CEE 5104: Environmental Chemistry

Meeting Times and Locations: Whittemore 281; Monday & Wednesday: 2:30-3:45 p.m.
Instructor: Peter Vikesland (pvikes@vt.edu); Office: Durham 415; Phone number: 540-231-3568
Instructor's Office Hours: Friday 1:00-2:30 (other times by appointment only), Durham 415
TA: Joyce Zhu (niz@vt.edu) Office hours to be determined.

Book(s): *Water Chemistry: An Introduction to the Chemistry of Natural and Engineered Aquatic Systems* (Brezonik and Arnold).

Other potentially useful books: *A Problem Solving Approach to Aquatic Chemistry* (Jensen); *Aquatic Chemistry 3rd edition* (Stumm & Morgan), *Aquatic Chemistry Concepts* (Pankow), *Water Chemistry* (Snoeyink & Jenkins), *The Cartoon Guide to Chemistry* (Gonick & Criddle)

COURSE DESCRIPTION

> Applied, environmental aspects of physical, organic, and inorganic chemistry; including applications in sanitary engineering of the phenomena of precipitation, complexation, buffering capacity, and chemical equilibria. Review of nomenclature and properties of organic compounds. (3H, 3C) I
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> Pre-requisites: Students must have a firm knowledge of the material covered in general chemistry and math through calculus (MATH 1206 and MATH 1224). This course has a strong quantitative component; student must meet the pre-requisites.

The goal of this course is to provide students with a fundamental understanding of inorganic and organic environmental chemistry and its application towards solution of problems relevant to natural and engineered systems. Topics covered include acids and bases, titrations, the carbonate system, solubility of minerals, metal ion complexation, oxidation/reduction chemistry, chemistry in water treatment, nutrient cycling, organic matter, and organic pollutants. Both chemical equilibrium and chemical kinetics will be explored. Students will be introduced to software that can be used to solve water chemistry problems.

Students taking this course typically have diverse backgrounds (i.e., some students have previously had one year of general chemistry, while other students have already had two or three years of chemistry). Nonetheless, at the conclusion of this course, all students are expected to be able to solve basic problems in environmental chemistry, understand chemical principles, and identify and name organic molecules.

COURSE ORGANIZATION

In an effort to enhance student comprehension of environmental chemistry the course will be taught using a 'hybrid' model. Instead of having the in-class time be primarily dedicated to instructor-led lectures, the class periods will be used for problem solving, case studies, and other interactive activities. Lectures that discuss the material in the textbook will be available online and should be watched prior to a given class period. As noted below, a major portion of your grade will be based upon completion of short online quizzes that will test your comprehension of the posted "online" lecture materials.

ONLINE LECTURES

The "lectures" for this course will primarily be pre-recorded and made available to everyone via Scholar and/or YouTube. Each "lecture" will be designed such that it covers a manageable set of materials and then there will be a short online quiz for each of you to complete after watching the "lecture".

I recommend that you treat these videos as you would lectures in class and take notes while you watch them. Alternatively you can watch the lectures multiple times – whatever works for you. In any case, I will provide 'powerpoint' templates that will make it easier for each of you to follow along during the "lecture". **The quizzes associated with a given lecture must be completed prior to a class during which the material will be discussed/used in class.** I will spend the first 10-15 minutes of each class answering questions that people might have about the "lectures" and the material presented in them. To facilitate my answers to these questions I ask that they be submitted to me via email (pvikes@vt.edu) by noon on the day of class so that I have sufficient time to find the appropriate materials that will enable me to address the issue(s) at hand.

COURSE OBJECTIVES

The following are the stated objectives for the course:

Chemical Units and Chemical Bonding

1. Apply and use standard units of chemical concentration: Moles/liter; Equivalents/liter; Convert between weight/volume and moles/volume.
2. Balance chemical reactions and distinguish covalent or ionic bonds.

Chemical Thermodynamics

3. Demonstrate knowledge of principles of chemical thermodynamics and apply them to determine equilibrium constants (K_H, K_a, K_s) and predict the direction of a reaction.

Acid/Base Chemistry

4. Calculate pH numerically from K_a, and C_T or graphically from pCpH diagrams.
5. Use Henry's Law (K_H) to predict solution phase concentrations based on partial pressure gas transfer between aqueous and atmospheric phases and apply to the carbonate system.

Precipitation and Complexation

6. Use solubility (K_s) constants to calculate solution phase concentration of ions, free metals, and complexes.
7. Draw and interpret solubility diagrams (predominance area diagrams).

Redox Chemistry

8. Balance a redox equation and identify oxidizing agent and reducing agent.
9. Calculate concentrations of oxidized and reduced species based on pE and C_T and interpret pE/pH diagrams.

Organic Chemistry

10. Apply standard nomenclature to name classes of organic molecules (e.g, aliphatics, aromatic, carbonyls and carboxylic acids, esters, ethers, alcohols, amines)
11. Relate trends in boiling points, vapor pressures, and water solubility to chemical structure.

SPECIAL NEEDS / DISABILITY STATEMENT

Students are encouraged to address any special needs or special accommodations with me during the first two weeks of the semester, or as soon as you become aware of your needs. Those seeking accommodations based on disabilities should obtain a Faculty Letter from the Services for Students with Disabilities Office, located at 310 Lavery Hall, which is located between ICTAS and Randolph Hall (http://www.ssd.vt.edu ; 540-231-0858).

GRADING

As our ultimate goal is to help everyone learn the material and to earn an "A", there is no curve in this class. Forty percent of your grade will be based on your exam scores, and the remaining sixty percent will be based on your homework, your completion of the online quizzes, and your attendance/participation in the in-class exercises. The grade scale is defined as follows: A = 100-94; A- = 93-90; B+ = 89-87; B = 86-83; B- = 82-80; C+ = 79-77; C = 76-73; C- = 72-70; D+ = 69-67; D = 66-63; D- = 62-60; F = <59.

	#/semester	*Individual Weight*	*% Overall*
In-class exercises/attendance/ participation*			***20***
Homework			***20***
Online Quizzes			***20***
Mid-Term Exams	***2***	***10***	***20***
Final Comprehensive Exam	***1***	***20***	***20***
Total			***100***

*We will be using the in-class time for problem solving, case studies, and interactive activities. You should make every effort to attend class throughout the semester. Occasionally there will be case studies for which attendance will be taken. These case studies will be announced in advance.

Online quizzes should be completed ***prior to the beginning of class*** on the day that the material will be discussed (these due dates will be clearly indicated on Scholar). Completion of the quizzes prior to class will enable you to receive 100% credit for that quiz, completion anytime after the beginning of class (2:30 Monday or Wednesday) will result in 50% credit. Note that for some class periods there will be multiple quizzes due at the same time and for other class periods there may only be a single quiz that is required so please pay attention!

Homework assignments are due ***at the beginning of class*** on the due date (Blacksburg students should turn in hard copies, NoVA students should submit their homework electronically using the Scholar Dropbox). You have three "grace late days" to use throughout the semester without penalty. That is, you may turn in three assignments one day late, or one assignment three days late. After your late days have been used, assignments handed in up to 24 hours late will incur a 25% penalty, and assignments handed in over 24 hours late will not be accepted**.** If you believe that an error has been made in the grading of an assignment or exam, the material in question will be accepted for re-grading up to one week after the assignment is ***returned to the class.*** **Note: we will make every effort to limit the size of the homework assignments so that each of you is not overly burdened by the out-of-class activities (i.e., online "lectures", online quizzes, homework) associated with this course. Typical weekly homework assignments will be 2-3 problems from the textbook.**

HONOR CODE

The Honor Code will be strictly enforced in this course. All assignments submitted shall be considered graded work, unless otherwise noted. Working together on homework problems is encouraged, but each student must submit their own work and direct copying of another's answers is not allowed. All aspects of your coursework are covered by the Honor System. Any suspected violations of the Honor Code will be promptly reported to the Honor System (see http://www.honorsystem.vt.edu/). The following is the Honor Code copied verbatim from the VT Honor System Constitution:

The Virginia Tech ***Honor Code*** *applies to all work in this class, including homework, project and examinations. When written work is submitted for grading, it is implied that the work is the sole effort of*

the person, or persons, whose name(s) appears on the paper. You may seek help on the principles involved in the homework problems, and you may talk to each other about these principles, but you are not to copy the work of another person or allow another person to work a problem for you. Special provisions apply to the group homework and project and will be described on those assignment sheets.

The Honor Code is the University policy that expressly forbids the following academic violations:
1. **Cheating** -- Cheating includes the actual giving or receiving of any unauthorized aid or assistance or the actual giving or receiving of any unfair advantage on any form of academic work, or attempts thereof.
2. **Plagiarism** -- Plagiarism includes the copying of the language, structure, ideas and/or thoughts of another and passing off same as one's own, original work, or attempts thereof.
3. **Falsification** -- Falsification includes the statement of any untruth, either verbally or in writing, with respect to any circumstances relevant to one's academic work, or attempts thereof. Such acts include, but are not limited to, the forgery of official signatures, tampering with official records, fraudulently adding or deleting information on academic documents such as add/drop requests, or fraudulently changing an examination or other academic work after the testing period or due date of the assignment.

VIRGINIA TECH'S PRINCIPLES OF COMMUNITY

Virginia Tech is a public land-grant university, committed to teaching and learning, research, and outreach to the Commonwealth of Virginia, the nation, and the world community. Learning from the experiences that shape Virginia Tech as an institution, we acknowledge those aspects of our legacy that reflected bias and exclusion. Therefore, we adopt and practice the following principles as fundamental to our on-going efforts to increase access and inclusion and to create a community that nurtures learning and growth for all of its members:

- We affirm the inherent dignity and value of every person and strive to maintain a climate for work and learning based on mutual respect and understanding.
- We affirm the right of each person to express thoughts and opinions freely. We encourage open expression within a climate of civility, sensitivity, and mutual respect.
- We affirm the value of human diversity because it enriches our lives and the University. We acknowledge and respect our differences while affirming our common humanity.
- We reject all forms of prejudice and discrimination, including those based on age, color, disability, gender, national origin, political affiliation, race, religion, sexual orientation, and veteran status. We take individual and collective responsibility for helping to eliminate bias and discrimination and for increasing our own understanding of these issues through education, training, and interaction with others.
- We pledge our collective commitment to these principles in the spirit of the Virginia Tech motto of *Ut Prosim* (That I May Serve).

GENERAL BEHAVIOR ITEMS

- Talking to classmates during class disrupts the normal learning environment. If you engage in such behavior, you may be asked to leave the room. **TURN YOUR CELLPHONES OFF.**
- During the lecture, the reading of materials, e.g., Roanoke Times, Collegiate Times, Sports Illustrated, other than those appropriate for class should not occur.
- If you arrive late to class, please sit down quietly near the entrance to the room.
- If you have to leave early, please sit near the exit so that your departure does not disturb the class.
- Please be polite and patient with other students when they ask a question.

GENERAL SCHEDULE

Subject to change with respect to topics covered on particular dates.

Week	Dates	Topics	Readings	Pages
1	8/26, 8/28	Introduction; nature and structure of water; concentration units; types of reactions; thermodynamics and equilibrium	Chapters 1-3	5-115 [focus on 90-115]
2	9/2, 9/4	Activity and activity coefficients; equilibrium calculations; principles of chemical kinetics	Chapters 4 & 5	116-188
3	9/9, 9/11	pH; introduction to acids and bases; chemical equilibrium	Chapter 7 Chapter 8.1-8.2	220-263 267-276
4	9/16, 9/18	Solution of chemical equilibrium problems (algebraic, iterative, computational); acid-base chemistry and calculations		
5	9/23, 9/25	Titration; pH calculation; pH buffers; ionization fraction	Chapter 8.3-8.4	276-283
6	9/30, 10/2	Composition of natural waters; carbonate system (closed, open) **10/2 – Exam 1 (covers through 9/23)**	Chapter 2 Chapter 8.5-8.7	50-56 283-310
7	10/7, 10/9	Metal-ion complexation	Chapter 9	311-363
8	10/14, 10/16	Solubility	Chapter 10	364-405
9	10/21, 10/23	Solubility of metal (hydr)oxides and carbonates		
10	10/28, 10/30	Principles of redox equilibria; pe-pH diagrams	Chapter 11	406-447
11	11/4, 11/6	**11/4 - Exam 2 (covers through 10/23)** Chlorine/oxidant chemistry	Chapter 13	482-517
12	11/11, 11/13	Sorption processes; iron and manganese chemistry	Chapter 14 Chapter 15.2	518-557 559-577
13	11/18, 11/20	Organic structures and nomenclature; functional groups	Chapter 6	189-219
14	12/2, 12/4	Natural organic matter	Chapter 18	672-712
15	12/9, 12/11	Properties of organic compounds; fate of organic pollutants **Exam #3 (cumulative, during exam period)**	Chapter 19	713-758