

ECHE 363: Thermodynamics of Chemical Systems

Lectures:	MW (12:45–2:00 PM)	AW Smith 349
Recitations:	F (2:15–3:05 PM)	AW Smith 349

Instructional Team

<i>Instructor:</i>	Prof. Robert Warburton	<i>Email:</i> rew134@case.edu ** Course emails will be answered once per day, which means you should receive a response within ~24 hours. <i>Office hours:</i> Times TBD, AW Smith 151 or by appointment (no drop-ins)
<i>Teaching Assistants:</i>	Ruth Dikki	<i>Email:</i> rcd82@case.edu <i>Office hours:</i> TBD
	Kangjin Lee	<i>Email:</i> kxl785@case.edu <i>Office hours:</i> TBD

Textbook (required)

M. D. Koretsky, *Engineering and Chemical Thermodynamics 2nd ed.*, John Wiley & Sons. (2013)

Note: All exams will be closed book and no notes. An equation sheet will be provided.

Additional supplemental materials will be provided on the course Canvas page.

Learning Goals

Upon completion of ECHE 363, students should be able to:

- Apply mass balances, energy balances, and entropy balances to model non-reactive steady-state and transient chemical processes using analytical and numerical methods.
- Derive thermodynamic properties of gases and liquids using equations of state and/or tabulated data.
- Understand the concepts of phase equilibrium, stability, and distinguish between reversible and irreversible processes.
- Use partial molar properties to analyze the properties of multicomponent mixtures.
- Apply thermodynamic principles to describe the equilibrium properties of coexisting vapor–liquid, liquid–liquid, and solid mixture phases.
- Establish connections between course materials/exercises with engineering problems encountered by practicing chemical engineers.
- Investigate solutions to engineering thermodynamics problems through collaboration in teams.

Course Description

ECHE 363 is a required course in the undergraduate chemical engineering curriculum. Thermodynamics forms a conceptual basis for understanding how heat and work transform the properties of matter.

Most science and engineering majors require a thermodynamics course. The emphasis on real fluids, equilibrium between different components and phases, and chemical reaction equilibrium in ECHE 363 distinguishes it from analogous courses in other disciplines. Such phenomena are ubiquitous in problems being solved by practicing chemical engineers.

Concepts and skills in this course form a foundation for subsequent courses in the Chemical Engineering curriculum, as well as in chemical engineering careers. Thermodynamics involves analysis of material properties at equilibrium (i.e., when a system is not changing with time). Subsequent courses in transport phenomena, separations, and chemical reaction engineering will address transient processes that are driven by an approach toward equilibrium.

Content Delivery

This is an in-person course with Monday and Wednesday lectures and Friday recitations. The lecture sessions will focus on delivery of new concepts and problem solving. The recitations will primarily be focused on problem solving but may in some cases also cover new material not covered on Monday or Wednesday.

Attendance and Participation

Attendance is required for all lecture and recitation sections. Participation is strongly encouraged. While your final grade does not explicitly include points for attendance/participation, it may be considered in borderline cases.

Assessments and Grading

Final Grade Calculation

Final grades will be calculated according to the following breakdown:

Homework	20%
Quizzes	10%
Midterm 1	20%
Midterm 2	20%
Final Exam	30%

Final letter grades will be assigned according to the following scale:

A	90–100
B	80–89
C	70–79
D	>60

Adjustments to this scale *may* be made at the end of the course. However, any adjustments to the scale *will not negatively affect your final grade* (i.e., you are guaranteed *at least* the letter grade as determined by the above scale).

Exams

There will be three exams (two midterms and one final exam). All exams will be closed book and closed notes. Midterm exams will be given during the 75-minute lecture on either Monday or Wednesday. An equation sheet will be provided with the exam and given ahead of time to aid in preparation.

While the Second Midterm will focus on material covered after the First Midterm, it can be seen as cumulative because of the reliance on foundational concepts from earlier in the course. The Final Exam can also be considered a comprehensive assessment covering material from throughout the course.

There will be no make-up midterm exams. Unexcused absences from a midterm exam will result in a 0 for that assessment. If you have an excused absence from a midterm (e.g., documented illness), the grade you earn for the next exam will also be applied to your missed exam. The two possible scenarios for a missed exam with an excused absence are the following:

1. If you miss Midterm 1 with an excused absence, your Midterm 2 grade will be doubly counted.
2. If you miss Midterm 2 with an excused absence, your grade for the missed Midterm 2 will be replaced with your Final Exam grade (i.e., the Final will be worth 50% of your grade).

Quizzes

There will be ~4–5 quizzes, held ~biweekly, and generally given at the end of the Monday's lecture. The quizzes will build upon the homework assignment due the following Friday and should be seen as low-stakes opportunities to work through additional practice problems.

In cases of excused absences due to university-sponsored commitments, make-up quizzes will be permitted. However, it is the student's responsibility to coordinate arrangements for the quiz to be made up promptly. These arrangements must be made ahead of the scheduled quiz date/time.

The lowest quiz score will be dropped in the final calculation of your semester quiz grade.

Homework

Homework will be assigned approximately on a weekly basis. Each homework set will be posted to the course Canvas page immediately following Friday's lecture, and will be due the following Friday at the beginning of class (see the course calendar for specific due dates). All homework assignments are to be scanned and submitted electronically through the dropbox on the Canvas page for the respective assignment; hard copies of homework solutions will not be accepted. The dropbox will close promptly at 2:15 PM on Friday (i.e., the start of class) and there will be no late assignments accepted. Technical difficulties will not be accepted as an excuse for late assignments.

Each student must complete their own unique homework. Collaboration with classmates on the homework is strongly encouraged, but everyone must turn in their own assignment. Copying

or making minor modifications to the work of others (other student, solution manuals, AI chatbots, etc) and passing off the work as your own will be treated as academic misconduct. Ignorance will not be accepted as an excuse. All work must be shown to receive full credit.

The lowest homework score will be dropped in the final calculation of the semester homework grade.

Regrade Policy

Students have the right to request a regrade of their Exams, Quizzes, or Homeworks if they believe the grading was unfair or incorrect.

Regrade requests must be submitted through Canvas using the “Ungraded Quiz” link provided for each assignment. The timing of regrade requests will be restricted to:

- No earlier than 24 hours following the return of a graded assignment.
- No later than one week following the return of a graded assignment.

The regrade request dropbox open/close dates will be restricted based on this policy. The request should clearly indicate why the student considers the grading to be incorrect or unfair. Early or late regrade requests will not be accepted. It is the student’s responsibility to review their assignments alongside the solutions, provide a clear explanation of what they perceive to be the grading issue(s), and to complete this promptly to be considered for a regrade. Note that a granted request will entail a regrade of the entire assignment, so your final grade may either increase, decrease, or stay the same.

Tentative Course Schedule

The following Course Schedule indicates the planned lecture topics, corresponding sections in the Koretsky textbook, assignment information, and exam information. This schedule is subject to change. Please see Canvas for the most up-to-date information and due dates.

Week	Dates	Lecture topics (textbook sections)	Items assigned	Items due	Notes/ Assessments
1	1/13, 1/15, 1/17	Math review, thermodynamic properties (1.1–1.7)	pre-class survey, HW 1	pre-class survey	
2	1/22, 1/24	First Law, hypothetical paths, reversibility, closed systems (2.1–2.7)	HW 2	HW 1	No class 1/20 (Martin Luther King Jr. Day)
3	1/27, 1/29, 1/31	First Law, closed systems (cont'd) and open systems (2.7–2.8)	HW 3	HW 2	
4	2/3, 2/5, 2/7	Carnot cycle, entropy, Second Law (2.9, 3.1–3.7)	HW 4	HW 3	<i>Quiz 1</i>
5	2/10, 2/12, 2/14	Second Law, equations of state (3.6–3.7, 4.1–4.3, 4.5)		HW 4	
6	2/17, 2/19, 2/21	Thermodynamic web (5.1)	HW 5		<i>Tentative: Midterm 1 - Wed. 2/19 (Chs. 1–3)</i>
7	2/24, 2/26, 2/28	Property/Maxwell relations, real gas property calculations (5.2–5.3)	HW 6	HW 5	
8	3/3, 3/5, 3/7	Real gas property calculations (cont'd) (5.3)	HW 7	HW 6	<i>Quiz 2</i>
Spring Break, March 10-14					
9	3/17, 3/19, 3/21	Phase equilibria, Clapeyron equation (6.1–6.2)	HW 8	HW 7	
10	3/24, 3/26, 3/28	Partial molar properties, mixing, Gibbs–Duhem equation (6.3)	HW 9	HW 8	<i>Quiz 3</i>
11	3/31, 4/2, 4/4	Chemical potential, multicomponent phase equilibria; fugacity introduction (6.3–6.4, 7.1–7.2)		HW 9	
12	4/7, 4/9, 4/11	Vapor fugacity calculations (7.3)	HW 10		<i>Tentative: Midterm 2 - Wed. 4/9 (Chs. 1–6)</i>
13	4/14, 4/16, 4/18	Liquid fugacity calculations, activity coefficients (7.4)	HW 11	HW 10	
14	4/21, 4/23, 4/25	Vapor–liquid equilibrium (VLE), azeotropes (8.1)		HW 11	<i>Quiz 4</i>
15	4/28	VLE (cont'd), liquid–liquid equilibrium (LLE) (8.1–8.2)			
Final Exam: Wed. May 7th, 8–11 AM (Location: TBD)					

Academic Integrity Policy

Students at Case Western Reserve University are expected to uphold the highest ethical standards of academic conduct. Academic integrity addresses all forms of academic dishonesty, including cheating, plagiarism, misrepresentation, obstruction, and submitting without permission work to one course that was completed for another course. This includes, but is not limited to, consulting with another person during an exam, turning in written work that was prepared by someone other than you, making minor modifications to the work of someone else and turning it in as your own, or engaging in misrepresentation in seeking a postponement or extension. Ignorance will not be accepted as an excuse. If you are not sure whether something you plan to submit would be considered either cheating or plagiarism, it is your responsibility to ask for clarification.

Please review the complete academic integrity policy: <https://bulletin.case.edu/undergraduate-studies/academic-integrity/>. Any violation of the policy will be reported to the Dean of Undergraduate Studies and the Office of Student Conduct & Community Standards.

Mental Health and Wellness Resources

College can be challenging and stressful, but there are various resources here at CWRU to support students with concerns that could interfere with their learning and overall well-being.

- **University Health & Counseling Services:** UH&CS offers free services to all CWRU students. Their clinic at 220 Sears is open from 9 AM (9:30 AM on Thursdays) to 12 PM, and 1 PM to 4:30 PM, Monday–Friday. UH&CS can be reached by email at uhcs@case.edu or by phone at 216.368.5872. Counselors are on call 24/7 and may be reached at 216.368.5872. Further information may be found on the UH&CS website: <https://case.edu/studentlife/healthcounseling>.
- **Disability Resource Office:** In accordance with federal law, if you have a documented disability, you may be eligible to request accommodations from Disability Resources. To be considered for accommodations, you must first register with the Disability Resources office. Please contact their office to register at 216.368.5230 or get more information on how to begin the process at the following link: <https://case.edu/studentlife/disability/getting-started>. Please keep in mind that accommodations are not retroactive.
- **Office for Equity:** The Office of Equity is available to support anyone experiencing or who has experienced sexual harassment or misconduct, as well as discrimination and harassment. Further information may be found on their website: <https://case.edu/equity/>. Note that your instructors are Responsible Employees that are required by law to report actual or suspected incidents of sexual harassment/misconduct to the Office of Equity.

It is important to advocate for your own mental health, as well as the mental health of your fellow students. Please reach out to your instructor if you notice behavioral changes or are concerned about the wellbeing of one of your classmates.