SPEA E539 **Aquatic Chemistry** **Spring 2025**

Instructors. Your instructor is Prof. Jonathan Raff. Contact him via e-mail at jdraff@iu.edu. Please address all grade and administrative correspondence to Prof. Raff exclusively via email (not Canvas) and allow up to 2–3 days for response. Your associate instructor (AI) for the course is Janet Mireku whose email address is jmireku@iu.edu.

Class Meeting. In-person lectures will be held on Tuesdays and Thursdays from 2:20–3:35 pm EST in PV A221. We will be recording each lecture online via Zoom (https://uits.iu.edu/zoom), and recordings will be posted to Canvas (under the relevant course module) as soon as they are processed. Please try to attend in-person or tune into the live lectures so you can participate in discussions and support your classmates. Your in-person presence in class is required. However, if for some reason, you are unable to tune in, then please watch the recorded video as soon as you can.

Learning Assistance. The instructor will offer office hours via Zoom at times listed on the class Canvas site. Instructions on how to join will be provided via Canvas Announcement. I will also make use of the Discussions feature of Canvas to field questions about homework problems, course material, and provide answers.

Suggested Prerequisite: E536 Environmental Chemistry, college-level general chemistry and/or inorganic chemistry, or permission of the instructor.

Course Description. This course will emphasize applications of principles of chemistry to the understanding of processes affecting the distribution and cycling of important chemicals in surface, subsurface, atmospheric waters, and their analysis. In addition, these principles will be applied to understanding technologies used in water and wastewater treatment. Chemical equilibrium modeling will be a critical tool used by students in learning about the aqueous chemistry of natural and engineered systems through problem solving. In addition, equilibrium chemistry will provide a framework for understanding common methods of water quality analysis.

Course Objectives. To provide fundamental skills necessary for: (1) the analysis and interpretation of water quality data and the scientific literature; (2) graduate-level research in fields such as aquatic ecology, biogeochemistry, multiphase atmospheric chemistry, and water resource science; and (3) basic understanding of the chemistry of pollution control technologies. Inorganic chemical species will be emphasized.

Learning outcomes. By the end of the semester students should be able to:
(1) Perform quantitative tasks related to aqueous equilibrium chemistry of natural waters and engineered systems in the substantive areas of acid/base, precipitation/dissolution, metal complexation and redox chemistry.
(2) Solve quantitative problems in water chemistry using spreadsheet/graphical tools such as Excel.
(3) Interpret data related to the chemistry of natural waters and water-related engineering systems in the substantive areas of acid/base, precipitation/dissolution, metal complexation and redox chemistry.
(4) Communicate in written form the importance of quantitative results on water chemistry derived for natural and engineered systems.

Textbook. I will rely on several textbooks and the peer-reviewed literature in preparing course material. However, the textbook I will assign reading from will be:

Pankow, J. F. 2020, Aquatic Chemistry Concepts, 2nd Edition. CRC Press, Boca Raton, FL

https://www.routledge.com/Aquatic-Chemistry-Concepts-Second-Edition/Pankow/p/book/9781439854402

Your registration for this class includes access to the eText version of this textbook, which you may access on Canvas (via the Engage e-reader). I have chosen this text because it covers most of the topics I feel are important, is tutorial in nature, and is one of the more affordable texts on this subject. Although they are not required, another useful (pioneering) reference text is as follows:

Stumm, W. and J. J. Morgan. 1996. Aquatic Chemistry, 3rd ed. Wiley-Interscience, New York.

Course Drop Policy. It is the student's responsibility to know about the deadlines for dropping this class; please see the official academic calendar on the IU Registrar's webpage or your student handbook for deadlines. Dropping the class after the official deadline will result in a grade of "W" (withdrawal) unless the student qualifies for an incomplete ("I"). Please note that according to the official Academic Guide, "The grade of Incomplete may be given *only* when the completed portion of a student's work in the course is of passing quality." This policy will be strictly followed.

Problem Sets. Homework problems are designed to reinforce important concepts and to provide opportunities for students to improve problem-solving skills. You will generally have one week to work on the problems individually or in groups, after which time an answer key will be posted to the Canvas class website. This assignment will be graded for completeness, not accuracy so it is your responsibility to consult with the answer key, AI, or instructor to ensure that you understand the problems and their solutions.

Modeling Work. Many problems discussed in class, on homework and exams will be solved using MS Excel spreadsheets. Be sure to familiarize yourself with spreadsheet programs since they are important analytical tools in this and many other fields. We will not have time in this class to spend time going over spreadsheet basics, so I suggest using online tutorials to brush up on functionality that may be useful in our quantitative approaches. We will also cover the basics of using equilibrium models such as Visual MINTEQ to evaluate complex chemical reaction systems.

Exams. There will be two take-home exams that are to be completed individually. You are not allowed to collaborate with anyone or seek help from anyone to complete the exam. You will have 7 days to complete each exam and submit (upload as *.pdf) onto Canvas. Exams will be based on material covered in the lecture and problem sets. The exams will be graded in detail and returned to the student; answer keys for the exams will not be provided so students are encouraged to consult with the instructor with questions. *Important:* All inquiries related to the exam should be directed solely to Prof. Raff (not the AI).

Grading. The final grade will be based on the following activities: Two take home exams and the average of the seven problem sets. The contribution of each assignment to the grade is as follows:

Take-home exams (2):	75%
Problem Sets (7):	25%

Your final average grade will determine your letter grade in the course with this approximate scale: 100-90 A, 89-80 B, 79-70 C, 69-60 D, < 59 F, although the instructor reserves the right to use an alternative grading scale. The +/- grading scheme will be used for course grades. In all grading, neatness will count, so show all work clearly in detail to explain how you derived the answer. No make-ups or extra credit opportunities will be possible.

Absences. Please attend all lectures in person. Even though we are recording and posting each lecture on Canvas, please only use this option when you miss a lecture due to illness or when reviewing notes that you

have taken in-person. That being said, we realize that some students may fall ill during the course of the semester. If you fall ill, then by all means stay home and prevent exposing your classmates and instructors to illness. In this case, please contact Prof. Raff to let him know that you will be attending lecture remotely via the Zoom link. Because your assignments, lecture recordings, and problem set solutions are available online, and exams are take-home, open book exams, there will be no make-up assignments or exams, and due dates/times are *non-negotiable*. If you have questions or concerns about this, please contact Prof. Raff.

Course Professionalism Policy. Students are expected to uphold and maintain academic and professional honesty and integrity, as outlined in IU's Code of Students Rights, Responsibilities and Conduct (please see: http://www.iu.edu/~code/_code/responsibilities/_academic/index.shtml). In addition, the O'Neill Student Honor Code may be found at https://myspea.indiana.edu/doc/ugrad-doc/ugrd-student-honor-code.pdf. Violations of The Code include the intentional use of unauthorized study aids, equipment, or another person's work during an exam, allowing or facilitating another student to cheat from you, copying assignment answers from any unapproved source (e.g., another student, answer keys, etc.), and presenting someone else's work as one's own (plagiarizing). Please consult with the instructor if you are unsure of what constitutes plagiarism.

Additional Information

1. *Adapting to Online Learning*. IU has created the KeepLearning.iu.edu website to help students move to the online environment. If you run into technical problems along the way, please contact the UITS Support Center (812-855-6789; ithelp@iu.edu) for technical help 24 × 7. If you have internet connectivity problems you might consider emailing vpsa@indiana.edu, the division of student affairs. They apparently have some mobile hotspots to distribute.

2. *Counseling and Psychological Services*. For information about services offered to students by CAPS: http://healthcenter.indiana.edu/counseling/index.shtml. CAPS is still running online during COVID time. Starting Monday, March 23, CAPS will be offering limited services by phone/video only. Students may schedule 30-minute virtual visits with a counselor by calling 812-855-5711. The crisis line is available to students 24/7 by calling 812-855-5711 and choosing option (1).

3. *Access Journal articles* via the following link:

https://kg6ek7cq2b.search.serialssolutions.com/ejp/?libHash=KG6EK7CQ2B#/?language=en-US&titleType=JOURNALS. When searching journal titles, you must enter the full journal title (not the abbreviation. VPN is not required to access these resources and should not be used to help from overloading the VPN. If you need to find/interpret a journal abbreviation see: https://www.library.caltech.edu/journal-title-abbreviations

Major databases can be found on the Sciences Library website: https://libraries.indiana.edu/sciences-library. I personally use *Web of Science* and *SciFinder Scholar* most often, although Google Scholar is useful for quick internet searches.

4. *Note Selling:* Several commercial services have approached students regarding selling class notes/study guides to their classmates. Selling the instructor's notes/study guides in this course is not permitted. Violations of this policy will be reported to the Dean of Students as academic misconduct (violation of course rules). Sanctions for academic misconduct may include a failing grade on the assignment for which the notes/study guides are being sold, a reduction in your final course grade, or a failing grade in the course, among other possibilities. Additionally, you should know that selling a faculty member's notes/study guides individually or on behalf of one of these services using IU email, or via Canvas may also constitute a

violation of IU information technology and IU intellectual property policies; additional consequences may result.

5. *Online Course Materials*: The faculty member teaching this course holds the exclusive right to distribute, modify, post, and reproduce course materials, including all written materials, study guides, lectures, assignments, exercises, and exams. While you are permitted to take notes on the online materials and lectures posted for this course for your personal use, you are not permitted to re-post in another forum, distribute, or reproduce content from this course without the express written permission of the faculty member. Any violation of this course rule will be reported to the appropriate university offices and officials, including to the Dean of Students as academic misconduct.

6. *Sexual Misconduct & Title IX*: As your instructor, one of my responsibilities is to create a positive learning environment for all students. IU policy prohibits sexual misconduct in any form, including sexual harassment, sexual assault, stalking, sexual exploitation, and dating and domestic violence. If you have experienced sexual misconduct, or know someone who has, the University can help. If you are seeking help and would like to speak to someone confidentially, you can make an appointment with the IU Sexual Assault Crisis Services at (812) 855-5711, or contact a Confidential Victim Advocate at (812) 856-2469 or cva@indiana.edu. It is also important that you know that University policy requires me to share certain information brought to my attention about potential sexual misconduct, with the campus Deputy Sexual Misconduct & Title IX Coordinator or the University Sexual Misconduct & Title IX Coordinator. In that event, those individuals will work to ensure that appropriate measures are taken and resources are made available. Protecting student privacy is of utmost concern, and information will only be shared with those that need to know to ensure the University can respond and assist. I encourage you to visit http://stopsexualviolence.iu.edu/index.html to learn more.

7. *Miscellaneous.* It is not possible to foresee every kind of circumstance that may arise during the semester. Consequently, I reserve the right to handle any situation as I see fit. Also note, this syllabus is only a guide. Any changes or adjustments will be documented through Canvas announcements.

Tentative E539 Course Calendar Spring 2025 (*subject to change – check Canvas*)

Date	Unit/ Lecture	Topic	Pre-Lecture Preparation*	Exams
January				
14	1A	Intro to natural and polluted water	Ch. 1, 3-26	
16	1B	Thermodynamic Principles	Ch. 2, 27-50	
21	1C	Activity and activity coefficients	Ch. 2, 50-54	
23	2A	The proton, ENE, MBE, PBE	Ch. 3 & 4	
28	2B	Tableau for representing complex aq systems	extra reading	
30	2C	Quantitative Acid/Base Calculations I	Ch. 5	
February				
4	2D	Quantitative Acid/Base Calculations II	Ch. 6	
6	2E	Quantitative Acid/Base Calculations II		
11	2F	Buffer Intensity	Ch. 8	
13	2G	Buffer Intensity II	Ch. 8	
18	3A	Carbonate Equilibrium: Closed vs Open Systems	Ch. 9, 159-175	
20	3B	Carbonate Equilibrium: Alkalinity & Buff. Cap.	Ch. 9, 175-198	
25	3C	Applications of CO_3^{2-} Equilibria	Ch. 9	
27	3D	Intro to Aquatic Chemistry Modeling	extra reading	
March				
4	3E	Acid Rain and Ocean Acidification	Ch. 9	
6	3F	Cloud and aerosol chemistry		Exam 1 due
11	4A	Complexation by Ligands	Ch. 10	
13	4B	Complexation by Ligands	Ch. 10	
18	-	Spring Break		
20	-	Spring Break		
25	4C	Complexation by Ligands	Ch. 10	
27	5A	Solubility of Solid (Hydr)oxides	Ch. 11	
April				
1	5B	Solubility of Carbonates	Ch. 12	
3	5C	Solubility Limitation and Predominance Diagrams	Ch. 14	
8	5D	Modeling Solid Equilibria	extra reading	
10	6A	Fundamentals of redox Equilibria	Ch. 17	
15	6B	Quantitative measures of redox Equilibrium	Ch. 17	
17	6C	log C vs. pe and pe vs. pH diagrams	Ch. 17, 18	
22	6D	pe-pH diagrams	Ch. 18	
24	6E	pe and Natural Systems I	Ch.21	
29	6F	Drinking water disinfection	Ch.19, 20	
May				
1	6G	Applications: Direct & Indirect Aquatic Photochemistry	extra reading	Exam 2 out
8		*Take Home Final Exam Due, 5:00 pm*		Exam 2 due

*Reading assignments are chapters/pages from the assigned textbook; additional readings may be provided in class.