Geol 588 Aqueous Geochemistry

Tues & Thurs 1130-1245 

Instructor: Dr. Dorothy Vesper
Office: G37 Brooks Hall
Office hours: Thursdays 3-4 PM and by appointment
Email: djvesper@mail.wvu.edu
Class Website: Google Drive for most materials (link will be emailed): eCampus for grade-related items

PURPOSE. The purpose of this class is to provide graduate students with a strong theoretical background in inorganic, aqueous geochemistry for application in a wide range of research topics. My approach is to combine conceptual knowledge with quantitative skills in a cyclic fashion – to build independent understanding and “chemical intuition”. Ultimately, this class is about obtaining the problem solving skills to allow you to better analyze natural geochemical systems.

STUDENT OUTCOMES: Upon completion of this course students will be able to do the following:

1. Understand fundamental aqueous geochemistry of acid-base and oxidation-reduction systems
2. Derive chemical and mathematically expressions to analyze data and evaluate hypotheses
3. Use geochemical models MINTEQ and PHREEQC to solve problems
4. Interpret natural settings and test hypotheses using geochemical calculations and data
5. Construct effective graphics to illustrate data trends and predict chemical outcomes

GRADING

<table>
<thead>
<tr>
<th>Topics Covered</th>
<th>Problem Sets (%)</th>
<th>Exams (%)</th>
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<tbody>
<tr>
<td>Thermodynamics</td>
<td>15</td>
<td>10</td>
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<tr>
<td>Acid-base chemistry, carbonate dissolution, karst waters</td>
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<td>Redox chemistry, coal mine drainage</td>
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<td>Modeling project</td>
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<td><strong>TOTAL</strong></td>
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Letter grades: A≥90%; B≥80%; C≥70%; D≥60% (strict cut-off, no rounding)
Recommended Text:

Alternative Texts and References:

Drever, James I (1997) The Geochemistry of Natural Waters. Surface and Groundwater Environments, Third Edition. Prentice Hall, Inc. 436p. This is the textbook I’ve used in the past but it is now out of print.


Readings: In addition to the text book there are numerous readings on Google Drive that I will direct you to over the course of the semester. (You have unlimited google drive space via your MIX account)

Problem Sets: This is a problem solving class. For that reason, the problem sets are designed to be challenging and not simply a re-do of examples done in class or in the text. I suggest that you start on each set early. If you wait to start until the night before the problem set is due, you probably won’t be able to complete it in time. Any questions at all – come see me! A “Guideline for doing problem sets” will be handed out with the first assignment.

You are encouraged to work together on the problem sets. This means you can share ideas, help each other out, and check that you got to the same conclusions. However, this does not mean you can copy answers, materials or spreadsheets from each other. That constitutes plagiarism. Learn from each other but submit your own work. Duplicate spreadsheets and problems will be awarded zero’s and be treated as academic integrity issues.

Deadlines: UNLESS otherwise specified.... All problem sets are due at the end of the specified day. In reality, this means that your problem set is due by the time I arrive the following morning. The penalty for late assignments is 10% per day (that includes weekend days). No credit will be given for problem sets handed in after the graded assignments are returned.

Exams: There will 3 exams over the course of the semester – covering each of the major groups of topics. These will lag the topics somewhat so that there is sufficient time for you to review your returned problem set on that topic prior to the quiz. The purpose of these exams is to test your mastery of the basic fundamentals.

WVU Academic Policies and Syllabus Statements. Please review the information on course policies provided by WVU: https://tlcommons.wvu.edu/syllabus-policies-and-statements#10.

Topics include (1) Academic Integrity; (2) Academic Standards; (3) Accessibility; (4) Adverse Weather; (5) Attendance; (6) Campus Safety; (7) Inclusivity; (8) Incompletes; (9) Sale of Course Material; (10) Sexual Misconduct; and, (11) Student Evaluation of Instruction.
Water is H\(_2\)O, hydrogen two parts, oxygen one, but there is also a third thing, that makes it water and no one knows what that is (D H Lawrence)

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### INTRODUCTION AND BASIC TOOLS (~ 1 WEEK)

I could scarcely sleep for the excitement the night after seeing the periodic table – it seemed to me an incredible achievement to have brought the whole, vast, and seemingly chaotic universe of chemistry to an all-embracing order. (Oliver Sacks)

- Introduction, syllabus, Chemistry Reunion, concentrations vs. (re)activity, the structure of water

  Intro chemistry text; Benjamin 1; Berner & Berner

### REACTIVITY & ENERGY CONTROLS (~ 2-3 WEEKS)

... the determination of the energy states of substances, and how they change.. is fundamental to understanding what processes are possible and why they happen. (Anderson)

- Introduction to energetics and thermodynamics, activity-concentration relationships, Gibbs Free Energy calculations & derivations, solubility, ionic strength, disequilibrium

  Anderson Ch 1-2_Thermo Philosophy

### ACID-BASE SYSTEMS (~3 WEEKS)

Gutta cavat lapidem: For water continually dropping will wear hard rocks hollow (Plutarch)

- Acids and bases, pH, speciation plots
- Carbonate waters – alkalinity, equivalence points, saturation indices, open and closed systems, PCO2-SiC relationships, carbonate solubility

  Applications in karst geochemistry

  Benjamin 3-5, 7; White Ch 5 Carbonate Chem;
  White Ch 7 Karst Waters  White (1997)_Thermomin;
  Eby (2004) Buffer Capacity

### REDOX-CONTROLLED SYSTEMS (~2 WEEKS)

If redox species all came to equilibrium it would destroy life. Life depends on redox gradients and redox disequilibria (DK Nordstrom)

- Redox chemistry, balancing equations, half cells, Nernst equation, Eh as a master variable, Eh-pH diagrams; Natural Waters, field readings, redox couples

  Benjamin 9; Kehew Ch 5_Redox_in field; Barcelona et al (1989) _when Eh_works

### WEATHERING PROCESSES (~2 WEEKS)

Nothing on earth is so weak and yielding as water, but for breaking down the firm and strong it has no equal. (Lao-Tsze)

- Weathering, mineral stability diagrams;
- Watershed chemistry

  Benjamin 6, 8, 10
  Rose and Cravotta (1998) AMD Chem

  BernerBerner1996_Ch 5_WorldRivers

### MINTEQ, METALS, MISC. (~2 WEEKS OR AS TIME PERMITS)

"When the water of a place is bad it is safest to drink none that has not been filtered through either the berry of a grape, or else a tub of malt. These are the most reliable filters yet invented. (Samuel Butler)

- MINTEQ in computer lab; Metal chemistry

  Benjamin 8, 10

Comments on the schedule: The schedule is tentative. Stay flexible and expect there to be some changes. I like to leave time for discussion, questions, and tangents that make sense.
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