WATER/GEOLOGY 487: GROUNDWATER GEOCHEMISTRY
Spring Semester, 2020

Instructor:

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Office Hours:

Monday: 10:00-11:30; 2:00-4:30
Tuesday: 2:00-4:30
Wednesday: 9:00-11:30; 2-4:30
Thursday: 2:00-3:00

Required Texts:

The University Bookstore has the following two texts available through text rental:

Kehew, AE (2001) Applied Chemical Hydrogeology, Prentice Hall, 368 p.

Domenico, PA, and FW Schwartz (1998) Physical and Chemical Hydrogeology, 2nd ed., 506 p.

Course Overview:

The principles of low temperature, aqueous geochemistry are used to evaluate and understand ground-water quality. In terms of learning objectives, students will be able to do the following:

1. Convert mass concentrations to units of molarity and normality
2. Calculate and/or estimate a solution's ionic strength from available water chemistry
3. Create graphical depictions of water chemistry and interpret their significance
4. Explain the hydrogeochemical processes that control the evolution of groundwater chemistry
5. Calculate the activities of dissolved species and complexes from a water quality analysis
6. Calculate mineral saturation indices from a water analysis and interpret what they mean
7. Explain how kinetic processes and mechanisms influence groundwater chemistry
8. Interpret groundwater chemistry controlled by the dissolution of carbonate minerals
9. Interpret groundwater chemistry controlled by the dissolution of silicate minerals
10. Use the concepts of Eh, pe, and redox pairs to calculate and interpret redox conditions
11. Explain the evolution of redox conditions in natural groundwater and within contaminant plumes
12. Explain the influence of redox conditions on the biotransformation of organic compounds
13. Explain how the processes of ion exchange and adsorption influence groundwater quality
14. Use chemical isotopes and to infer groundwater age and interpret geochemical processes

Attendance Policy:

Attendance is expected at every class meeting, and all absences shall be noted. A student whose final average is on the border between two letter grades will receive the lower grade if he/she has more than three absences without a legitimate excuse (e.g., a lengthy illness).

Student rights and responsibilities, including the behaviors that are expected of both students and faculty in the classroom environment, are described in the **UW-SP Student Handbook**. Links to the various policies can be accessed online at: https://www.uwsp.edu/dos/Pages/handbook.aspx.

Grading Policy:

Grades will be determined by three hour exams, eight problem sets, and a final exam. There is ***no opportunity*** to earn *"extra credit"*, and students are advised to start preparing for the exams well in advance of their scheduled dates (see last page of syllabus). The relative weightings of the various assessment tools are as follows:

Assessment Tool	Individual Weighting	Overall Weighting
Hour Exams (3)	Each exam is worth 20%	60% of final grade
Problem Sets (8)	Each set is worth 1.25%	10% of final grade
Final Exam	Final exam is worth 30%	30% of final grade

"Make-up" exams may be given only to those students who have prior approval from the instructor. Acceptable reasons for missing an exam include a serious or prolonged illness (valid only when a student has verifiable evidence of that illness from a doctor) and a family emergency.

Final grades in the course will include the plus and minus option. ***In no case*** will an incomplete be granted for the course unless the student has a long-term illness, lengthy hospital stay, or a family emergency. A student in one of these situations must arrange for an incomplete with me prior to the end of the semester.

Examinations:

Each of the three hour exams and the final exam will be an "open-book, open-notes test" and shall include short-answer questions and problems to solve. Exams emphasize the various topics listed as course learning objectives. Problem sets assigned throughout the semester provide students with opportunities to practice solving the types of problems covered by exams.

Problem Sets:

Eight problem sets are assigned during the course of the semester. Solutions to the problems are due *two class periods* after the problem sets are assigned and *may **not** be turned in after that time* unless there are extenuating circumstances (e.g., prolonged illness or death in the family). Credit is earned if problem sets are ***completed*** and turned in ***on time***. Therefore, a student will receive full credit for an assignment *if* he/she has attempted to answer ***each*** question correctly, even if the answers are not correct. The problem sets will be returned during the class meeting after they are due, at which time the correct answers will be presented.

Reading Assignments:

The last page of this syllabus is a schedule of lecture topics with associated reading assignments. Students are expected to have read the assigned pages before coming to class. Note that under the column of reading assignments **D & S** stands for **Domenico and Schwartz**, the 1998 *Physical and Chemical Hydrogeology* text, and **Kehew** stands for his 2001 *Applied Chemical Hydrogeology* textbook. In several instances, neither text adequately covers the lecture topic, so the class notes serve as the assigned reading.

DATES	LECTURE TOPICS AND EXAMS	READINGS
01/21	Water as a Solvent, Units of Concentration	**D & S:** 238-240
01/23	Total Dissolved Solids versus Residue @ 180^{o}C	**Kehew:** 1-11
01/25	Specific Conductance and Total Dissolved Solids	Lecture Notes
01/28	Ionic Strength and Total Dissolved Solids	Lecture Notes
01/30	Graphical Displays of Water Chemistry Data	**D & S:** 248-254
01/31	Statistical Treatment of Water Chemistry Data	Lecture Notes
02/04	Statistical Treatment of Water Chemistry Data	Lecture Notes
02/06	Groundwater Quality Controls (Overview)	Lecture Notes
02/07	Review for Exam 1	---
02/11	**EXAM 1**	
02/13	Mass Action and Equilibrium Constants	**Kehew:** 16-17
02/14	Thermodynamics and Chemical Equilibrium	**Kehew:** 18-23
02/18	Mineral Solubility and Equilibrium (Saturation)	**Kehew:** 23-28
02/20	Relationship Between Concentration and Activity	**Kehew:** 28-30
02/21	Models for Estimating Solute Activity	**D & S:** 241-243
02/25	Complexes and Stability Constants	**D & S:** 263-266
02/27	Speciation and Chemical Equilibrium	**Kehew:** 30-31
02/28	The Kinetics of Geochemical Processes	**Kehew:** 32-36
03/03	The Kinetics of Geochemical Processes	**Kehew:** 32-36
03/05	Kinetics and Metastable Conditions	**Kehew:** 36-38
03/06	Review for Exam 2	---
03/10	**EXAM 2**	
03/12	Carbonate Equilibria Reactions	**Kehew:** 40-44
03/13	Dissolved Carbon Dioxide and pH Control	**Kehew:** 44-49
03/24	Alkalinity, Hardness and Corrosivity	**Kehew:** 49-53
03/26	Carbonate Minerals and Water Chemistry	**Kehew:** 53-63
03/27	Groundwater Chemistry in Carbonate Rocks	**Kehew:** 64-77
03/31	Groundwater Chemistry in Carbonate Rocks	**D & S:** 306-312
04/02	Congruent Silicate Mineral Dissolution	**Kehew:** 79-93
04/03	Incongruent Dissolution and Stability Diagrams	**Kehew:** 93-95
04/07	Silicate Weathering and Water Chemistry	**Kehew:** 95-107
04/09	Silicate Weathering and Water Chemistry	**Kehew:** 95-107
04/10	Review for Exam 3	---
04/14	**EXAM 3**	
04/16	Oxidation-Reduction Reactions, pe and Eh	**Kehew:** 129-138
04/17	Field Measurements of Redox Potential (Eh)	**Kehew:** 138-143
04/21	The Interpretation of Eh-pH (pe-pH) Diagrams	**Kehew:** 143-158
04/23	Redox Conditions in Natural Waters	**Kehew:** 158-164
04/24	Nitrogen Compounds in Groundwater	**Kehew:** 330-337
04/28	Dissolved Iron Mobility in Groundwater	Lecture Notes
04/30	Biotransformation of Organic Compounds	**Kehew:** 226-254
05/01	Colloids, Adsorption, and Ion Exchange	**Kehew:** 107-128
05/05	Use of Stable Isotopes in Hydrogeology	**Kehew:** 256-277
05/07	Use of Radioisotopes in Hydrogeology	**Kehew:** 277-288
05/08	Review for Final Exam	---
05/14	**FINAL EXAM (2:45 PM)**	