# Thermodynamics (CHM ENG 141)

Spring Semester 2024

Instructor: Rui Wang ruiwang325@berkeley.edu

Karthik Shekhar kshekhar@berkeley.edu

Teaching Assistant: Siddharth Rajupet siddharth.rajupet@berkeley.edu

Michael Bowen michael_Bowen@berkeley.edu

Kushal Nimkar kushalnimkar@berkeley.edu

Lecture: Monday/Wednesday/Friday 1pm-2pm 145 Dwinelle

Discussion Sections:
Monday 10-11am (Section 101) Dwinelle 242 (Sidd)
Wednesday 8-9am (Section 103) Dwinelle 243 (Michael)

Thursday 11am-12pm (Section 105) 9 Evans (Sidd)

Friday 11am-12pm (Section 106) 9 Evans (Kushal)

Instructor's Office Hour:

Rui Wang: Thursday 4-5pm, 110B Gilman

Karthik Shekhar: TBD

TA's Office Hour:

Siddharth Rajupet: Thursday 12-1pm, Location TBD

Michael Bowen: Tuesday 2:00-3:00pm, Latimer 425

Kushal Nimkar: Friday 9:00-10:00am, Hildebrand Library Seminar Room E

**Learning Objectives:**

In this course, we will pursue the study of thermodynamics from both conceptual and applied viewpoints. The conceptual perspective requires us to construct a broad intuitive foundation that provides us the ability to address the topics that thermodynamics spans. The applied perspective enables us how to actually use these concepts to solve problems of practical interest and thereby enhances our conceptual understanding.

**Course Outline:**

1. Introduction of thermodynamics: basic concepts, postulates and language
2. First law of thermodynamics: work and heat, reversible processes in closed systems and first law in open systems.
3. Carnot engine and refrigerator
4. Entropy and the second law of thermodynamics (part 1): concept of entropy from Carnot cycle
5. Entropy and the second law of thermodynamics (part 2): calculation of entropy change
6. Entropy and the second law of thermodynamics (part 3): microscopic view of entropy
7. Entropy and the second law of thermodynamics (part 4): second law in open systems, Rankine cycle
8. Thermodynamic potentials: fundamental equations
9. Using thermodynamic potentials: calculation of fundamental and derived properties
10. Equations of state
11. Intermolecular forces
12. Phase equilibrium in one component system: equilibrium criterion, Clapeyron-Clausius equation
13. Thermodynamics of mixture: partial molar properties, Gibbs Duhem equation
14. Entropy of mixing and gas separation
15. Fugacity: calculation for pure substance, fugacity coefficient of mixture
16. Liquid phase mixture: ideal solution, Lewis-Randall rule and Henry's law, activity coefficient
17. Phase equilibrium (part 1): vapor liquid equilibrium (VLE)
18. Phase equilibrium (part 2): liquid-liquid equilibrium (LLE), metastability, surfactants
19. Phase equilibrium (part 3): colligative properties, osmotic pressure
20. Chemical reaction equilibrium (part 1): thermodynamics and kinetics, equilibrium constant
21. Chemical reaction equilibrium (part 2): calculation of equilibrium constant, multiphases, heterogeneous reactions
22. Chemical reaction equilibrium (part 3): equilibrium in electrochemical systems.

**Homework:**

Homework will be distributed every Friday afternoon and is due the next Friday night before 12am. You may collaborate on the homework; however, the solutions you write must reflect your own

understanding. For your own benefit, it is recommended that you think through the homework independently before collaborating.

**Credit of the Course:**

Homework+Midterm+Final

30% 30% 40%

10% of the credit will be deduced if homework has not been handed in on time.

**Textbook:**

Engineering and Chemical Thermodynamics, by Milo D. Koretsky, 2nd Ed.

**Reference Books:**

Introduction to Chemical Engineering Thermodynamics, by J. M. Smith, H. C. Van Ness, M. M. Abbott and M. T. Swihart, 8th Ed.

**Technical Requirements**

- This course is built on a Learning Management System (LMS) called Canvas and UC Berkeley's version is called bCourses. It can be accessed with a computer, tablet, or smartphone.
- If you are having technical difficulties, please alert one of the instructors immediately. In addition, please email tech support immediately to resolve any issues.
    - In bCourses, click on "Help" in the panel on the left.
- We will use Gradescope for assignments (e.g., homework, midterms, and the final exam).
    - Gradescope can be accessed with a computer, tablet, or smartphone.
    - You do not need a printer/scanner to submit your Gradescope assignments. For handwritten work, please use a free scanning app like Scannable.

**bCourses Site**

- The bCourses site will be the central hub for all course information.

- Please set your bCourses notifications so that you do not miss any announcements or assignments.
- Check the bCourses site frequently (at least twice per week) to stay current with all course activity.

**Gradescope**

- New homework assignments will be posted in bCourses every Friday and due by the following Friday.
- We will do our best to grade your assignment and post solutions within 1 week of submission.
- You will upload your assignment to Gradescope. Be sure to assign the correct pages to each problem, the grader will only grade what has been designated for each problem. We recommend writing each problem on a new page.
- Use a free scanning app like Scannable to upload handwritten work. Graders will not grade work that is not legible. Whether you use Scannable or another means of converting written work to submittable formats, it is your responsibility to make sure that it is legible.
- You may use the regrade request feature in Gradescope. Regrade requests must be submitted within 1 week of the grades being posted. Please include a comment thoroughly explaining why you believe more points should be awarded based on the rubric. We will only regrade the requested problem.

**Piazza**

- We will use Piazza as an alternative format to Office Hours to ask questions about course content.
- The same expectations for respectful communication hold for Piazza as they do for face to face interaction.
- Respond to your peers! We encourage you to help each other by responding to students' questions. Please do not share complete answers to homework problems until the solutions have been posted.
- Anonymous posting has been activated, you may post your questions anonymously.

**Academic Integrity**

- It is considered academically dishonest to turn in work to be graded (homework, lab assignment, project, quiz, exam) that is not your own work, unless the assignment explicitly states otherwise. You may work with others in preparing homework and studying for exams, but the work you turn in must be the product of your own thinking. Academic dishonesty can result in no credit for an assignment or the course. It can also result in referral to UC Berkeley authorities for additional sanctions.