Syllabus for Geochemistry (EAS 4803MT)

EAS 4803 Lectures: L1105 EST - MWF 10:05-10:55 am
EAS 4801 Laboratory: L1155 EST - Th 3:05-5:55 pm

I. Instructor

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II. Course Objectives

The objective of this course is to learn how chemical, biological, and geological processes control the distribution of chemicals in aquatic and soil environments. Geochemical processes are central to a variety of environmental issues, including the distribution of CO_2 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, you will study the fundamental geochemical processes regulating the distribution of chemicals in environmental systems and learn how to predict the distribution of these species in aquatic systems and soils using an equilibrium approach. This course is designed for students interested in securing jobs in environmental agencies (EPA, USGS, EPD, NOAA) or consulting companies or pursuing graduate studies in the geosciences, environmental science, or environmental engineering.

III. Laboratory (EAS 4801 MT)

The laboratory is worth 1 credit and is separate from the course (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 to three short trips will be taken to the field sites during the semester to collect samples, and each student will be responsible to analyze a series of samples and discuss their results in class.

IV. Course Material

Course material will consist of class notes, handouts, and assigned readings. The official textbook of the course is:

- Kula C. Misra. 2012. Introduction to Geochemistry: Principles and Applications. Wiley and Blackwell.

In addition, the following books might be useful:

- Werner Stumm and James J. Morgan. 1996. Aquatic Chemistry. Chemical equilibria and rates in natural waters (3rd Ed). Wiley.
- Donald Langmuir. 1997. Aqueous Environmental geochemistry. Prentice Hall.

V. Grading

One mid-term and one final: 50%
Homeworks (one per week): 25%
Written project: 25%

VI. Course Outline

1. Introduction to Geochemistry
- Geochemistry and aqueous geochemistry
- Engineering vs. scientific approach
- The hydrological cycle

2. Chemical Thermodynamics and Kinetics
- Principles of chemical thermodynamics
- Chemical potential and activity of solutions
- The equilibrium constant: temperature and pressure effects
- Kinetics vs. thermodynamics
- Rates, mechanisms, and elementary reactions

3. Acid and Bases
- The strength of an acid or base
- pC-pH diagrams: pH as a master variable
- Buffer intensity and neutralizing capacity
- Production of acidity in the environment

4. The Carbonate System and pH in Natural Waters
- Dissolved carbonate equilibrium in closed and open systems
- Atmosphere water interactions: Henry's law
- Alkalinity changes: the effect of photosynthesis and respiration
- Equilibrium with solid carbonates
- The use of C, N, and S isotopes in biogeochemical cycling

5. Metal Complexation in Aqueous Solutions
- Hydrolysis of metal ions
- Natural and anthropogenic inorganic and organic ligands
- Metal ions and ligands: classification of metals
- Chemical speciation in natural waters: toxicity of heavy metals

6. Precipitation and Dissolution of Minerals
- The solubility of minerals: clays, hydroxides, carbonates, sulfides
- The phase rule: components, phases, and degrees of freedom
- Kinetics of mineral dissolution: weathering

7. Oxidation and Reduction
- Redox equilibria and the electron activity
- Electrode potential: the Nernst Equation
- pe-pH diagrams
- Redox conditions in natural waters: microbial vs. chemical influence

8. Reactions at the Mineral-Water Interface
- Adsorption and adsorption isotherms
- Hydrous oxide surfaces: complexation by H^+, OH^-, cations and ligands
- Surface charge and the electrical double layer
- Effect of surface charge on equilibrium constants
- Ion exchange reactions in groundwaters

VII. Written Project

A term paper will be required from each student in the class. This paper should be a critical review on a geochemical topic of interest to the student. The term paper should be typed in a standard word processor and be 10 pages in length (Font: Times 12; Lines: double-spaced) not including figures and references. It should contain an introduction that present the importance of the topic in geochemistry and outline the rest of the paper. The discussion on the topic should highlight the recent progresses made on the topic, include any calculations that have been performed, and should provide recommendations on the progresses that need to be made in the next decade. Topics should be approved by the instructor by **October 26, 2012**.

VIII. Regulations and Honor Code

We expect all students participating in the course to follow the honor code of Georgia Tech. Absences need to be excused prior the beginning of the class. E-mail is fine but the instructor reserves the right to ask for an official excuse. Homeworks must be turned in at the beginning of class on the designated dates. There will be a 10% deduction per day the home is turned late. Homeworks do not have to be typed in but are supposed to be neatly presented, ordered in a logical fashion, and include clear responses. Students are encouraged to work together on the homeworks, though each student will return their own answers to the problems. No plagiarism will be tolerated with homeworks, exams, or the written project.