Water Chemistry
CE 115
Fall 2020

3 semester credits

Course Description

The application of principles of inorganic, physical, and dilute solution equilibrium chemistry to aquatic systems, both in the aquatic environment and in water and wastewater treatment processes.

Prerequisites

Upper division or graduate standing in engineering or physical science, or consent of instructor.

Course Objectives

After successfully completing this course, you will be able to:

- Employ concepts of equilibrium chemistry to predict the speciation of solutes in the aquatic environment.
- Assess the forms and concentrations of metal species present in water and their fate under conditions encountered in natural and engineered systems.
- Quantify the effects of mineral dissolution and precipitation on the composition of water.
- Predict the effects of oxidation and reduction reactions on the fate of nutrients, trace elements and organic compounds in natural and engineered systems.

Course Meeting Times

Lecture: Tu/Th 9:30 AM-11:00 AM Pacific Time
Optional Discussion Section: Wed 12:00 PM-1:00 PM Pacific Time

Instructor Information, Office Hours, & Communication

Course Instructor

David Sedlak: sedlak@ce.berkeley.edu
Office Hours: Thursday 3-4 PM or by arrangement.
The link for the Zoom room for instructor office hours is available on the bCourses site.

Graduate Student Instructors (GSIs)

Angela Perantoni (Main GSI): angela_perantoni@berkeley.edu
Office Hours: Tuesday 4-5 PM or by arrangement.

Yanghua Duan: duanyanghua@berkeley.edu
Office Hours: by arrangement.
The link for the Zoom room for the GSI office hours is available on the bCourses site.

Course Mail

You can contact your GSIs and instructor using bCourses emailing system, accessed via your Inbox. You can also send e-mail directly to your GSIs and instructor. Make sure to check the Inbox for messages from the instructor and GSIs. You can also choose to have your bCourses mail forwarded to your personal email account or your cell phone.

Question & Answer Discussion via Piazza

Please use the Piazza site within bCourses to post questions relevant to the entire class. This can include questions about the course materials and topics or mechanics around assignments. The instructor and GSIs will monitor this discussion**,** but you should also feel free to answer questions posted by other students. This helps to create a general FAQ so that all students in the course may benefit from the exchange.
See https://piazza.com/berkeley/fall2020/ce115/home

Course Materials and Technical Requirements

Technical Requirements

This course is built on a Learning Management System (LMS) called Canvas and UC Berkeley's version is called bCourses. You will need to meet these computer specifications to participate within this online platform.

The class will meet through the Zoom platform. Separate links to the Zoom lectures will be sent to you and will be available on the bCourses web site.

Optional

Zoom allows you to communicate with a web camera. We encourage you to leave your web camera on during lecture and discussion section. Although doing so is not required for any of the activities, using these features will enhance your engagement in the course. If you would like to use these features, you will need to have a webcam and a microphone installed on your computer.

Technical Support

If you are having technical difficulties with bCourses or Zoom please alert one of the GSIs immediately. However, understand that neither the GSIs, nor the instructor can assist you with technical problems. You must call or email tech support and make sure you resolve any issues immediately.

Be sure to document (save emails and transaction numbers) all interactions with tech support. Extensions and late submissions will not be accepted due to avoidable to "technical difficulties."

Discussion Section

The discussion section for CE 115 is part of the course but attendance is not required. It will provide you with insight into problem solving and practice with problems similar to those that are assigned as homework. Developing the skills necessary to solve equilibrium chemistry problems is essential to mastery of the material in this class. From past experience, many students consider discussion section to be a critical element of the class.

Study Groups

To facilitate collaborative learning and build community within the class, we will be arranging study groups consisting of approximately

eight students. The groups will have a scheduled meeting time during which your GSI or instructor will be available to answer questions. Participation in study groups is optional.

Textbook and Reading Assignments

Each week includes assigned readings relevant to the topics covered in the course textbook: Mark Benjamin's "Water Chemistry" (second edition). They also are included in the course schedule at the end of the syllabus. The readings do not exactly overlap with the lectures. However, they do cover similar material from a slightly different perspective. You are not responsible for information presented in the textbook that is not discussed in class.

Some students find it useful to finish the readings prior to lecture. Others prefer to attend lecture and only read parts of the textbook pertaining to material that they did not fully understand. And some students do just fine without ever reading the textbook.

Lectures

Each week our Tu/Th meetings will include lectures that provide important information and insights related to the week's topics. We will do our best to make these lectures engaging and interactive. You are required to engage with all lecture materials and will be responsible for addressing the concepts in your course assignments. Although the lectures will be recorded and posted on bCourses, we encourage you to attend them in the live format.

Assignments

Occasionally, you will be required to answer one or two simple questions prior to lecture or during lecture. These activities, which will be available in bCourses, are intended to prepare you for lecture or give you hand-on experience with a concept presented in lecture. They should be considered a low stress learning activity.

Homework

Approximately eleven assignments will be given during the course of the semester. You are encouraged to work with your study group or other students in the class to develop strategies for solving the

problems. You also may ask questions about the assignment to your GSI or instructor. However, the assignment that you turn in should reflect your own work and should be completed independently of others.

Exams

This class will include three exams and a final. Copies of exams given in previous years are available on the bCourses site. The exams will employ an open book format with a time limit. Please note that previous offerings of this class employed two midterms and a final. Therefore, old exams may include information from a later part of the course.

Special Events

Throughout the semester we will create opportunities for you to gain additional insight into the applications and implications of the information that you are learning in class. These special events, which will take place immediately after class or in the afternoon or evening are meant to be fun and interesting. You are required to attend at least two of these events during the semester, but you are encouraged to come to more. Details will be provided in class.

Grading and Course Policies

Your final course grade will be calculated as follows:

Table 1: Final Grade Percentages

Category	Percentage of Grade
Assignments & Special Events	10%
Problem Sets	20%
Exams (3)	45%
Final Exam	25%

Late Work Policy During a Stressful Time

Everyone has a bad day. Sometimes we even have bad weeks. To take some of the pressure off your shoulders, this class has a relatively liberal policy with respect to late assignments and poor exam performance. If you need a few extra days to complete a homework assignment, please e-mail your request to me prior to the due date. Extensions will usually be granted. Your lowest homework score will not be included in the calculation of course grade (i.e., you can skip handing in one homework). If your performance on one of your exams is substantially lower than the other three (i.e., three exams plus the final), I will take it into consideration when I assign your grade for the course.

In other words, don’t panic. The idea is to learn. Testing and assignments are only tools to assist in the learning process.

Course Policies

Honor Code

The student community at UC Berkeley has adopted the following Honor Code: "As a member of the UC Berkeley community, I act with honesty, integrity, and respect for others." The expectation is that you will adhere to this code. Read the entire Berkeley Honor Code for more information.

Collaboration and Independence

Reviewing lecture and reading materials and studying for exams can be enjoyable and enriching things to do with fellow students. This is recommended. However, all assignments are to be completed independently and should be the result of one's own independent work.

Cheating

A good lifetime strategy is always to act in such a way that no one would ever imagine that you would even consider cheating. Anyone caught cheating on a Mid-Term Exam or the Final Exam will receive a failing grade in the course and will also be reported to the University Center for Student Conduct. The expectation is that you will be honest in the taking of quizzes and exams.

Plagiarism

To copy text or ideas from another source without appropriate reference is plagiarism and will result in a failing grade for your assignment and usually further disciplinary action. For additional information on plagiarism and how to avoid it, read the UC Berkeley Library Citation Page, Plagiarism Section.

Academic Integrity and Ethics

Cheating on exams and plagiarism are two common examples of dishonest, unethical behavior. Honesty and integrity are of great importance in all facets of life. They help to build a sense of self-confidence, and are key to building trust within relationships, whether personal or professional. There is no tolerance for dishonesty in the

academic world, for it undermines what we are dedicated to doing - furthering knowledge for the benefit of humanity.

Incomplete Course Grade

Students who have substantially completed the course but for serious extenuating circumstances, are unable to complete the exams and homework assignments, may request an Incomplete grade. This request must be submitted in writing to the instructor. You must provide verifiable documentation for the seriousness of the extenuating circumstances. According to the policy of the university, Incomplete grades must be made up within the first three weeks of the next semester.

Students with Disabilities

If you require course accommodations due to a physical, emotional, or learning disability, contact UC Berkeley's Disabled Students' Program (DSP). Notify the instructor and GSI through course email of the accommodations you would like to use. You must have a Letter of Accommodation on file with UC Berkeley to have accommodations made in the course. For anyone needing extra time for an exam, please notify your instructor at least a week prior to the exam.

Course Evaluations

We will administer a mid-semester course evaluation to provide you with an opportunity to make anonymous suggestions about how the class can be improved. Please feel free to e-mail suggestions on ways to improve the course to the instructor or GSIs at any time.

Before your course ends, please take a few minutes to participate in the final course evaluation to share your opinions about the course. Information about the course evaluation will be made available in bCourses.

Course Outline

Below is a weekly course schedule, which is subject to change. Check bCourses for specific assignment due dates.

Week 1: Salts of the Earth (Solutions & Thermo)

Reading

- Chapter 1: Concepts in Aquatic Chemistry
- Chapter 2: Chemical Reactivity, Reactions, and Equilibrium
- Chapter 4: Potentials, Energy, and Forces (Optional & Confusing)

Lectures

- Lecture 1: Introduction & Terminology
- Lecture 2: Thermodynamics Lite

Assignments

- Assignment 1: Salty Waters
- Homework 1: Thermodynamics Applied to Polluted Waters

Week 2: Protons All Around Us (Acids & Bases)

Reading

- Chapter 5: Acid/Base Speciation & Exact Solutions to Problems

Lectures

- Lecture 3: Classification of Acids & Setting Up Problems
- Lecture 4: Exact Solutions & Simplifications

Assignments

- Assignment 2: An Exact Solution
- Homework 2: Calculating pH of Simple Solutions

Week 3: Rethinking pH (Visualization and Titration)

Reading

- Chapter 6: Use of log C-pH Diagrams and the *TOT*H Equation
- Chapter 8 (8.1-8.8 only): Titrations

Lectures

- Lecture 5: Classification of Acids & Setting Up Problems
- Lecture 6: Exact Solutions & Simplifications

Assignments

- Assignment 3: A Simple log[C]/pH plot
- Homework 3: Mixing Waters

Week 4: Bicarbonate: Nature's Buffer (Alkalinity)

Reading

- Chapter 8 (8.9 only): Alkalinity and Acidity

Lectures

- Lecture 7: Alkalimetric Titration of Natural Waters
- Lecture 8: Alkalinity and Natural Buffering

Assignments

- Assignment 4: Berkeley Titrations
- Homework 4: Mixing Waters

Week 5: Carbonated & Smelly Waters (Open Systems)

Reading

- Chapter 9: Gas/Liquid Equilibrium

Lectures

- Lecture 9: Henry's Law and Alkalinity
- Lecture 10: Synthesis and Discussion (Lectures 1-9)

Assignments

- Assignment 5: An Exact Solution
- Homework 5: Effect of Air/Water Partitioning on Solutions

Week 6: Beyond a Beautiful Cation (Metal Speciation)

Reading

- Chapter 10: Chemistry of Metals: Solution-Phase Reactions

Lectures

- Lecture 11: Metal Hydrolysis and Complex Formation
- Lecture 12: Metal Speciation in Complex Systems

Assignments

- Assignment 6: Speciation Solution
- Homework 6: Metal Speciation Across a Salt Gradient

Week 7: Red, White & Blue (Oxides & Carbonates)

Reading

- Chapter 11 (11.1-11.7): Metals: Precipitation & Dissolution

Lectures

- Lecture 13: Metal Oxides, Hydroxides & Oxyhydroxides
- Lecture 14: Metal Carbonates

Assignments

- Assignment 7: Log[C]/pH Diagram for a Heterogeneous System
- Homework 7: Metal Hydroxide Solubility

Week 8: A World of Possibilities (Other Minerals)

Reading

- Chapter 11 (11.8-11.11): Metals: Precipitation & Dissolution
- Chapter 7: Software for Solving Equilibrium Problems (Optional)

Lectures

- Lecture 15: Metal Oxides, Hydroxides & Oxyhydroxides
- Lecture 16: Metal Carbonates
- Additional In-Class Tutorial on Visual MINTEQ

Assignments

- Assignment 8: Log[C]/pH Diagram for a Heterogeneous System
- Homework 8: Metal Hydroxide Solubility

Week 9: Trading Electrons (Redox Reactions)

Reading

- Chapter 12 (12.1-12.8): Redox: Introduction to pe

Lectures

- Lecture 17: Review of Redox and Electron Activity
- Lecture 18: Introduction to Predominance concepts

Assignments

- Assignment 9: Log[C]/pH Diagram for a Heterogeneous System
- Homework 9: Balancing Redox Equations/Stoichiometry

Week 10: Poor, Poor Pourbaix (pe/pH Diagrams)

Reading

- Chapter 12 (12.9-12.19): Redox: Introduction to pe

Lectures

- Lecture 19: Example Systems: Chlorine & Lead
- Lecture 20: The Redox Ladder (COHNISM)

Assignments

- Assignment 10: Titrating a Lake with Electrons
- Homework 10: Redox Chemistry in an Aquifer

Week 11: Sticky Situations (Surface Interactions)

Reading

- Chapter 13: Adsorption Reactions

Lectures

- Lecture 21: Surface Functional Groups
- Lecture 22: Quantitative Description of Surfaces

Assignments

- Assignment 11: Surface Speciation as a Function of pH
- Homework 11: Adsorption of metals on oxide surfaces

Note: Exams will occur approximately 10 days after all of the relevant material has been covered. The exams will build upon previous information with a specific focus as follows:

Exam 1: Lectures 1-6

Exam 2: Lectures 7-12

Exam 3: Lectures 13-18

Exam 4: Lectures 19-22 (or additional material if time allows)