

Spring 2022

ENE 663-102: Water Chemistry

Lucia Rodriguez Freire

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ENE 663 Water Chemistry – Spring 2022

INSTRUCTOR: Dr. Lucia Rodriguez-Freire
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CLASS MEETING: Thursday, 6:00 – 8:50 pm
Faculty Memorial Hall, Rm 314
If online: WebEx meeting, link is provided every week and posted on Canvas

OFFICE HOURS: Wednesdays 12 – 2 pm
Thursdays 4 – 5 pm
Via WebEx personal room (<https://njit.webex.com/meet/lrfreire>)
Also available by appointment

Description: The course provides a comprehensive survey to aqueous-phase equilibria impacting the water quality in natural waters, and water distribution and treatment facilities. We will work to understand the acid-base and metal-ligand equilibria, oxidation-reduction reactions and chemical reaction thermodynamics. There is some emphasis on equilibria governing inter-phase (gas-liquid, solid-liquid) chemical distribution. Mathematical approaches to prediction of equilibrium chemical speciation are stressed.

Course Objectives and Student Learning Outcomes:

- 1) Students will understand with the equilibrium reactions in close and open systems, the interaction between different phases (liquid, gas and solid), and the reduction-oxidation reactions in environmental systems.
- 2) Students will learn to predict the chemical composition, pH and redox condition of an aquatic system
- 3) Students will develop the tools to solve problems with complex chemical reactions in natural and engineer systems

REQUIRED TEXT:

- Water Chemistry, 1st Edition,
Mark Benjamin, Waveland Press, Inc., 2010.

Supplemental Texts:

- Water Chemistry,
Vernon L. Snoeyink and David Jenkins, John Wiley & Sons, 1980.
- Aquatic Chemistry, 3rd Edition
Werner Stumm and James J. Morgan, Wiley-Interscience, 1996.

RECOMMENDED SOFTWARE:

- MINEQL Software.

POLICIES AND PROCEDURES:**Lectures:**

- It's important that you read the assignment (text and/or notes) prior to class. You will also need to watch the videos posted on Canvas on the week's topic. We will try to spend class time summarizing important points from the readings and videos, working examples, and getting practice with quizzes.
- It is required that students attend class. Information will be provided that will be critical to student performance
- Please be on time for lectures. If online, mute your mic unless for asking a question and be mindful of the technical limitations.

Homeworks will be due at the beginning of the class period on the date specified by the instructor. You are strongly encouraged to work in groups and to consult with the instructor if questions arise for homework assignments. Everyone in the study-group must read and sign the homework before submission via email or Canvas.

Exams are open-book and open-note and they can cover any material presented in the class. Missed exams may not be made up except for special circumstances such as for health reasons, the instructor must be notified of an absence prior to the exam.

COVID Honor Code: The health and safety is a priority as we returned to face-to-face classes, and we all commit to create the safest classroom that it can possibly be. With this in mind, in-person attendance is encouraged but not required with prior discussion with me, to allow students who feel sick, question a potential exposure, or are worried to act on the best interest for themselves and everybody else in the class. With this in mind, the following are rules to be follow during the class time:

- Students **MUST** wear masks in the classroom. Masks need to cover **mouth and nose**, and they need a tight fit. Instead of one 10-min break, two 5-min break will be done to allow us to drink/eat outside the classroom.
- Monitor your health closely, if you have any of the COVID-symptoms as describe per the CDC (<https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html>), please let me know and do not attend the lecture.
- If you suspect a close-contact or exposure, please let me know and do not attend the lecture.

NJIT Honor Code *Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. **Cheating is strictly prohibited and devalues the degree that you are working on.** As a member of the NJIT community, it is your responsibility to protect your educational investment by knowing and following the academic code of integrity policy that is found at:*

<http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf>.

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary

action. This may include a failing grade of F, and/or suspension or dismissal from the university. If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu

GRADING:

- Homework (25%)
- Class Project (20%)
- Midterm Exam (25%)
- Final Exam (25%)
- Participation (5%)

Students need to have a grade in every section to obtain a final grade in the class. Students are required to submit all homework assignments, work in a class project, and complete all exams. Any extenuating circumstances that might prevent the student to complete a task must be discussed with the instructor prior to the deadline.

The following percentages are guaranteed to receive at least the indicated grade:

- A: 90-100%
- B+: 85-89.99%
- B: 80-84.99%
- C+: 75-79.99%
- C: 70-74.99%
- F: < 70%

The grade of Incomplete ("I") may be given in rare instances where a student, and for documented (by the Dean of Students) reasons, could not complete parts of the work of the course.

Tentative Course Schedule:

Class Date	Topics	Student Learning Outcomes	Reading
Jan. 20	Introduction, General Chemistry Concepts. Chemical Reactivity	<ol style="list-style-type: none"> 1. Define water chemistry and recognize its importance in environmental systems 2. Describe water and its main properties 3. Calculate concentration in different media/systems 	Chapter 1 Chapter 2
Jan. 27	Reaction Kinetics and Equilibrium	<ol style="list-style-type: none"> 1. Balance chemical reactions 2. Quantify reaction rates 3. Define chemical equilibrium 	Chapter 2
Feb. 3	Introduction to Acid and Base Chemistry	<ol style="list-style-type: none"> 1. Distinguish between an acid and a base 2. Define water dissociation 3. Know acidity and basicity constant 4. Define and calculate pH 	Chapter 3
Feb. 10	Graphical and Numerical Solutions for Acid Base Chemistry 1 <i>Term paper: Title and objective due</i>	<ol style="list-style-type: none"> 1. Solve numerical problems to calculate the pH of a solution 2. Estimate the speciation of a solution for a known pH 3. Draw log C-pH diagrams 	Chapter 4
Feb. 17	Graphical Solutions for Acid Base Chemistry 2 Titration, Buffers and the Carbonate System 1	<ol style="list-style-type: none"> 1. Solve problems using log C-pH diagrams 2. Identification of the predominant species in a solution 3. Solving problems using Proton Condition approach 4. What is a titration? 	Chapter 4 Chapter 5
Feb. 24	Titration, Buffers, and the Carbonate System 2	<ol style="list-style-type: none"> 1. Titration in buffer systems 2. Define alkalinity and understanding the importance in environmental systems 3. Solve problems for the carbonate system 	Chapter 5
Mar. 3	Gas-Liquid Equilibrium	<ol style="list-style-type: none"> 1. Working with gas-phase concentration in an ideal gas 2. Using Henry's constant to predict partition between liquid-gas systems 3. Calculate the pH of a solution in an open systems 4. Log C – pH diagrams in open systems 5. Estimate the speciation of a solution in an open system 	Chapter 7
Mar. 10	REVIEW SESSION + Software lab Minteq		
Mar. 17	SPRING BREAK		
Mar. 24	MIDTERM EXAM		
Mar. 31	Chemistry of Metals in Aqueous Solutions: Precipitation Reactions <i>Term paper first draft due</i>	<ol style="list-style-type: none"> 1. Define what a metal is 2. Identify the role of metals in acid-base chemistry 3. Describe metals behavior in water 4. Distinguish between the different dissociation constant for metal systems 	Chapter 8

		<ol style="list-style-type: none"> Calculating metal speciation in water and with other ligands Drawing predominant area diagrams 	
Apr. 7	Chemistry of Metals in Aqueous Solutions: Precipitation Reactions	<ol style="list-style-type: none"> Describe the formation of solid in water systems Use the solubility constant to predict the formation of a solid Log C – pH diagrams in the presence of solids Solving problems with solids in open systems 	Chapter 8
Apr. 14	Chemical Thermodynamics Redox Chemistry 1	<ol style="list-style-type: none"> Define the Laws of Thermodynamics and their relation with water chemistry Calculate the energy in chemical reactions – Gibbs Energy Define equilibrium based on energy state of a reaction Calculate the equilibrium constant of a chemical reaction What are the oxidation states of atoms? Calculate oxidation states of atoms Balance redox reactions 	Chapter 2 Chapter 9
Apr. 21	Redox Chemistry 2 <i>Term paper due</i>	<ol style="list-style-type: none"> Define electron activity Calculate the electron standard potential using the Nernst equation Calculate the speciation of a solution using the Electron Condition Describe oxidation and reduction of water Understand pe-pH diagrams 	Chapter 9
Apr. 28	<i>Student project presentations</i>		
May 5	READING DAY		
TBA		FINAL EXAM	

STAY SAFE and STAY HEALTHY!

Outcomes Course Matrix- ENE 630 Water Chemistry

Strategies, Actions, Assignments	Assessment Measures	ABET Student Outcomes	Program Educational Objectives
Student Learning Outcome 1: Students will understand with the equilibrium reactions in close and open systems, the interaction between different phases (liquid, gas and solid), and the reduction-oxidation reactions in environmental systems.			
Students will learn and apply chemical concepts to natural water systems	Class and group discussion Homework and examination	2, 6	1,2
Students will learn the importance of water chemistry and the equilibrium processes between environmental compartments: water, air, soil	Class and group discussion Homework and examination Team project: Paper and presentation assessment rubrics	2-7	1,2
4) Student Learning Outcome 2: Students will learn to predict the chemical composition, pH and redox condition of an aquatic system			
Students will learn to formulate chemical reactions and formulate equilibrium reactions that define a water system	Class and group discussion Homework and examination	1,2,6	1
Students will use numerical and graphical solutions to solve water chemistry problems	Class and group discussion Homework and examination	1,2,6	1
5) Student Learning Outcome 3: Students will develop the tools to solve problems with complex chemical reactions in natural and engineer systems			
Students will learn to use a water chemistry simulator (MINEQL) software to solve complex numerical problems in natural and engineer systems	Class and group discussion Homework and examination	1,2,6,7	1
Students will apply numerical, graphical and software solution to understand a water chemistry problem impacting their daily life	Team project: Paper and presentation assessment rubrics	1-7	1,2

CEE Mission, Program Educational Objectives and Student Outcomes

The mission of the Department of Civil and Environmental Engineering is:

- to educate a diverse student body to be employed in the engineering profession
- to encourage research and scholarship among our faculty and students
- to promote service to the engineering profession and society

Our program educational objectives are reflected in the achievements of our recent alumni:

1 – Engineering Practice: Alumni will successfully engage in the practice of civil engineering within industry, government, and private practice, working toward sustainable solutions in a wide array of technical specialties including construction, environmental, geotechnical, structural, transportation, and water resources.

2 – Professional Growth: Alumni will advance their skills through professional growth and development activities such as graduate study in engineering, research and development, professional registration and continuing education; some graduates will transition into other professional fields such as business and law through further education.

3 – Service: Alumni will perform service to society and the engineering profession through membership and participation in professional societies, government, educational institutions, civic organizations, charitable giving and other humanitarian endeavors.

Our Student Outcomes are what students are expected to know and be able to do by the time of their graduation:

1. an ability to identify, formulate and solve complex engineering problems by applying principles of engineering, science and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety and welfare, as well as global, cultural, social, environmental and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Revised: 2/13/18