ChEE 400/500R Water Chemistry for Engineers

Fall 2016

INSTRUCTOR: Robert Arnold
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GRADER/TEACHING ASSISTANT: None assigned at this point.

TEXT BOOK: *Water Chemistry*, 2nd edition Waveland Press Inc. 2015

OFFICE HOURS: At least two hours per week. I will try to select these hours so that everyone can make it to at least one session. I will also be available immediately after most classes for general discussion, talk about homework, and etc. We can have periodic review sessions on Saturday or Sunday mornings, as necessary.

Topics covered and approximate timing of topics in environmental chemistry.
Reading assignments are from the chapters indicated. I will try to be more specific about reading as we get into the course. The book is excellent, with lots of detailed explanation. Please take advantage of it.

1.	**Background and review**. Concentrations, unit conversions, water structure and properties, activity coefficients, elementary kinetics, temperature dependence of equilibrium constants, combining and reversing reactions. Mostly getting up to speed.	Chapters 1-3 2 weeks
2.	**Introduction to acid-base equilibria**. Definitions, strengths of acids and bases, pH as a master variable, α values, pC/pH diagrams, multiprotic acids (carbonate system, equilibrium speciation, non-ideal solutions).	Chapter 5 2 weeks
3.	**Use of pC/pH diagrams to solve acid-base speciation problems**. General solution strategy, the proton condition, finding dominant species (introduction to titration concepts), graphical solutions	Chapter 6 2 weeks
4.	**Titrations and buffers**. Interpretation of data, weak acid/strong base titrations, etc., multiprotic acids and bases, equivalence points and alkalinity, acidity, buffers and buffer intensity. Predominant species analysis.	Chapter 8 2 weeks
5.	**Gas/liquid equilibrium**. Henry's Law, application to the carbonate system, the proton condition in gas/liquid problems.	Chapter 9 1 week

6. **Metals in aqueous systems**. Speciation, ligands and chelators, pC/pH diagrams, metal in buffers, predominance area diagrams precipitation/dissolution reactions. In some years, this precedes the section on chemical thermodynamics. — Chapters 10-11, 3 weeks

7. **Introduction to chemical thermodynamics.** Application to equilibrium water chemistry problems. Note—this may come after our work with metals and metal/ligand chemistry. — Handout matl., 1 week

8. **Redox chemistry**. Electron activity and the E_H scale, energy changes in redox conditions, speciation problems, pC/pε diagrams, water reactions, pε/pH predominance area diagrams. — Chapter 12, 3 weeks

Basis of your grade:	**Percentage of total grade:**
In-class exams (2)	50
Homework (~5 assignments, in groups)	10
Final exam	40

Homework assignments can be done and submitted in groups of two, three or four. If you prefer, however, you may act as a group of one. Find your partners as soon as possible. I will post solutions for homework assignments. I will be happy to discuss solutions to all assigned problems. **Homeworks will be normally be given out in class on Mondays and turned in the following Monday—one paper per homework group.** Late papers won't be accepted.

Water chemistry is an essential part of what we do in environmental engineering. This course should be an excellent experience for you. If you have suggestions that will improve that experience for others, please make them known.

There is a wet laboratory course for environmental engineering graduate students (ChEE 500L). If you are an environmental graduate student, you should probably sign up for the lab and go to all meetings—unless you and your advisor have a better plan. In any case, you will be required to take ChEE 500L at some point. Chemical engineering undergraduates should not take ChEE 500L since there is so much overlap with your own lab courses.

Undergraduates who may want to pursue a Masters degree in environmental engineering at the University of Arizona should consider the **Accelerated Masters Program** in environmental engineering. Those folks should register for ChEE 500R instead of ChEE 400R. If I fail to talk about this in class, please remind me.

Notes:

1. The class **will not** meet on the following holidays:
   September 7 (Labor Day Holiday) and November 11 (Veterans Day) and November 27 (Thanksgiving Holiday).

2. Wednesday, December 9, is the last day of class.

3. Your final examination for this class is on Monday, December 14, starting at 1 pm. in our normal classroom.

4. I have no specific honor policy other than that of the University because none has been necessary. I expect each of you to be honorable. If you don't know what that means, we can discuss it on a personal level. You should carry an equal or more than equal share of the load in your homework group, but only you and your partners will know what your contribution is. Exams must be your own work. If I am convinced that this is not the case, you will not pass the class—I guess that is the policy. FYI—I attended a college at which cheating resulted in expulsion, without exception. More important is the opinion that you will develop about yourself and the sense of personal honor that you will carry throughout the majority of your life. We are born neither honorable nor dishonorable. We acquire honor through continuous practice. Honor in much more difficult to acquire than it is to lose, something that is true of just about anything of great value.

5. Examinations will be open book. This highlights the need for you to purchase and read our excellent textbook.

6. Avoid make-up exams at all costs. For some reason, they are always more difficult.

7. Water Chemistry should enable you to test and expand your problem solving abilities in an interesting subject area. You will have to solve water chemistry problems in order to pass this course. It should also be a lot of fun. The fun part depends primarily on your ability and willingness to stay up with or ahead of classroom presentations of materials. You are in the middle of a transformative process in which you are asked less frequently to learn from classroom presentations and more frequently from self-study, homework exercises and your peers. Please be aware that I will not provide a blueprint that ensures your success in this course. My expectation is that you will learn enough fundamental chemistry and that your problem solving intuition will improve enough to enable you to pursue mathematical solutions to water chemistry problems of a great many types and in a great many contexts. Doesn't that sound like fun?

8. Don't sleep in class, or if you do, have a (reasonably clean) joke to share with your classmates when you awaken. If you have trouble remembering jokes, write one down ahead of time. Our class is immediately after lunch.

9. Try to avoid communication by email. Most questions can be handled in class or during office hours.