

Course title: Environmental Geochemistry
Course number: EAS 4220/8803 (lecture); 4221/8801 (lab)
Term: Fall 2017
Credits: Lecture 3, Lab 1
Time & location: TR 1:30-2:45pm, ES&T L1175 (lectures)
W 12:15-3:00pm, ES&T L1155 (lab)

Instructors

Prof. Jennifer Glass (lecture); office: ES&T 1234; email: jennifer.glass@eas.gatech.edu
Office hours: Monday 2-4pm or by appointment

Meg Grantham (lab); office: ES&T L1112; email: meg.grantham@eas.gatech.edu
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Office hours: Mondays 1-3pm or by appointment

Course Description (EAS 4220/8803): The objective of this course is to learn how chemical, biological, and geological processes control the distribution of chemical elements on Earth and the solar system. Geochemical processes are central to a variety of environmental issues, including the distribution of CO₂ on Earth and the transformation and storage of inorganic and organic contaminants. Simultaneously, geochemical processes are involved in the transformation of natural species, including nutrients, carbon, and minerals. In this course, we will study the fundamental geochemical processes regulating the distribution of chemicals in aqueous solutions and at the mineral-water interface, and will learn how to predict the distribution of these species in aquatic systems and soils using an equilibrium approach. This course will also introduce stable and radiogenic isotopic techniques essential for tracing elements through biogeochemical cycles and dating the age of planetary materials. This course is designed for students interested in securing jobs in environmental agencies or consulting companies or pursuing graduate studies in the geosciences, environmental science, or environmental engineering.

Learning Objectives:

Upon completion of this course, students will be able to:

1. Understand the thermodynamic and kinetic principles that control chemical composition and microbial activity in waters and soils.
2. Explain how source rock mineralogy influences weathering processes and soil type.
3. Practice using chemical principles to find solutions to real-world geochemical crises, such as lead contamination in drinking water.
4. Describe how radiogenic and stable isotopes have been used to determine the timeline and nature of Earth's chemical evolution.

Laboratory Description (EAS 4221/8801): The laboratory is worth 1 credit and is separate from the lecture (3 credits). EAS majors have to register for the laboratory, but the laboratory is optional for students from other majors. The laboratory component will teach you how to obtain physical and chemical measurements in the field, collect and preserve natural samples, and conduct chemical analyses of these samples in the laboratory. Two short trips will be taken to the field sites during the semester to collect samples, and each student will be responsible for analyzing a series of samples and discussing their results in class. *Please refer to lab syllabus for more information.*



Serve-Learn-Sustain: This course is part of Georgia Tech's Serve-Learn-Sustain (SLS) initiative, which provides students with opportunities to combine their academic and career interests with their desire to make worthwhile contributions to the world and build sustainable communities where people and nature thrive, in Georgia, the United States, and around the globe. More information about SLS can be found at www.serve-learn-sustain.gatech.edu. On the website, you can subscribe to the [SLS Email List \(https://www.contact.gatech.edu/sls/subscribe\)](https://www.contact.gatech.edu/sls/subscribe), view the full list of [affiliated courses and projects \(http://serve-learn-sustain.gatech.edu/courses-20162017\)](http://serve-learn-sustain.gatech.edu/courses-20162017), and find links to Facebook, Instagram and Twitter.

Textbook: The required text is **Introduction to Geochemistry by Kula C. Misra (2012; Wiley and Blackwell)**. The e-book is available for free when you log in with your GT account to the GT Library (<http://site.ebrary.com.prx.library.gatech.edu/lib/gatech/detail.action?docID=10560556>), and the print version is available from the GT Bookstore and online book suppliers. Assigned chapters are listed in the schedule below. Note that there are some typos in this book; pay close attention to lecture slides and running compilation on Piazza for corrections. For two weeks, we will use chapters from **Aqueous Environmental Geochemistry** by Donald Langmuir (1997; Prentice Hall). Other relevant references: **Aquatic Chemistry** by Stumm & Morgan (1996; 3rd Ed; Wiley), **Environmental Chemistry** by vanLoon & Duffy (2000; 3rd Ed; OUP), **Physical Chemistry** by Engel & Reid (2014; 3rd Ed; Pearson); and **Isotopes: Principles and Applications** (2005; 3rd Ed; Wiley) by Faure and Mensing.

Evaluation:

Attendance/Participation: 5%; **Weekly homework** (10 total): 30%; **Final Project:** 25%; **Exams:** Midterm 20%, Final 20%; *Note: Graduate students taking the lecture for credit will be required to answer several extra questions on the midterm and final exams.*

Grading Scale:

90.00-100% = A; 80.00-89.99% = B; 70.00-79.99% = C; 60.00-69.99% = D; <60.00% = F

Note: The scale above *may* be curved slightly (a few %) upward depending on class performance. This will be decided and announced *after* the final exam.

Pass/Fail: Any student earning a score greater than or equal to 70% will earn a Satisfactory. Any student earning a score less than 70% will earn an Unsatisfactory.

Withdrawal Deadline: October 28, 2017

T-Square: The course will make extensive use of T-Square (<http://t-square.gatech.edu>, then log on with your GT username and password, and then select EAS 4220 or EAS 8803). The links on the left hand side of the page will take you to the following:

- 1) **Syllabus** (where this document is posted)
- 2) **Resources** (lecture slides, previous exams, homework assignment, answer keys, term paper/presentation examples, grading rubrics, PHREEQC resources)
- 3) **Gradebook** (where all scores are posted weekly and you can view your current grade)
- 4) **Piazza** (post here to ask questions and communicate with students and instructors)
- 5) **Assignments** (for submitting term paper presentation PowerPoint files and extra credit)

Grades and Grade Changes: Students can check current grades at any time on T-Square Gradebook. Scores will be posted within 1 week after an exams or homework assignment deadline. Requests for grade changes must be received by email to Prof. Glass with a detailed explanation of the grading error no more than one week after the homework or exam is returned.

Piazza: Piazza is an online forum that facilitates interaction among class members and allows you to post questions, comments, answers, pictures, and other materials to share with classmates. You should have already received an email inviting you to enroll for Piazza; once you have accepted this invitation, log on at <http://t-square.gatech.edu> and select EAS 4220 or EAS 8803 and “Piazza” from the left menu. From there, you can get help from other students and participate in student discussions about course material and related topics. Do not post answers to assignments. Instructors have access to the discussion on Piazza and will sometimes comment on posts to help clarify difficulties with course material. Instructors will also use Piazza to post announcements, which will also be emailed to you.

Computing: Homework and lab reports will require use of a computer for plotting graphs in Excel or MatLab, as well as running geochemical models in PHREEQC (available for free download at http://wwwbrr.cr.usgs.gov/projects/GWC_coupled/phreeqci). Please note that PHREEQC1 software will only work on computers running Windows. Students are encouraged to bring laptops to lecture to work on homework at designated times at the end of classes and in office hours. Students without laptops that run Windows can either borrow a Dell laptop from the GT library (<http://libguides.gatech.edu/gadgets/macbooks>) or else run PHREEQC1 on one of the 16 computers in the EAS computer lab (ES&T L1110; door code will be provided in class). Students should also bring a scientific calculator to every lecture for practice problems.

Homework: Weekly homework assignments will be posted on T-Square (see above) and announced in class. *Homework assignments must be turned in at the beginning of class on the designated due dates (see schedule below).* No emailed homework will be accepted; they must be turned in printed or hand-written. *There will be a 10% deduction per day the homework is turned in late and homeworks will not be accepted after the next class meeting when answers are reviewed.* Homework should be neatly hand-written or typed, ordered in a logical fashion, and contain clear responses. *If responses are illegible, no points will be awarded.* Students are encouraged to work together on the homework, but each student should turn in their own answers. Homework answer keys will be posted on T-square > Resources after graded homework is returned. We will review homework briefly during the first 10 minutes of class on the day graded homework is returned, but all students are responsible for careful individual review of their graded homework and answer keys.

Attendance: It is expected that students attend lectures if at all possible. Attendance (1 point per lecture) will be taken at the beginning of class, and students will be allowed 3 absences (taken into account at the end of the semester) before absences will begin to be deducted from their grades. The Institute Absence policy is available at: www.catalog.gatech.edu/rules/4/ Participation grades will be posted monthly. Class participation will be evaluated as follows:

- 90-100%: always attend, participating often by asking
- 80-90%: Less than two unexcused absences, participating often
- 70-80%: 2 to 4 unexcused absences, participating in class activities
- < 70%: More than 4 unexcused absences. Likely irregular participation.

Exams: The midterm and final will cover all material presented before the exam (e.g. both are cumulative for all the material covered to that date). A midterm answer key will be posted on T-

Square after graded midterms are returned and the answers will be reviewed in class. Students are responsible for careful individual review of their graded midterm and the midterm answer key. For exam preparation, students are highly encouraged to study their notes, lecture slides, homework and previous exams posted on T-Square > Resources.

Final project: paper, podcast or video essay: 25% of your final course grade is based on a science communication project. This can be a term paper, documentary, podcast, video essay or alternative form (if approved by the instructor), as long as it is your original work (does not violate copyright laws, no reproductions of images/text from the textbook or other sources), related to an environmental geochemistry topic. A handout with detailed directions will be provided on the second lecture. Example of a successful term paper and presentation is available on T-square > Resources. Grading rubrics will be posted on T-square. Instructors will provide written comments and recommendations for improvement on term paper presentations, and students are highly encouraged to communicate with instructors about project progress or setbacks in office hours. The final project will be due by **noon (12pm) on Thursday, Nov. 30, 2017** via the Assignments Folder on T-square.

Extra Credit: For 1 point of extra credit in the homework category per week, students may attend the Thursday EAS seminar talk (10:50-11am in ES&T L1205) and submit a 1 paragraph summary of the seminar (or, if you cannot attend, about a paper by the seminar speaker) to the T-square Assignments Folder within 1 week after the talk. The file name should be yourlastname_speakerlastname.doc. The paragraph should summarize the major points of the talk or article, and then discuss its connection(s) to geochemistry. Some seminars will be more geochemistry-focused than others, so think deeply and creatively about possible connections if they are not at first obvious. The seminar schedule is available at eas.gatech.edu/content/eas-seminar-schedule. There may be additional extra credit opportunities announced in class.

Student Accommodations: If you have any kind of disability, whether apparent or non-apparent, learning, emotional, physical, or cognitive, and you need some accommodations or alternatives to lectures, assignments, or exams, please feel free to contact me to discuss reasonable accommodations for your access needs. Students with disabilities who require reasonable accommodation to fully participate in course activities or meet course requirements are encouraged to register with the Office of Disability Services at 404-894-2563 or disabilityservices.gatech.edu. Please contact Prof. Glass following registration to discuss necessary accommodations, allowing *more than one week before an upcoming exam* should accommodations be sought.

Cancellation of Classes: If classes are cancelled by Georgia Tech owing to campus closing, the schedule of topics and exams will be re-evaluated by Prof. Glass once campus has re-opened, and announcements about any changes to the schedule and assignments will be made by email.

Honor Code: The instructor, teaching assistants and students in this class, as members of the Georgia Tech community, are bound by the Georgia Tech Academic Honor Code. No plagiarism will be tolerated on homework, exams, or the written project. Please see honor.gatech.edu for Georgia Tech's Academic Honor Code, which you are required to uphold.

*Assigned chapters on schedule on next page refer to Misra textbook unless otherwise noted

Week	Dates	Lecture	Reading*	Lab	Deadlines
1	8/22 8/24	Introduction and overview - Periodic table and atomic structure - Origin and abundance of elements - Chart of the nuclides, radioactive decay types	1, 2, 10.1, 12.1.2	8/23: Introduction; lab safety	N/A
2	8/29 8/31	Minerals: Ion Coordination and Substitution - RR, CRR, CN - Goldschmidt and Ringwood's rules - Crystal field theory for octahedral coordination	3	8/30: Intro to quantitative analysis; anion standards	8/31: HW #1 due
3	9/5 9/7	Thermodynamics and Phase Diagrams - Gibbs free energy - Pressure/temperature phase diagrams - Clapeyron equation	4.2-4.10	9/6: Field Trip I (Tanyard Creek)	9/7: HW #2 due
4	9/14	9/12: Hurricane Irma : class cancelled 9/14: Non-Ideal Solutions - Activity coefficients	7.0-7.2	9/13: Intro to Alkalinity	9/14: HW #3 due
5	9/19 9/21	Solubility and Carbonate System - Solubility, IAP, K_{sp} , saturation index (SI) - pH and dissociation constants	4.1, 7.3-7.9	9/20: Field Trip II (Proctor Creek)	N/A
6	9/26 9/28	9/26: Solubility and Carbonate System (cont) - Carbonate alkalinity and equilibrium 9/28: Chemical Weathering and Soils - Silicate dissolution - Mineral stability diagrams	7.3-7.9	9/27: Cation analysis by FAAS	9/26: HW #3 correction due
7	10/3 10/5	10/3: HW3-5 review and midterm prep 10/5: Midterm exam	N/A	10/4: Anions by IC, Alkalinity	10/3: HW #4+5 due
8	10/12	10/10: Fall recess (no lecture) 10/12: Aqueous Speciation - Aqueous complexation	3 (Langmuir)	10/11: No lab	N/A
9	10/17 10/19	10/17: Adsorption - Mineral surface properties, isotherms, CEC 10/19: Redox Reactions - Nernst equation, Eh-pH diagrams - Microbes and biogeochemical cycles	10 (Langmuir) Misra 8, 13.6	10/18: PHREEQC modeling	10/19: HW #6 due
10	10/24 10/26	Kinetics - Reaction rates and rate law expressions - Temperature dependence of rate constants	9.1-9.2 + Engel/Reid (35.1-35.9)	10/25: Analysis of dissolved Si and P by UV-Vis	10/26: HW #7+8 due
12	10/31 11/2	Radiogenic Isotopes - Radioactive decay and half-life - Geochronology and isochrons	10	11/1: Analysis of dissolved Fe by UV-Vis	N/A
11	11/7 11/9	Stable Isotopes - Isotopic fractionation and delta notation - Mass-dependent / independent fractionation - Carbon, nitrogen, oxygen, sulfur systems	11-11.4, 11.7, 11.8	11/8: Pb chemistry; discussion of field data	11/9: HW #9 due
13	11/14 11/16	Solar System and Earth Evolution - Planetary formation and elemental distribution in terrestrial vs. Jovian planets - Geologic eons, controls on atmospheric O ₂ - Stromatolites, banded iron formations	12.1.3, 12.1.4, 12.1.6, 12.2, 12.3.2, 13.2, 13.5.2	11/15: Final lab presentation and lab clean-up	11/16: HW#10 due
14	11/21	11/21: TBD 11/23: Thanksgiving (no lecture)	N/A	11/22: No lab	N/A
15	11/28 11/30	11/28: TBD 11/30: Final project presentations	N/A	11/29: No lab	11/30: Final project due
16	12/5	Final exam review	N/A	12/6: No lab	N/A

Final exam: Thursday Dec 7, 2017 2:50-5:40pm, ES&T L1175