Thermodynamics of Geological Processes – Fall 2021
GEO 371T/390M (Unique 28186/28294)

Class Time: Tue. and Thur. 9:30–11:00 AM
Class Location: EPS 1.126
Instructor: Chenguang Sun
Office: JGB 4.126
E-mail: csun@jsg.utexas.edu
Office Hours: Wed. 12–2 PM or by appointment

Course Description: This course is designed for graduate and upper-level undergraduate students to study the principles of thermodynamics for in-depth understanding Earth and planetary processes. It will cover the three fundamental laws of thermodynamics, quantitative analyses of chemical reactions among solid, liquid (or fluid), and gaseous phases, and phase diagrams in mineralogical and petrological systems. This course also emphasizes the applications of thermodynamic tools to geological processes from the surface to deep interior of terrestrial planets, such as fluid-rock reaction, volcanic degassing, magma generation and differentiation, and Earth’s redox and thermal evolution.

Prerequisites: Undergrad-level math, chemistry, or physics

Textbooks:

- Thermodynamics of Natural Systems (by Anderson, G. M.): This book will be the primary source of readings and is required for this course. UT students have free access at https://doi.org/10.1017/CBO9780511840258.
- Thermodynamics in Geochemistry (by Anderson, G.M. and Crerar, D.A.): This book is optional but is useful to learn more mathematic aspects of thermodynamics.
- Additional readings will be posted online through Canvas (http://canvas.utexas.edu).

Grading: Letter grades will be assigned according to the ranges of final scores:

- A (90-100), B (80-89), C (70-79), and D (60-69)

Actual grade boundaries may shift at the discretion of the instructor. Final scores will be calculated using weighting factors for different assignments.

| Assignment     | Weight (%) | | Assignment     | Weight (%) |
|----------------|------------|-----------------------------|------------|
| Homework       | 25%        | Class participation         | 10%        |
| Exam I         | 15%        | Exam II                    | 15%        |
| Project report | 25%        | Project presentation       | 10%        |

Software: Students will need Microsoft Excel or programming languages (e.g., Matlab or Python) for homework assignments, exams, and the final project. Matlab and Microsoft Office are available to download for free at the IT service website (https://it.utexas.edu/services).

Safety and Health: Students are expected to be mindful of their own and other people’s health and safety in the classroom. If you feel sick, please take advantage of the University Health Services (https://hr.utexas.edu/current/services/occupational-health-program).
Academic Integrity: Students are expected to abide by the University of Texas Honor Code. Any form of dishonesty, such as cheating, plagiarism, and forgery, is subject to academic disciplinary action, including failure of the course. Detailed information of Student Discipline and Conduct can be found at https://catalog.utexas.edu/general-information/appendices/appendix-c/student-discipline-and-conduct/.

Course Material: Students are not allowed to share materials from this class (including, but not limited to, lecture notes/slides, homework assignments, and exams) online or with anyone outside of the class. Exceptions can only be made with written permissions of the instructor. Unauthorized sharing of materials promotes cheating. It is a violation of the University’s Student Honor Code and an act of academic dishonesty. Any unauthorized sharing of course materials will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure of the course.

Course-Instructor Survey: Standard evaluation forms will be provided at the end of the semester for students to evaluate this course and the instructor. However, students are welcome and encouraged to provide feedbacks to the instructor during office hours or by email throughout the course.

Class Learning Environment: This class aims to provide an inclusive and supportive learning environment. Every student has the right to participate in the class equally and respectfully, regardless of backgrounds, identities, and abilities. Harmful and disrespectful language and actions are prohibited. The instructor promises fair assessments and grades for every student in this class. Students are welcome and encouraged to reach out to the instructor in case of any concerns about the classroom environment.

University Resources for Students: This class values the success of every student and makes effort to accommodate individual needs for learning. However, this goal requires the students and instructor to work together towards practical strategies that meet both the students’ needs and the course requirements. Students are responsible to discuss with the instructor regarding any issues of this course that prevent learning. A range of resources are also available on campus:

- Services for Students with Disabilities: http://diversity.utexas.edu/disability
- Counseling and Mental Health Center: http://www.cmhc.utexas.edu
- Sanger Learning Center: http://ugs.utexas.edu/slcl
- Libraries: http://www.lib.utexas.edu
- University Writing Center: http://uwc.utexas.edu
- Information Technology Services: http://its.utexas.edu
- Student Emergency Services: http://deanofstudents.utexas.edu/emergency

Instructor’s Note to Students: This course has not been taught in recent years at UT’s Jackson School of Geosciences. This is the first time I am teaching it in a more structured way for graduate and upper-level undergrad students. I would appreciate your feedbacks on how to improve it. Please feel free to reach out during office hours or through email.
Course Schedule and Outline (subject to revision)

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Aug. 26</td>
<td>Syllabus, Introduction, and Basic Definitions</td>
<td>Ch 1, A, F</td>
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<td>2</td>
<td>Aug. 31</td>
<td>Essential Mathematics and Matlab</td>
<td>App. C, TBA</td>
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<td></td>
<td>Sep. 2</td>
<td>Equilibrium, State Variables, Reactions, and Energy</td>
<td>Ch 2, 3.1-3.3</td>
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<td>3</td>
<td>Sep. 7</td>
<td>First Law: Work, Heat, and Enthalpy</td>
<td>Ch 3.4-3.8</td>
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<td>4</td>
<td>Sep. 14</td>
<td>Entropy, Heat Capacity, and Gibbs Free Energy</td>
<td>Ch 4.8-4.18</td>
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<td>Sep. 16</td>
<td>Third Law</td>
<td>Ch 5.4-5.5</td>
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<td>5</td>
<td>Sep. 21</td>
<td>Clapeyron Equation, Adiabat, and Solidus</td>
<td>Ch 6.1-6.6, TBA</td>
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<td>Sep. 23</td>
<td>Ideal Solution</td>
<td>Ch 7</td>
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<td>6</td>
<td>Sep. 28</td>
<td>Fugacity and Activity</td>
<td>Ch 8.1-8.2</td>
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<td>Sep. 30</td>
<td>Activity Coefficients and Standard States</td>
<td>Ch 8.3-8.6</td>
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<td><strong>Project Topic Due by 4 PM</strong></td>
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<td>7</td>
<td>Oct. 5</td>
<td>Exam I (Open Book in Class)</td>
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<td></td>
<td>Oct. 7</td>
<td>Equilibrium Constant</td>
<td>Ch 9.1-9.5</td>
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<td>8</td>
<td>Oct. 12</td>
<td>Equilibrium Constant</td>
<td>Ch 9.6-9.11</td>
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<td>Oct. 14</td>
<td>Real Solution</td>
<td>Ch 10.1-10.4</td>
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<td>9</td>
<td>Oct. 19</td>
<td>Real Solution</td>
<td>Ch 10.5-10.10</td>
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<td>Oct. 21</td>
<td>Phase Rule</td>
<td>Ch 11</td>
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<td>10</td>
<td>Oct. 26</td>
<td>Redox Reactions</td>
<td>Ch 12.1-12.6</td>
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<td>Oct. 28</td>
<td>Redox Reactions</td>
<td>Ch 12.7-12.12</td>
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<td>11</td>
<td>Nov. 2</td>
<td>Gas and Equation of State</td>
<td>Ch 13</td>
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<td>Nov. 4</td>
<td>Volatile Solubility in Minerals and Melts</td>
<td>TBA</td>
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<td>12</td>
<td>Nov. 9</td>
<td><strong>Exam II (Open Book in Class)</strong></td>
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<td>Nov. 11</td>
<td>Solid Solutions</td>
<td>Ch 14</td>
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<td>13</td>
<td>Nov. 16</td>
<td>Phase diagram: Unary and Binary Systems</td>
<td>Ch 17.1-17.3</td>
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<td>Nov. 18</td>
<td>Phase diagram: Binary and Ternary Systems</td>
<td>Ch 17.3-17.5</td>
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<td>14</td>
<td>Nov. 23</td>
<td>Geothermometers and Geobarometers</td>
<td>TBA</td>
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<td>Nov. 25</td>
<td>Thanksgiving Holiday (No Class)</td>
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<td>15</td>
<td>Nov. 30</td>
<td>MELTS Modeling: Melting and Crystallization</td>
<td>TBA</td>
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<td>Dec. 2</td>
<td><strong>Project Presentation (Report Due by Dec. 6th 4 PM)</strong></td>
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Assignments: This course will have 5 homework sets, two open-book exams, and one final project including a report and a presentation. Project topics could be any research subjects related to thermodynamics. Presentations are expected to be about 10 min. The project reports should be about 8 pages (double space, 12-pt font, and 1” margin) plus references.