

**CEE461L Chemical Processes in Environmental Engineering
CEE561L/ENV542L Environmental Aquatic Chemistry**

Fall 2014

Instructor:

Prof. Heileen (Helen) Hsu-Kim
127A Hudson Hall

660-5109 hsukim@duke.edu

Office hours: Mondays and Wednesdays 2:40-4:00 or by prior arrangement

Teaching Assistant:

Sarah Diring

sarah.diring@duke.edu

Office Hr: Tuesdays 3:00-4:00, 053 Hudson Hall (Annex basement)

Lecture time: Mon and Wed 1:25 – 2:40 pm Location: 2102 Env Hall

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

Prerequisites: CHEM 18, CHEM 19, CHEM 21L , CHEM 31L, or CHEM 43L 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, and oxidation-reduction reactions.
- 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).

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.

*** 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.

Midterm Exams: Two closed book exams during class on Wednesday, September 24 and November 5. One sheet of notes will be allowed. These notes will be submitted with your answers after the exam.

Final exam: time and date to be determined.

3 hour written exam. Two sheets 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. 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 2 lab sessions that will help you familiarize yourself with water quality concepts of pH buffering and alkalinity.

Grading: 15% Assignments
25% Midterm Exam 1
25% Midterm Exam 2
35% Final exam

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

Weekly Outline

	<u>Topic</u>	Reading Assignments	
		<u>Benjamin⁽¹⁾</u>	<u>B&A⁽²⁾</u>
Aug 25, 27	Introduction; Thermodynamics	Ch. 1, 2	<i>Ch. 1,2, 3</i>
Sept. 1, 3	Thermodynamics & Acid/base equilibria	Ch. 2, 3	<i>Ch. 3,4,7</i>
Sept. 8, 10	Acids/Bases, Buffers, Lab Orientation	Ch. 4, 5	<i>Ch. 7,8</i>
Sept. 15, 17	Buffers and titrations, Buffers Lab		
Sept 22	Review		
Sept 24	Exam #1		
Sept. 29, Oct 1	Carbonate system, Alkalinity	Ch. 5	<i>Ch. 8</i>
Oct. 6, 8	Water-air partitioning, Alkalinity Lab	Ch. 5, 7	<i>Ch. 8</i>
Oct. 15	Metal-ligand chemistry	Ch. 8	<i>Ch. 9</i>
Oct. 20, 22	Metal-ligand chemistry	Ch. 8	<i>Ch. 9</i>
Oct 27, 29	Mineral phase solubility	Ch. 8	<i>Ch. 10</i>
Nov. 3	Review		
Nov. 5	Exam #2		
Nov 10, 12	Redox reactions	Ch. 9	<i>Ch. 11</i>
Nov. 17, 19	Redox Biogeochemistry	Ch. 9	<i>Ch. 11</i>
Nov. 24	Surface chemistry and sorption processes	Ch 10	<i>Ch. 14</i>
<i>Nov. 26</i>	<i>Thanksgiving holiday, no class</i>		
Dec 1, 3	Water treatment, Summary and Review		<i>Ch. 13</i>
Final Exam, date/time TBD			

Aquatic chemistry books on overnight reserve at Perkins Library:

1. Benjamin M. Water Chemistry. 1st Ed. McGraw Hill. (551.460154 B468, M324, 2002)
2. Brezonik P.L. and Arnold W.A. Water Chemistry: An Introduction to the Chemistry of Natural and Engineered Aquatic Systems. Oxford. 2011.
3. 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)

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^0_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.