GEOL 4777/5777: Geochemistry of Natural Waters (3 Cr.)
Syllabus, Fall 2018

Instructor:

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Office hours: Mon. 2-3, Thurs. 12:30-2:30. Other times by appointment. In previous years, I have said "you are free to drop by, I will help if I am free". This remains true, but as department head the chances of my being free will be rather low without an appointment.

TA: There is no TA for this course.

Prerequisites:

Math 2205, Chem 1030, Geol 2010, or consent of instructor … instructor's consent does **not** imply any guarantee of success, especially for those with limited backgrounds in chemistry and facility with algebra. This course can prove very difficult for some, but fairly easy for others. It all depends on previous background and the conceptual understandings developed both before and during the course – if you lack some background, it will be some work to catch up.

Class meeting times and place:

Lectures: Tues-Thurs (TR), 2:45 to 4:00, Rm. 318

Content:

This course covers the basic physical chemistry of aqueous solutions, with application to understanding natural waters. Much of the course deals with basic chemical background. Along the way, we will examine natural waters using whatever chemical tools that we have established to that time. The aquatic chemistry that we cover is applicable to speciation of chemical elements in natural aquatic systems, rock/mineral weathering, sources of and controls on major, minor and trace elements in natural waters, redox transformations, and basic chemical behavior of watersheds. The emphasis is on fresh waters, not much on seawater. This subject forms the basis for a large amount of scientific research and environmental consulting worldwide – particularly from the point of view of surface and ground water quality.

Sometimes, the course content comes as a surprise– some students imagined something different when hearing "Geochemistry of Natural Waters". I too was surprised when I first took a similar course – I was thinking we'd be spending more time talking about natural watersheds and weathering, and not so much on thermodynamics. So - I understand. Nevertheless, the chemical basics are necessary, and learning them provides the scientific underpinning of everything that follows. This is a foundational course. It sets a tone of inquiry. There is an old saying that the quality of one's science is directly related to the quality of one's assumptions – and this course content confronts the necessary assumptions.

My advice is: let's get on top of the chemical basics so that we can spend some time later on dealing with more "real" situations. The fact is that equilibrium thermodynamics – typified by what we call "aqueous speciation" – is a necessary starting point. Once we've learned the basics of aqueous thermodynamics and speciation, then we can know pretty much what a given package of water is like, chemically speaking. We can make a pretty good stab at what minerals are under- or over-saturated, what chemical species exist in solution even though we don't measure their concentration directly (we cannot measure everything, most things need to be calculated on the basis of foundational data), what the charge on mineral surfaces is, and the adsorption of solutes to surfaces along with the rates of natural chemical reactions including biotic ones.

These are all key things to know for several reasons. First, measurements take time and money, and the more we can use our brains to figure out what must be true with the fewest measurements the more efficient we are. Second, the act of measurement can change things in these reactive systems, so in fact there is much that we cannot measure in a practical or routine sense. Third, the application of this knowledge in businesses requires maximum efficiency – for example, managers want to know "what's down there" and "what's going to happen to it" without spending any money on finding out. By learning this stuff, we gain the tools to help answer those kinds of questions – sometimes – with minimum expense. Doing so safely, however, requires a strong chemical foundation that is able to avoid pitfalls that can lead you very far astray.

The course texts contain a number of problems that allow you to work your way through problems in basic aquatic chemistry. **There is no substitute for working your way through some problems like this *manually* in order to learn what the assumptions and limitations of such calculations are. I do not advocate going directly to a computer first.**

Having said this, we will use an aqueous speciation program to solve some problems using the computer. It will be clear that without an understanding of the limitations of such calculations, gained from thinking your way through problems yourself, programs treated simply as black boxes and quickly lead users astray with wildly inaccurate answers. The quality of the answer depends on the quality of the question one asks!

In addition, the introduction to computational solutions will serve you well should you choose to take the follow-on course to this course, GEOL 5450, taught by Prof. John Kaszuba in many spring semesters. This course will use a much more sophisticated program to approach aquatic chemistry problems.

<u>Textbook:</u>

Drever, J.I. (1997) *Geochemistry of Natural Waters: Surface and Groundwater Environments*, 3rd Ed. Prentice Hall, 436 pp. Unfortunately, this book is out of print (according to the publisher). Therefore, I will provide you with textbook materials. There are a couple of copies in the library that you can check out if you're fast!

This book is a classic in the field. I had the first edition of this book when I was an undergraduate. The book covers a remarkably wide range of subject material very concisely. It remains one of the best books out there for instruction at the advanced undergraduate and beginning graduate levels. There are many other books that cover similar material, but which are perhaps suited to more advanced graduate students or which cover a less diverse set of subjects. A list of some other very good books in this area is found at the end of this syllabus.

I will supplement the Drever textbook with material from Stumm and Morgan, from a book published in german called "Aquatische Chemie" by Sigg and Stumm (I would recommend it if it were not in german … I'll translate for you when we use any of it), and from some research and review papers.

<u>Course Requirements:</u>

The course will be graded on the basis of weekly or bi-weekly **problem sets** and two **take-home exams**. Note: problems will not be assigned during the last week of the semester when you are working on the take-home final. Similarly, problems will not be assigned when you are working on the midterm exam.

Problem Sets: 50% of grade-

I will go through the problem sets, and will review common mistakes with problems in class if needed. The goal of the problem sets is that you understand what is going on. I will be looking for (1) that you turned in a problem set, (2) that you made a reasonable, good-faith effort to solve the problems, and (3) that you came up with a well-reasoned answer. A good-faith effort on the problems will prepare you for the exams. I want you to feel encouraged to get help if you are stuck – the point here is not to overwhelm you, it is to help you realize that although things may seem complicated, you are entirely capable of thinking your way through them. Generally, students realize that what seemed complex is simpler than it seemed at first.

That said, it takes me a LONG TIME to work my way through the problem sets because it takes a long time, sometimes, to follow your reasoning. Without a TA, I must require that the problem sets that you turn in are EASY TO FOLLOW. For this reason, I will start the course by providing Excel templates for solving the first, basic, problems. You are required to use these templates to solve problems and then to email the solutions – in an Excel file using the provided template – to me for review. AFTER THESE, you are expected to turn in solutions written out, very legibly and in a logical progression that I can follow without having to decipher your path (do not make your solution a mystery to me!!) – ON PAPER. If your problem set is not clear, I will not grade it. It may be necessary to re-write your solution once you figure it out, to make it clear!

Given that the answers to many of the problems are available in the book, the answer you get in your solutions is almost irrelevant. **I therefore don't care much whether you came up with the right answer, I need to see a complete path from problem to solution!**

I recognize that students often work together on the problem sets, and to the extent that this helps students learn I encourage this …***as long as students are learning how things work and not just copying***. I do **NOT** allow you to just copy the work of others. Some of you may see this as a gray area, but I do not. If I see problem sets that show signs of being copied, I will bring an academic dishonesty charge. **You are expected to reach your own understanding of the problem and to turn in problem solutions that represent your own thinking, your own work, and your own writing on your own paper.** Again, I expect that you will NOT turn in solutions that are copied from others. **By the same token, you may NOT allow other students to copy your solutions to problems or exams.** *You know what the stupidest thing is? It's so much easier to just do the work than it is to cheat!*

If I think you have cheated by copying from someone else or by allowing a student to copy from you, either in problem sets or exams, I reserve the right to either fail you for the problem set involved or to fail you for the entire course (these sanctions are both allowed in the University Regulations regarding cases of Academic Dishonesty). The fact that I said that you could work with other students shall not be construed to mean that I allow copying or cheating. Further information on UW Academic Dishonesty policies are found in University Regulation 6-802, "Procedures and Authorized University Actions in cases of Student Academic Dishonesty".

Late problem sets will be penalized in the first week they are late; after that, late problems sets will be given no credit.

Take-home exams: 50% of grade-

Exam I, Midterm, 25%, will be passed out in class on **Tuesday Oct. 9** and is due back to me on **Thursday Oct. 18** in class at **2:45 p.m.**

Exam II, Final, **25%**, will be passed out on **Tuesday Dec. 4**, and will be due back to me by **Thursday Dec. 13 by 5:30 pm**. (this is the end of the scheduled final exam period for this course, which is technically Thursday Dec. 13 3:30-5:30). Note that problems will not be assigned the last week of classes. Note that for students signed up for GEOL 5777, extra problems will be assigned for the exams and for some, but perhaps not all, of the problem sets.

EXAMS: Unlike the problem sets, the take-home exams are **NOT** teamwork projects. **The problem solutions on the take-home exams are expected to represent your own thinking - period.** You can use written resources to help you, but you may not use your fellow students for help on the exams! Mid-term and final exams are to be turned in written out legibly and neatly, with a logical progression that I can follow, **ON PAPER**.

Course Schedule

This outline represents initial, and probably optimistic, intent and hope only**! Depending on how things go, we may deviate substantially from this schedule – with the exception that the exam dates are SOLID. I deem it more important to cover the basics at your pace, as best I can for the whole class, than to rush headlong to meet a schedule.** Note that I will be away during the Geological Society of America meeting Nov. 5-7.

	Thurs. Aug. 30: Introduction: Looking at water analyses from a small alpine valley; concentration; elements vs. chemical species; complexes.
Week 1:	Tues. Sept. 4: Chapter 1: Some basics, Chapter 2: Start basic thermodynamics
	Thurs Sept. 6: Chapter 2: Basic thermodynamics, chemical potential
Week 2:	Tues. Sept. 11: Chapter 2: Basic thermodynamics, chemical potential, activity
	Thurs. Sept. 13: Chapter 2, Temperature correction and dependence, disequilibrium, complexation
Week 3:	Tues. Sept. 18: Chapter 2, Activity corrections
	Thurs. Sept. 20: Chapter 3, Carbonate equilibria
Week 4:	Tues. Sept. 25: Chapter 3, Carbonate equilibria
	Thurs. Sept. 27: Chapter 3, Open and closed systems
Week 5:	Tues. Oct. 2: Chapter 3, Mg carbonates
	Thurs. Oct. 4: Chapter 4, Clay minerals
Week 6:	Tues. Oct. 9: Chapter 4, Clay minerals and asbestos **Midterm Handed Out!**
	Thurs. Oct. 11: Chapter 5, Adsorption
Week 7:	Tues. Oct. 16: Chapter 5, Adsorption
	Thurs. Oct. 18: Chapter 7: Redox equilibria **Midterm Due!**
Week 8:	Tues. Oct. 23: Chapter 7, Nernst Equation
	Thurs. Oct. 25: Chapter 7, Eh-pH diagrams
Week 9:	Tues. Oct. 30: Chapter 7, Eh-pH diagrams

	Thurs. Nov. 1: Chapter 9, Metals and contamination
Week 10:	Tues. Nov. 6: Chapter 9, Metals and contamination
	Thurs. Nov. 8: Chapter 10, Silicate equilibria
Week 11:	Tues. Nov. 13: Chapter 10, Silicate equilibria
	Thurs. Nov. 15: Chapter 10, Silicate equilibria
Week 12:	Tues. Nov. 20: Chapter 11, Kinetics
	Thurs. Nov. 22: Chapter 11, Kinetics
Week 13:	Tues Nov. 27: Chapter 12, Weathering and watershed chemistry
	Thurs. Nov. 29: Chapter 12, continued
Week 14:	Tues. Dec. 4: Acid water, mine drainage
	Thurs. Dec. 6: Geomicrobiology

Final Exam Due: Thursday Dec. 13, 5:30 pm!

Obligatory messages from the Dean's Office:

University Regulation 802, Revision 2, defines academic dishonesty as "an act attempted or performed which misrepresents one's involvement in an academic task ini any way, or permits another student to misrepresent the latter's involvement in an academic task by assisting the misrepresentation." There is a well-defined procedure to judge such cases, and serious penalties may be assessed.

Okay, this is where my statements above on what I expect from you on the problem sets is relevant!

1) University Regulation 29, Change 1, states that the instructor can "establish reasonable standards of conduct for each class which should be made known at the outset."
Okay, here goes: I expect that student-professor and student-student interactions will take place with respect and courtesy, but I have almost never encountered anything else so I also don't expect to have any problem. Perhaps the most important part of this is that I encourage you to speak up and ask questions during class, as well as to point out any mistakes I might make up there…

3) College of Arts and Sciences document, **A&S - Students and Teachers Working Together**. A 5-page document is available at: http://www.uwyo.edu/as/current-students/ After getting to this site, click on "Students and Teachers Working Together"
This document lays out the guidelines for the course syllabus, attendance, classroom etiquette (no sleeping or cell phone use!), phone and email protocol, office hours and how to make appointments outside of office hours. Good stuff.

4) Disabilities. If you have a physical, learning, or psychological disability and require accommodations, please let the instructor know immediately. You will need to register with, and provide documentation of your disability to University Disability Support Services (UDSS) (in "Student Educational Opportunity"), 109 Knight Hall, Phone: 307 766-6189, Fax: 307 766-4010, Email: udss@uwyo.edu The UDSS websites is: http://uwadmnweb.uwyo.edu/udss/facultyandstaff/tipsforteaching.asp

Other recommended books:

Langmuir, D. (1997) Aqueous Environmental Geochemistry. Prentice Hall.

Morel, F.M.M. and Hering, J.G. (1993) Principles and Applications of Aquatic Chemistry. John Wiley & Sons.

Krauskopf, K.B. and Bird, D.K. (1995) Introduction to Geochemistry, 3rd Ed. McGraw-Hill, Inc.

Nordstrom, D.K. and Munoz, J.L. (1985) Geochemical Thermodynamics. Benjamin Cummings Publishing Co.

Stumm, W. and Morgan, J.J. (1996) Aquatic Chemistry, 3rd Ed. John Wiley & Sons.