ch. 4, 5	*Ch. 3,4,7*
Sept. 10, 12	Acids/Bases, **Buffers Lab**	Ch. 5, 6, 8	*Ch. 7,8*
Sept. 17, 19	Buffers and titrations	Ch. 5,6, 8	*Ch. 7,8*
Sept 24	Review		
Sept 26	**Exam #1**		
Oct 1, 3	Carbonate system, **Alkalinity Lab**	Ch. 8, 9	*Ch. 8*
Oct. 10	Water-air partitioning	Ch. 9	*Ch. 8*
Oct. 15, 17	Metal-ligand chemistry	Ch. 10	*Ch. 9*
October 22, 24	Mineral phase solubility	Ch. 11	*Ch. 10*
Oct 29	Review		
Oct. 31	**Exam #2**		
Nov. 5	Mineral phase solubility **and Lab**	Ch. 11	*Ch. 10*
Nov. 7, 12, 14	Redox reactions, Redox biogeochemistry	Ch. 12	*Ch. 11*
Nov. 19	Surface chemistry and sorption processes	Ch 13	*Ch. 14*
Nov. 21	*Thanksgiving holiday, no class*		
Nov. 26	Surface chemistry and sorption processes		
Dec. 3	Review		
Dec. 5	**Exam #3**		

Aquatic chemistry books on the reserve shelf at Perkins Library:

1. Benjamin M. Water Chemistry. 2nd Ed. Waveland. 2015.

2. Brezonik P.L. and Arnold W.A. Water Chemistry: An Introduction to the Chemistry of Natural and Engineered Aquatic Systems. Oxford. 2011.

Other books on this subject:
3. Stumm W. and Morgan J.J., Aquatic Chemistry; Chemical equilibria and rates in natural waters. Wiley and Sons, Inc. 1996. (The classic text on the subject; too encyclopedic for a 1 semester course)

4. Morel F and Hering J. Principles and Applications of Aquatic Chemistry. Wiley. 1993. (Another classic; relies on the 'tableau' method for equilibrium calculations)

Course Policies/Requirements

Duke Community Standard (DCS)
(http://www.integrity.duke.edu/standard.html)
> It is my expectation that everyone will abide by the DCS. Violations will be dealt with appropriately and may involve the Undergraduate Conduct Board or your graduate program director.

> The DCS states:
> Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and non- academic endeavors, and to protect and promote a culture of integrity.

> To uphold the Duke Community Standard:
> I will not lie, cheat, or steal in my academic endeavors;
> I will conduct myself honorably in all my endeavors; and
> I will act if the Standard is compromised.

Authorship:
> All work submitted for a grade (e.g., exams, homework, laboratory assignments), unless specifically authorized by me to be a collaborative effort, is expected to be the sole work of the individual whose name appears on it. In particular, there will be occasions when you will collect lab data as a group. Nevertheless, lab data (and the questions associated with that data) are to be analyzed individually.

Assistance:
> Exams are solely an individual effort. No assistance in any form can be provided by fellow students (even for the preparation of your allowed "notes" for the exams).

> The main purpose of the weekly assignments is to help you learn the material, and your success in learning is best fulfilled by first working on these problems individually. However, sometimes you may encounter difficulties that cannot be surmounted on your own. In this case, you are permitted to ask clarifying questions to your peers, and you are permitted to provide assistance to your peers in this manner.

> Appropriate examples: "Can ideal conditions be assumed in solving this problem?"; "What is the difference between ΔG_r and ΔG^o_r"?; "Look at this example problem covered during class lecture".

> Inappropriate questions: "How did you do this problem?"; "What did you get for an answer to Problem 3?". Please do not put your classmates in an awkward position by asking such open-ended questions.

Attendance:
> You are responsible for everything covered in lectures and lab. Much of this material is covered in the course textbook, but not all of it. The textbook is recommended, though not required, and is primarily intended as supporting materials for the lectures. As such, the course lectures are self-contained and, thus, it is extremely important to attend all lectures.

> Attendance at and participation in lab is a prerequisite for submitting the corresponding laboratory data. When you submit data from a lab activity, you are representing that you participated in the collection of the data therein. Receiving lab data or submitting solutions for a lab assignment which you did not attend in its entirety constitutes falsification of data and is academic misconduct. Providing raw lab data to someone who was not present at the lab is also academic misconduct. Under no circumstances can processed data (any data generated by calculations on raw data) be shared.