

Thermodynamics of the Earth System

EAS 3603 - Fall 2026

Instructors:

Jennifer Bowen, Assistant Professor

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Course Description: In the first half of this course, we cover the core principles of thermodynamics that are commonly taught across chemistry, chemical engineering, mechanical engineering, and physics. In the second half of the class, thermodynamic principles are applied to problems with relevance to earth science, aquatic chemistry, environmental science, and atmospheric science.

Course Objectives/learning outcomes:

By the end of the course, students should be able to:

- Apply the laws of thermodynamics to closed and open systems.
- Analyze work, heat, internal energy, enthalpy, entropy, and Gibbs free energy in physical and environmental systems.
- Use equations of state and phase-equilibrium concepts to describe gases, liquids, and phase transitions.
- Evaluate chemical potential, solution thermodynamics, and equilibrium relationships relevant to aqueous and environmental chemistry.
- Solve thermodynamics problems connected to Earth and atmospheric systems, including redox processes and atmospheric thermodynamics.

Required course materials:

Textbook: Physical Chemistry for the Chemical and Biological Sciences

By Raymond Chang, ISBN 978-1891389061

Additional worksheets, homework assignments, and course announcements will be provided through Canvas.

Instructional approach:

Classes use a worksheet-based format in which lecture is followed by guided in-class practice. Homework assignments extend the concepts covered in class and provide additional environmentally relevant applications.

Grading:

Exams 70%

Homework 30%

There will be 3 midterm exams during the semester and a final exam. Of these 4 exams, the lowest score will be dropped. There will be 6 homework assignments and the one with the lowest score will be dropped.

Attendance policy:

Students are expected to attend class regularly and participate in the worksheet-based learning activities. If a student misses an exam for any reason that is not covered by an approved Georgia Tech absence, that exam will normally count as the dropped exam. For GT-documented official absences, students should contact the instructors as early as possible and, when feasible, at least one week before the scheduled exam to discuss alternate arrangements. In emergencies, students should also work through the Dean of Students office when appropriate.

Additional criteria for successful completion of the course:

To successfully complete the course, students are expected to complete homework assignments, take the required exams, follow course instructions and deadlines, and engage with course materials distributed through Canvas. Students are responsible for monitoring course announcements and for meeting all posted expectations for assignments and assessments.

Academic honesty / academic integrity statement:

The instructor and students in this class are bound by the Georgia Tech Academic Honor Code. The instructor will make available copies of previous examinations and/or other appropriate assignments, samples, and readings. Unauthorized use of any previous semester course materials is prohibited in this course. Using these materials will

be considered a direct violation of academic policy and will be dealt with according to the GT Academic Honor Code. The complete text of the Academic Honor Code may be found at: <http://osi.gatech.edu/content/honor-code>

Acceptable student conduct: Students are expected to uphold the Georgia Tech Student/Faculty Expectations Agreement and to contribute to a respectful, professional, and productive learning environment. Disruptive behavior, harassment, or conduct that interferes with instruction or with the learning of others is not acceptable.

Disability services: If you are a student with learning needs that require special accommodation, 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 also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Student Resources: It is normal for students to feel stressed during the semester. Fortunately, Georgia Tech has organized resources related to Well Being which can be accessed by clicking the GT Student Resources tab on Canvas, which is located on the left navigation bar.

Lecture & Worksheet Topics, Relevant Book Chapters:

- 1 Gas Laws, Chap. 1, 2
- 2 Equations of State, Non-ideal gases, Chap. 1, 2
- 3 Work Chap. 4
- 4 First Law, Internal Energy, Enthalpy Chap. 4
- 5 Heat capacity, Gas Expansion Chap. 4
- 6 Adiabatic Processes, Hess' Law Chap. 4
- 7 Enthalpy, Entropy Chap. 5
- 8 Entropy, Carnot cycle Chap. 5
- 9 Entropy Chap. 5
- 10 Entropy, Mixing, Phase Transition Chap. 5
- 11 Gibbs Free Energy Chap. 6
- 12 Clapeyron Equations Chap. 6
- 13 Phase Rule, Components Chap. 6

- 14 Concentrations, Raoult's and Henry's Law Chap. 7
- 15 Henry's Law, Chemical Potential Chap. 7
- 16 Activity Composition Relationships Chap. 7, 8
- 17 IAP/Ksp, Van't Hoff equation
- 18 Calcium carbonate in the ocean
- 19 Freezing point depression, Boiling point elevation Chap. 7
- 20 Osmosis Chap. 7
- 21 Balanced Redox equations
- 22 Redox Chap. 10
- 23 Ecological Redox sequence
- 24 pe-pH
- 25 Atmospheric thermodynamics