CEE/ENV666 Aquatic Geochemistry **Spring 2017**

Instructor:
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127A Hudson Hall
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Office hours: By appointment

Class Lecture time: Monday/Wednesday 10:05 am – 11:20 am
Location: 201 Hudson Hall

Bulletin description: Geochemistry of the water-solid interface of soils and particles in environmental systems. Topics will cover the chemical composition of soils, geochemical speciation, mineral weathering and stability, sorption and ion exchange, soil redox processes, and chemical kinetics at environmental surfaces.

Objectives: This course will cover chemical reactions and pathways occurring at the soil-water interface. Interfacial phenomena are important for environmental chemical processes, whether they involve sorption of ions to flocculates during water treatment or soil weathering processes that govern the global distribution of elements. Students will learn geochemical theory, with emphasis on reactions at the molecular-scale. We will utilize chemical equilibria and kinetics to quantitatively assess reactivity and chemical speciation in soils and at the particle-water interface. Throughout the course we will consider examples relevant to students in earth and environmental engineering sciences.

Prerequisites: CEE461L/561L or ENV542L or permission of instructor
Students should have completed at least one course that covered environmental chemistry in quantitative manner or had a previous degree in chemistry. See the list of example background questions.

Course website: 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: Sposito, G. “Chemistry of Soils” (2016). Oxford University Press.

Alternate Textbook: Essington, M.E. “Soil and Water Chemistry; An Integrative Approach” (2004). CRC Press. (Same topics covered, but with more details & more pictures.)

Homework Assignments:
Approximately 4-5 homework sets will be assigned during the semester. These assignments will incorporate lecture materials into quantitative problems related to soil composition and chemical speciation. One assignment will entail SMIF-based exploration and short presentation of your results in class.

Exams: Two take-home exams. Handed out in late February and late April with 1 week deadlines.

Grading: 50% Assignments
25% Exam #1
25% Exam #2

Weekly Outline

	Topic	Reading from Sposito textbook
Jan 11	*No class*	
18	Introduction; composition of soils	Ch. 1
23, 25	Soil Minerals, Pauling Rules	Ch. 2
30, 1	Soil organic matter,	*Ch. 3*
Feb 6, 8	Fundamentals of chemical kinetics and equilibria	*Ch. 4, handout*
13, 15	Mineral weathering and phase stability	*Ch.4, 5*
20	Mineral-water interface	*Ch. 7*
22	Review and Exam #1	
27, 1	Sorption models, surface complexation	*Ch. 8*
Mar. 6, 8	Sorption kinetics, Ion exchange	*Ch. 9*
13, 15	Spring break	
20, 22	Redox in soils, pE-pH predominance diagrams	*Ch. 6*
27, 29	Redox in soils, pE-pH predominance diagrams	
Apr. 3, 5	Electron microscopy	*lecture handout*
10, 12	Atomic spectroscopy	*lecture handout*
17, 19	Colloidal Phenomena	*Ch. 10*
24, 26	Nanogeochemistry, Review and Exam #2	*lecture handout*

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), 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.

Assistance:

Exams are solely an individual effort. No assistance in any form can be provided by fellow students for the exams.

For the homework assignments, the main purpose of the 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.

Source Attribution:

The homework assignments may require that you look up reference information (such as physical/chemical constants) or conceptual information discussed in the notes, textbook and recommended readings. The use of this information for homework assignments is fine (and encouraged). Additional information from other sources is not anticipated to be necessary, but if you choose to use this information, please cite the source.

For the exams, you will need to look up reference data and similar information for some of the problems. I will ask that you cite the sources of these data (including sources from our notes and textbook).

Word-for-word copying of text and as well as copying sentences that changes some words (while maintaining sentence structure) without source attribution is not acceptable and is considered to constitute plagiarism.

Prerequisites:

For students who have not taken Aquatic Chemistry: you should know how to answer these questions or look up the information necessary to answer these questions.

- Is nitric acid HNO_3 a strong acid or weak acid?
- At what range of pH values is bicarbonate HCO_3^- dominant over other forms of dissolved inorganic carbon (H_2CO_3 and CO_3^{2-})?
- What is the definition of ionic strength?
- For a compound that is dissolved in water, what is the definition of its *chemical activity* (i.e., {i} or a_i) and how is activity related to molar concentration?
- What is a ligand in the context of metal ion complexation?
- How do you determine if aquatic conditions are oversaturated with respect to a mineral phase?
- How is the equilibrium constant K_a for this reaction related to the molar concentrations of H_2CO_3, HCO_3^-, and H^+?

$$H_2CO_3 \leftrightarrow HCO_3^- + H^+ \qquad K_a = 10^{-6.35}$$