

Course title: Environmental Geochemistry
Course number: EAS 4220/6200 (lecture); 4221/6201 (lab)
Term: Fall 2019
Credits: Lecture 3, Lab 1
Time & location: TR 9:30-10:45pm, ES&T L1116 (lectures)
W 12:00-2:45pm, ES&T L1155 (lab)

Instructors

Prof. Jennifer Glass (lecture); office: ES&T 1234; email: jennifer.glass@eas.gatech.edu
Office hours: Thursdays 3-5pm or by appointment

Meg Grantham (lab); office: ES&T L1112; email: meg.grantham@eas.gatech.edu
Office hours: Tuesdays 3:30-4:30 pm and Wednesdays 3-4pm or by appointment

Shannon Owings (lab and lecture TA); office: EST 1108, email: smowings@gatech.edu
Office hours: 10am-12pm Wednesday or by appointment

Course Description (EAS 4220/6200): 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. Through a semester-long Wikipedia editing project, students will gain experience in scientific writing on notable topics in environmental sciences of high interest to the public. The Wikipedia editing project will also provide students with experience in identifying an audience, citing literature, peer review, revising, and ethical standards to avoid plagiarism.

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.
5. Learn practical applications of environmental geochemistry for industry positions.

Laboratory Description (EAS 4221/6201): 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. Special emphasis will be placed on Proctor Creek in Westside Atlanta. *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 Canvas 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%; Homework (10 total): 30%; Wikipedia 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 26th, 2019 at 4pm Eastern Time

Canvas: The course will make extensive use of Canvas (log on with your GT username and password, and select "EAS 4220-6200"). The links on the left hand side of the page will take you to the following:

- 1) **Announcements** (also sent via email)
- 2) **Assignments** (where homework is posted and submitted, and where you submit term paper presentation PowerPoint files and extra credit)
- 3) **Files** (lecture slides, previous exams, answer keys, Wikipedia assignment information, PHREEQC resources)
- 4) **Grades** (where all scores are posted and you can view your current grade)
- 5) **Discussions** (post here to ask questions and communicate with students and instructors)

Grades and Grade Changes: Students can check current grades at any time on Canvas 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.

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: Homework assignments will be posted on Canvas (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 Canvas > 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.

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 Canvas 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, answer keys, and previous exams posted on Canvas > Files.

Wiki Education dashboard: 25% of your final course grade is based on a semester-long Wikipedia editing project of an article you are assigned the first week of the semester. The overall objective

of this project is to gain experience in science communication to the broader public by editing existing Wikipedia articles on environmental science topics that have been ranked as high interest. You will gain skills in technical writing and editing, avoiding jargon, determining source credibility, weighing competing claims, and accurately describing differing viewpoints and their significance. We will be using the Wiki Education dashboard for article assignments, tracking progress, peer review, and project management. To access the Wiki Education dashboard, you must sign up on the course page with your Wikipedia username. Before Aug. 22, 2019, you must create Wikipedia usernames and enroll on your course page with the following custom enrollment link:

[https://dashboard.wikiedu.org/courses/Georgia_Institute_of_Technology/Environmental_Geochemistry_\(Fall_2019\)?enroll=mbqavykt](https://dashboard.wikiedu.org/courses/Georgia_Institute_of_Technology/Environmental_Geochemistry_(Fall_2019)?enroll=mbqavykt)

You will find all project instructions on the Wiki Education dashboard, including the semester schedule (“Timeline” link at top) and article assignments (“Articles”). Grading rubrics will be posted on Canvas > Files > Wikipedia. Additional instructions will be provided in lectures. If you have technical questions about Wikipedia throughout the semester, first review all online trainings (“Trainings” link on dashboard) and search the Help Forum (“Get Help” and type search term). If you still can’t find the answer, you may reach out to the Wiki Ed staff member using the "Get Help" button.

Extra Credit: For 1 point of extra credit in the homework category per week, students may attend the weekly EAS school seminar talk (Thursdays from 10:50-11:50am in ES&T L1205) or the weekly Planetary & Astrobiology Seminar (Fridays from 1:55-2:45pm in ES&T L1105) and submit a 1 paragraph summary of the seminar (or, if you cannot attend, about a paper by the seminar speaker) to the Canvas 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 EAS seminar schedule is available at eas.gatech.edu/content/eas-seminar-schedule and Planetary & Astrobiology seminars will be announced weekly by EAS email listserv. You may also submit summaries for other seminar series you attend, if they are related to geochemistry. 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 announcement on Canvas and email.

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 must contact the Office of Disability Services at 404-894-2563 or <http://disabilityservices.gatech.edu/>, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please contact Prof. Glass following registration to discuss necessary accommodations, allowing *more than one week before an upcoming exam* should accommodations be sought. Please also e-mail Prof. Glass as soon as possible in order to set up a time to discuss your learning needs.

Campus resources: Please know there are many resources on campus to provide you with the support you need during your busy (and at times, challenging) life as a student and a person. A few of these resources are listed below. They are here for you, so please take advantage of them!

Academic support:

- **Center for Academic Success** <http://success.gatech.edu>
 - 1-to-1 tutoring <http://success.gatech.edu/1-1-tutoring>
 - Peer-Led Undergraduate Study (PLUS) <http://success.gatech.edu/tutoring/plus>
 - Academic coaching <http://success.gatech.edu/coaching>
- **Residence Life's Learning Assistance Program**
<https://housing.gatech.edu/learning-assistance-program>
 - Drop-in tutoring for many 1000 level courses
- **OMED: Educational Services** (<http://omed.gatech.edu/programs/academic-support>)
 - Group study sessions and tutoring programs
- **Communication Center** (<http://www.communicationcenter.gatech.edu>)
 - Individualized help with writing and multimedia projects
- **Academic advisors for your major:** <http://advising.gatech.edu/>

Personal support:

- **The Office of the Dean of Students:** <http://studentlife.gatech.edu/content/services>
404-894-6367; Smithgall Student Services Building 2nd floor
 - You also may request assistance at https://gatech-advocate.symplicity.com/care_report/index.php/pid383662?
- **Counseling Center:** <http://counseling.gatech.edu>; 404-894-2575
Smithgall Student Services Building 2nd floor
 - Services include short-term individual counseling, group counseling, couple's counseling, testing and assessment, referral services, and crisis intervention.
 - *Students in crisis may walk in during business hours (8am-5pm, Monday through Friday) or contact the counselor-on-call after hours at 404-894-2204.*
- **Students' Temporary Assistance and Resources (STAR):**
<http://studentlife.gatech.edu/content/need-help>
 - Can assist with interview clothing, food, and housing needs.
- **STAMPS Health Services:** <https://health.gatech.edu>; 404-894-1420
 - Primary care, pharmacy, women's health, psychiatry, immunization and allergy, health promotion, and nutrition
- **OMED Educational Services:** <http://www.omed.gatech.edu>
- **Women's Resource Center:** <http://www.womenscenter.gatech.edu>; 404-385-0230
- **LGBTQIA Resource Center:** <http://lgbtqia.gatech.edu/>; 404-385-2679
- **Veteran's Resource Center:** <http://veterans.gatech.edu/>; 404-385-2067

- **Georgia Tech Police: 404-894-2500**

National Resources:

- The National Suicide Prevention Lifeline provides free and confidential support 24/7 to those in suicidal or emotional distress at **1-800-273-8255**
- The Trevor Project provides crisis intervention and suicide prevention support to members of the LGBTQ+ community and their friends. They are available 24/7 by telephone (**1-866-488-7386**), chat (<http://www.thetrevorproject.org>; 3-10pm Eastern, 7 days a week), and text (Text “Trevor” to **1-202-304-1200**; available 3-10pm, M-F).

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

Academic integrity and honor code: Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. 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. Please see <http://www.catalog.gatech.edu/policies/honor-code/> for Georgia Tech’s Academic Honor Code, which you are required to uphold. Students are cautioned not to look at the test papers of other students, nor speak to other students during exams, as these actions will be considered to be Honor Code violations. The possession of notes, texts, and electronic devices other than scientific calculator by a student within the lecture hall during the exam period will be considered an Honor Code violation. Students will be asked to acknowledge their acceptance of this stipulation and their willingness to abide by all terms of it by signing a copy of the "Honor Agreement" attached to all exams. Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Student-Faculty Expectations Agreement: In order to create a mutually respectful classroom environment, your instructors abide by the principles for student-faculty expectations laid out by Georgia Tech. This means that we will:

- create a positive, engaged academic environment;
- be available to meet with you outside of class at a mutually convenient time;
- provide you in advance with all necessary materials so that you can complete all course assignments;
- make my grading criteria and rubrics available to you so that you understand how we evaluate your assignments.

In turn, instructors expect that students too will fulfill your responsibilities. Specifically, we expect that:

- you will work with us to create a respectful, engaged academic environment;
- you will attend classes regularly and on time;
- you will attend exams and presentations unless you have an emergency or formal, pre-approved excused absence;
- you will come to class prepared, having read the required material, and ready to engage in class discussions;
- you will adhere to the principles of Georgia Tech Student Honor Code.

You can review exactly what Georgia Tech’s student-faculty expectations are at <http://catalog.gatech.edu/rules/22/>.

EAS 4220/6200 – Fall 2019 - Environmental Geochemistry

Week	Dates and Topics Covered	Reading*	Lab	Deadlines
1	Aug 20 & 22: 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	8/21: Introduction; lab safety	8/22: Create Wikipedia account and join course page
2	Aug 27 & 29: Ion Coordination & Substitution - RR, CRR, CN - Goldschmidt & Ringwood's rules for minerals - Crystal field theory for octahedral coordination	3	8/28: Field Trip I (Chattahoochee River)	8/27: Canvas Wiki Articles Ranking Survey due
3	Sept 3 & 5: Thermodynamics - Gibbs free energy - Pressure/temperature phase diagrams	4.2-4.10	9/4: Field Trip II (Proctor Creek)	9/5: HW #1 due
4	Sept 10 & 12: Non-Ideal Solutions - Activity coefficients	7.0-7.2	9/11: Intro to quantitative analysis, standards	9/10: "Evaluate Your Article" due
5	Sept 17 & 19: Solubility - Solubility, IAP, K_{sp} , saturation index (SI) - pH and dissociation constants	4.1, 7.3-7.9	9/18: Field Trip III (Proctor Creek)	9/17: "Find Your Sources" due
6	Sept 24 & 26: Solubility & Carbonate System - Carbonate alkalinity and equilibrium	7.3-7.9	9/25: Cation analysis by FAAS, Anions by IC	9/24: "Add to An Article" due
7	Oct 1: Chemical Weathering and Soils - Silicate dissolution, mineral stability diagrams Oct 3: HW review and midterm prep	N/A	10/2: Intro to Alkalinity	10/3: HW #2 due
8	Oct 8: Midterm exam Oct 10: Aqueous Speciation, Complexation, and Adsorption - Mineral surface properties, isotherms, CEC	3 (Langmuir)	10/9: Analysis of dissolved Si and P (spectrophotometry)	10/8: Midterm
9	Oct 15: Fall recess (no lecture) Oct 17: Redox Reactions - Nernst equation, Eh-pH diagrams - Microbes and biogeochemical cycles	10 (Langmuir) Misra 8, 13.6	10/16: No Lab	10/17: "Draft Your Contributions" due
10	Oct 22 & 24: Kinetics - Reaction rates and rate law expressions - Temperature dependence of rate constants	9.1-9.2 + Engel/Reid (35.1-35.9)	10/23: Analysis of dissolved Fe (spectrophotometry)	N/A
11	Oct 29 & 31: Radiogenic Isotopes - Radioactive decay and half-life - Geochronology and isochrons	10	10/30: Nitrate and Nitrite analysis (spectrophotometry)	10/31: HW #3 due
12	Nov 5 & 7: Stable Isotopes - Isotopic fractionation and delta notation - Mass-dependent / independent fractionation - Carbon, nitrogen, oxygen, sulfur systems	11-11.4, 11.7, 11.8	11/6: Pb chemistry; discussion of field data	11/7: "Peer Review An Article" due
13	Nov 12 & 14: Solar System & 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: Finalization of data and lab clean-up	11/14: HW #4 due
14	Nov 19 & 21: Biogeochemical cycles: - C, O, N, S, P	13.6.0-13.6.3	11/20: Final Presentation	11/21: "Final Article" Due
15	Nov 26: Wikipedia project presentations Nov 28: Thanksgiving (no lecture)	13.6.4, 13.6.5	11/27: No lab	11/26: Wikipedia presentation due
16	Dec 3: Final exam review	N/A	12/4: No lab	N/A

Cumulative Final exam: Monday, Dec 9 11:20 AM - 2:10 PM, ES&T L1116

**Assigned chapters refer to Misra textbook unless otherwise noted*