GEOL 460: Geochemistry Syllabus **Spring 2022**

Instructors (order of appearance)

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Office hours: All of us can usually be found in our offices during the work day, and we are happy to be contacted by email, phone, or in person to make specific appointments.

Meeting Times

Lecture: MW 1:30-2:50 pm, ZHS200
Lab: TBD, see below

Text: We will not require a text, but strongly encourage you to obtain one if you find this helpful. Some choices are listed below, with comments. Lecture notes and some pdf reading will also be distributed, but a good reference is often very useful. Several of these can be purchased less expensively as e-book versions, but these do not have the same feel as one you can hold and flip pages by hand. We will not specify pages to be read, but you should focus on learning topics (Use the index!).

Albarede, Francis, *Geochemistry: An Introduction*, 2nd ed. Cambridge University Press, 2009. This text provides a good, condensed reference for many concepts that we will cover. It is concise, and consequently has a high information density, particularly about isotope topics.

White, W.M., *Geochemistry*, Wiley, 2013. The text is very comprehensive, written at a high level and will serve as a useful reference for many years to come. Some chapters may be found on-line. Lengthy, but very informative.

Faure, G. *Principles and Applications of Geochemistry*, Prentice Hall, 1998. This has a good section on thermodynamics and many examples of worked problems. More introductory than the two listed above.

Krauskopf, K.B. and D.K. Bird, *Introduction to Geochemistry*, McGraw-Hill, 1994. This has a range of topics with many worked examples, but is less quantitative and a bit dated compared to others above. However, it is excellent for its treatment of thermodynamics. You might also consider the 2nd edition of this book (very inexpensive) for coverage of classic solution chemistry and thermodynamic background.

A little about this course and its objectives

Catalogue Description: *Composition and origin of Earth; principles of physical chemistry applied to aqueous systems; reaction-diffusion modeling; environmental problems.*
This course will provide you with a relatively advanced introduction to geochemistry, which is a very interdisciplinary subject, but has many common underlying principles. Our goal over the course of the semester is to explore many fascinating problems that may be addressed by geochemistry, while also exposing you to tools that will build your capacity to solve geochemical, geological, and environmental problems. We will gradually work our way from the origin and composition of the Universe and the Earth itself, to focusing on the planet's surface environment, including the oceans and atmosphere.

Key techniques in geochemistry often involve experimental and analytical work in the lab, and using software for geochemical modelling. You will gain exposure to both in this course, though we will only be able to scratch the surface and give you some familiarity with these.

- *Lab:* The main lab will involve an experiment to evaporate a solution resembling seawater, and students will learn analytical techniques to evaluate the changes in solution composition that occur as evaporation occurs. We will cover the background needed for this during the lab hours, but you will need to form small groups to do the analytical work at a time you can be assisted by the TA. We will organize this during the first week, so evaporation can begin. There will also be one or two ancillary labs, as well as discussion of problem sets.
- *Field trip:* There will be a **weekend field trip (date to be determined)** to see geochemistry in action, including both natural waters, trees and rocks.
- *Problem Sets and Computer exercises:* We will assign a modest number of problems that can be solved with the principles we discuss in lecture. Some of these may involve use of geochemical programs such as PHREEQC. We will provide a quick introduction during labs and run suitable tutorials outside of lecture hours as required, with times for these decided as a group.

Learning objectives we hope you will acquire from this course:

- competency with basic principles in geochemistry, including mass balance, solution chemistry and speciation, thermodynamics, kinetics, and reaction-diffusion transport;
- familiarity with application of both stable and radio isotopic measurements to problems in the Earth and environmental sciences;
- understanding of major problems in the Earth and environmental sciences that are addressed by geochemistry, ranging from questions about Earth's origin and evolution, to environmental concerns such as acid rain and water pollution;
- a better developed set of practical skills for working with geochemical problems.

Assignments and grading

There will be three exams, one of which will be the final exam. Other assessed work will include the lab and field trip assignment, and regular problem sets. You should expect one problem set approximately every two weeks. Grades will be weighted as follows:

Three exams:	60% (20% each)
Lab (16%) and field-trip (4%):	20%
Problem sets:	20%
Total:	100%

Final letter grades will be determined based on the distribution of class performance, with comparisons to results from previous years. There will be slightly different curves for undergraduate and graduate students.

Supplementary Lectures for Grad Students and Interested Undergrads

This class has a mixture of grads and undergrads, Some of the grad students (and possibly undergrads) will find themselves doing more advanced work, perhaps reaction-transport modelling in the near future. For these students, we may offer supplementary lectures that discuss more detailed applications and provide additional exercises, if there is sufficient interest. **There are many departmental seminars that will present applications of geochemistry to understand geological and oceanographic problems. Try to attend as many of these as possible.**

Note on academic honesty:
Information concerning academic misconduct (e.g. dishonesty and plagiarism) and support services for students with disabilities can be found in the most recent *USC Student Handbook.* Academic misconduct will not be tolerated in this class, and will be subject to maximum disciplinary action. We will expect that you will collaborate on the analytical aspects of labs and data collection. Discussion of assigned problems is also encouraged. However, we do expect each student to submit their own work, in their own words, for problem sets and for the final lab write-up.

Academic Accommodations: Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to one of us as early in the semester as possible. DSP can be reached at ability@usc.edu and is open 8:30am-5:00pm Monday through Friday. The phone number for DSP is 213-740-0776.

Support Services: There area a variety of support services available to USC students who are experiencing academic or personal problems. If you are experiencing difficulty, we encourage you to seek assistance. A guide to these is available at: https://undergrad.usc.edu/services/support-systems/

GEOL 460 - Lecture Schedule – Spring 2022

Date	**Topic**	**Lecturer**
1/10	Intro: Fundamental Forces, Atoms, Periodic Table	Hammond
1/12	Chart of Nuclides and Nuclear Stability	Hammond
1/17	**No Class, MLK day**	
1/19	The Big Bang, the Solar System	Hammond
1/24	Stars, Nucleosynthesis, the Solar System	Hammond
1/26	Radioactive Decay and Geochronology	Cooperdock
1/31	Radiogenic Isotope Systems (Rb-Sr, Sm-Nd, Lu-Hf)	Cooperdock
2/2	Radiogenic Isotope Systems (U-Th-Pb)	Cooperdock
2/7	Bulk Earth composition & Differentiation	Cooperdock
2/9	Trace Elements	Cooperdock
2/14	Fractionation, melting, phase diagrams	Cooperdock
2/16	***Exam 1***	
2/21	**No Class, Presidents Day**	
2/23	Chemical Equilibria, Acids, Bases, Carbonate Chem	Hammond
2/28	Lab Demo: Carbonate Chemistry Demo & PHREEQ	Hammond
3/2	Gibbs Energy, Equilibrium Constant	Hammond
3/7	Diagenetic Reactions and Eh/pH Diagrams	Hammond
3/9	Mass Transport: Diffusion & Advection, Kinetics	Hammond
3/14-3/18	**Spring Break**	
3/21	Reaction-Transport Modeling/Sediment Diagenesis	Hammond
3/23	Precipitation, Rivers, Weathering, Evaporites	Hammond
3/28	Geochemical Reservoirs, Cycles, Mass Balance	Hammond
3/30	Earth's Atmospheric History	Hammond
4/4	***Exam 2***	
4/6	Geochemistry of Hydrothermal Systems	Cooperdock
4/11	The Origin of Life	Hammond or Cooperdock
4/13	Atmospheric Chemistry, Acid Rain	Hammond
4/18	Stable Isotopes-Part 1	Cooperdock
4/20	Stable Isotopes-Part 2	Cooperdock
4/25	Chemistry of the Oceans-Part 1	Hammond
4/27	Chemistry of the Oceans-Part 2	Hammond
Sometime	**Field trip (tentative)**	
5/4	***Final Exam*** 2-4pm	