# ESS311 Aqueous Geochemistry

Instructor: Professor Grant Ferris

This course is intended to provide students with an introduction to aqueous environmental geochemistry, emphasizing the importance of thermodynamics and chemical equilibria, kinetics, mass transport, and microbiological activity in regulating the chemical composition of natural and contaminated systems. The subject material is quantitative in nature, which involves understanding and solving problems based on mathematical relationships applied in physical chemistry.

Course objectives:

- Understand and apply basic thermodynamic principles of mass action and mass balance to low temperature, generally less than 120 $^{o}$C, aqueous systems at equilibrium, and at steady state.
- Derive and interpret differential expressions for the rates of elementary and complex geochemical reactions.
- Quantify the role of aqueous and surface complexation reactions in regulating concentrations of dissolved chemical species, and the impact of such processes on mineral solubility.
- Evaluate the progress of oxidation-reduction reactions with an emphasis on the environmental fate and behavior of major redox-sensitive elements (e.g., carbon, nitrogen, iron, manganese, and sulfur), as well as their role in bioenergetics and biogeochemical cycling.
- Understand geochemical constraints on mineral solubility, congruent versus incongruent dissolution, and mineral weathering reactions.
- Assess mass transport in surface and groundwater systems, particularly in terms of reactive transport of chemical substances.

There are many adequate textbooks that focus on aqueous geochemistry including *Aqueous Environmental Geochemistry* by D. Langmuir and *Applied Chemical Hydrogeology* by A.E. Kehew, as well as considerable online resources. For these reasons, a text is not required specifically for this course. Course lecture presentations and supplementary materials will be posted on the course website.

Students are expected to attend lectures and take comprehensive notes which to study. If a lecture happens to be missed, arrangements should be made with ***another student*** to obtain notes that are lacking. Lectures are on Mondays from 2:00 pm to 5:00 pm; usually a 20 minute break is taken at the mid-point of the three hour period.

There will be a series of online quizzes (8) and two term tests over the course of the semester, as well as a final exam. Quizzes will be available on the course website immediately after lectures, and must be completed within one week. Term tests will take place during the regular lecture time in the course classroom. The time and place of the final exam is to be announced later in accordance with Faculty of Arts and Science policy.

Missed term tests will only be excused for cases in which the absence was entirely beyond your control (e.g., medical reasons, personal affliction), and only if the proper documentation is submitted to Scott Moore, the Department of Earth Sciences undergraduate studies officer. You must submit **within one week of the missed assignment during regular office hours (Monday to Friday, 9 am to 5:00 pm):**

**Marking Scheme**

Quizzes (8 worth 2 % each) 16 %, Term Tests 22% each, equivalent to 60% of the final grade.

Final exam 40% of the final grade

**Office Hours**

Email in advance for an appointment (grant.ferris@utoronto.ca)

**Schedule (Lecture topics are tentative)**

| Lecture | Date | Topic |
|---|---|---|
| 1 | 12-Sep | Introduction and Basic Concepts |
| 2 | 19-Sep | Thermodynamic principles |
| 3 | 26-Sep | Kinetics |
| *4* | *03-Oct* | *Midterm* |
| 5 | 17-Oct | Acid-base relationships |
| 6 | 24-Oct | Aqueous complexation and solid phase reactivity |
| 7 | 31-Oct | Mineral solubility and weathering |
| *8* | *14-Nov* | *Midterm* |
| 9 | 21-Nov | Redox processes |
| 10 | 28-Nov | Biogeochemistry of banded iron formations (Brock Edwards) |
| 11 | 05-Dec | Mass Transport and Geochemical Modeling |