Standing Instructions for Students (SIS)
CH365 Chemical Engineering Thermodynamics, AY2022-2023 (AY23-1)

REDBOOK DESCRIPTION

This course covers the body of thermodynamic knowledge necessary for understanding modern chemical process simulation. The course includes calculus- and numerical-based methods for determining the thermodynamic properties of substances, solutions, and multiphase mixtures. Topics include equations of state, pure component properties, properties of mixtures, fugacity, excess properties, activity coefficients, and phase equilibria. The problems in the course emphasize engineering applications. Topics covered in class are related to real systems using chemical process simulators.

COURSE INTRODUCTION, PHILOSOPHY AND OVERVIEW - (Beyond the Redbook)

A great deal of theory and operation of chemical process equipment is determined by the thermodynamic properties of the substances within the equipment. Differences in enthalpy, entropy, and Gibbs energy determine not only energy duty, but also how much performance we can ultimately expect from any given design. Furthermore, thermodynamics plays a role in the *optimization* of energy duty and performance.

For example, the design of a chemical reactor requires knowledge of how molecules react. This includes an understanding of the chemical kinetics of the reaction, or the rate at which molecules are converted. Since the holding time in the reactor must be large enough to obtain the desired conversion, the rate of reaction influences the reactor volume. However, there is more to the story. How do we know the desired conversion is feasible? The desired conversion *must* be thermodynamically consistent. That is, thermodynamics tells us how much chemical reaction is ultimately possible. Thus, the ability to predict the equilibrium constant and extent of reaction at equilibrium is critical for determining if the reactor design is plausible. Furthermore, since reactions require addition or removal of heat and the rate depends on temperature, thermodynamics tells us the amount of heat we need to add or remove from the system to sustain the reaction.

The same concepts apply to separation operations, but in slightly a different form. In your separations course, you learned that the design of separation equipment depends upon Raoult's Law K-values, Henry's Law constants, and partition coefficients in liquid-liquid extractors. These are all examples of forms of chemical equilibrium constants. This is the domain of thermodynamics. As an example, distillation tray design depends on the equilibrium distribution of the different substances between the vapor and liquid phases in the tray. In this course, we will show that the driving force

for mass transfer between phases is the difference in chemical potential between molecules in distinct phases. Chemical potential is a special form of equilibrium constant. It is true that the design also depends on movement of molecules, momentum, and heat, as well as the contact area available for movement between phases. These other properties are covered in your transport courses, but many of the physical properties used in the calculations are determined directly from thermodynamic methods.

In summary, this course is concerned with the properties of substances and mixtures of substances. You have already been exposed to some of this in your mechanical engineering courses, where you were introduced to the thermodynamics of pure substances. CH365 is a continuation of this theme, and the course objectives are listed below.

COURSE OBJECTIVES (What should you get out of this course?)

1. Understand how thermodynamic physical properties are calculated (and why is it important to be able to do so).
2. Understand the choices made by the CHEMCAD thermodynamics wizard and how to adjust them for specific cases.
3. Understand activity coefficients and why they are used.
4. Understand fugacity and fugacity coefficient and why they are used.
5. Know which thermodynamic methods are best for an application.
6. Understand how an equation of state allows calculations of properties like enthalpy and entropy.
7. When substances are mixed, know how the properties of the solution are calculated.

As in all courses, the course objectives are achieved through reading and study assignments, classroom lectures and lessons, graded homework problems, written partial reviews (WPRs), and writing assignments.

CONTACT INFORMATION

Instructor:	Dr. Biaglow
Office:	Room 441
Phone:	x4080
Classroom:	BH331, A1-hour (0740-0835), B1-hour (0845-0940)

TEXTBOOK

Introduction to Chemical Engineering Thermodynamics, 9th Edition, by J.M. Smith, H.C. Van Ness, M.M. Abbott, and M.T. Swihart. New York: McGraw-Hill, 2022. ISBN: 978-1-260-72147-8. Required, see CARD 800, USCC SOP.

GRADED EVENTS

1	Term End Examination (TEE) @ 500 pts.:	500	20.58%
1	Capstone Design Problem (CDP)	300	12.35%
3	CDP Progress Reports (IPRs) @ 30 pts	90	3.70%
3	Written Partial Reviews (WPRs) @ 200 pts. each:	600	24.69%
68	Homework Problems @ 10 pts. per problem:	680	27.98%
1	Writing Assignment @ 200 pts:	200	8.34%
1	SIS Quiz @ 60 pts:	60	2.47%
	TOTAL	2430	100.00%

LETTER GRADES

Letter grades in CH365 are based approximately on the scale shown in the table below. Prior to the TEE, letter grade equivalents can be computed at any time by dividing your earned points by the course point total. Please keep in mind that this is only an approximate scale and point cutoffs for final letter grades may vary somewhat from those shown here.

Letter Grade	Numerical Score	Letter Grade	Numerical Score	Letter Grade	Numerical Score	Letter Grade	Numerical Score
A+	97%	B+	87%	C+	77%	D	67%
A	93%	B	83%	C	73%	F	<67%
A-	90%	B-	80%	C-	70%		

GRADED EVENT POLICIES

Written Partial Reviews (WPRs) and Term-end Exams (TEE). Mastery of material is important and is assessed primarily through the WPRs and the TEE.

- WPRs are given during class and are allotted the full class period.
- Approved solutions will be made available immediately after the last exam. This could be several days if cadets schedule make-up exams.
- Cadets who know that they will be absent from a WPR must notify me via email at least 48 hours in advance.
- If you are absent on the day of an exam, you will be required to take either a make-up or make-ahead exam.
- In accordance with the Dean's policy in the buff card general information (paragraph 7), cadets may request relief from a WPR if you have more than two major graded event on the same day.
- Any requests for relief from an exam must be submitted via email. Include the reason for seeking relief in the request. You must also receive a written response from me to confirm the schedule change. Failure to follow this procedure will result in denial of your request.

- The TEE is scheduled during TEE week and is typically 3.5 hours. The date of the TEE will be posted as soon as it is available.

WPR Resubmissions. It is my philosophy that students should be offered a chance to learn from mistakes. When appropriate, you may be offered a chance to submit corrections of your errors to earn additional points on an exam. The amount of the credit available will depend on the average score for the WPR, but the total points awarded in this manner typically amounts to about 10-20% of your grade for the event.

WPR References. WPRs are normally open note, open computer, open book, and open web, unless announced otherwise. However, please note that with open exams comes the added responsibility for increased organization. You will not do well if you are disorganized. The exams are challenging, and preparation is required. If you assume that organization and preparation are not required, or if you organize poorly, you will be unable able to rapidly look up methods or implement them during the exam, and you will most likely do poorly. In my many years of experience, I have seen that students who are well-prepared always do better. Also, even though references are available during the exam, work must be individual, and you may not collaborate by sharing electronic files or by any other means. Use of references from outside of this course on an exam must be documented.

GRADED HOMEWORK. Homework consists of problem assignments aligned with the daily reading assignments. Homework is an important part of any engineering course, and this course is no exception. The homework is intended to illustrate and reinforce key concepts covered in both the classroom and the reading assignments. Assigned problems will be submitted for a grade. Problem solutions will be posted to the course web site after problem sets have been received from all cadets.

You are highly encouraged to work the problems using your computer with Mathematica and/or Excel. This serves two purposes. First, computerized problem solutions are useful during exams and for emailing me when you need assistance. Second, use of computer tech requires disciplined problem solving. You will develop an ability to organize your work in an "algorithmic approach," which is a fundamental skill in the engineering problem solving approach. Also, computers are quick but, in some ways, they are “dumb.” That is, while they are getting better, computers do not understand the way humans think and communicate. In order to communicate with the computer, you must learn how to organize your thoughts and express them in a manner that is understandable by the computer. This skill is a powerful learning method, and it works, provided you invest the individual effort in the process. Learning to interact with a

computer is like learning a foreign language, and like languages, there are always nuances and subtleties that empower you the more you use them.

The purpose of graded homework is to encourage frequent lesson preparation. To that end, homework problems will be collected and graded on a weekly basis. Each problem is worth 10 points and the problem sets contain different numbers of problems, so each problem set will vary somewhat in terms of total point value. The problem sets will range in value from 30 to 100 points and will have a total contribution toward your grade of 680 out of 2370 points. The sum of all problem sets for the semester is weighted to more than the value of the TEE (680 points versus 500 points for the TEE). This means homework grades can significantly raise or lower your final course grade.

Computerized problem solutions are easy to share, and you are completely free and encouraged to share and discuss problems with your classmates. I will warn you that this can be good or bad for you. Over-reliance on sharing or internet solutions can reduce your learning and, correspondingly, waste your time and your instructor's time. Try not to go to the well too quickly! I strongly advise that you try the problems on your own first and seek AI from your instructor or classmates as needed. It is far better if your instructor knows you are struggling than to present a false front by over-reliance on someone else's work. This could really hurt your exam scores when it comes time to prove your individual knowledge under time constraints.

Use of files from previous classes or from the internet is not discouraged. *However, use of solutions from previous years or from internet sources must be documented.* Not surprisingly, it is easy for me to recognize and confirm a cadet's work from a previous year. Failure to document may result in an approach for clarification. Please use extreme caution when using someone else's solution. You are ultimately responsible for knowing all aspects of the problems, and you will be expected to solve similar problems on exam. Copying solutions, even carefully, will not fully achieve this. Also, solutions change in subtle ways from year to year. An exact copy of a solution that received a specific grade in a previous year may result in a different score this year. This is because errors in the solutions are sometimes detected during reviews in subsequent years. Furthermore, my emphasis on details may change from year to year. Finally, alternate better solution methods are sometimes discovered from one year to the next, sometimes resulting from my own work or from unique cadet approaches. Also, be aware that problem solutions found online are often written by students (graduate or undergraduate) and frequently have errors or other issues.

Homework may be submitted in two ways, electronically or printed. Electronic submissions must be in pdf format in a single pdf document, contain a CAC-signed and CAC-initialed cover page, and be uploaded to SharePoint. Printed paper documents must include printouts of any Mathematica or Excel files used to solve the problem. Either submission version must be complete. You may not submit part of the document in print form and part electronic.

IMPORTANT NOTE: Graded homework, as well as all other graded assignments, MUST be documented in a manner that is consistent with the Documentation of Academic Work (DAW). Accordingly, **a signed cover sheet must be attached to all submissions completed outside of class**. Pages 29-31 of the DAW describe cover sheets for *electronic submissions*, which are important in this course. Page 34 has a sample cover sheet for electronic submissions. Appendices F and G cover the two approved methods for electronic submissions in detail. Your homework submission will be considered late until the approved procedures are followed. The DAW document is linked to the main course web page, along with a template cover sheet for electronic submissions. Submissions without a cover sheet will be returned to you and late policy will apply.

LATE HOMEWORK POLICY. Homework may be submitted late for a cut of 1 point per problem per day (including weekends and holidays). Date and time of late submissions must appear accurately on the cover page. After two days, the cut increases to 2 points per problem per day. Homework not submitted after four days will receive a zero grade. However, submission of all homework problems is required. You still need to submit the assignment even if you will receive a zero. Homework that is not submitted will result in a COR and an incomplete for the course.

HOMEWORK GRADING POLICY. The grading rubric and rubric procedure are shown below will be used to grade all homework problems.

Grade	Attributes
10	Cadets present complete problem solution and answers are correct.
4	Cadets present problem solution but answer is incorrect.
1	Cadet presents minimal work and answer is incorrect.
0	Solution is shown with no work.

Rubric Procedure:

1. Detailed grading comments will not be provided by instructor.
2. Cadets are responsible for reviewing the approved solutions and finding any mistakes.
3. Cadets may request a regrade upon correction of an assignment, subject to the following constraints:
    a. Corrections must be resubmitted under separate cover with a new title (e.g., PS10 Corrections).
    b. Resubmissions must be submitted within 48 hours of initial grade posting (weekends and holidays included). Beyond that time, requests for regrading will not be accepted.
    c. Cadets must notify the instructor in writing via email when the resubmission is posted in SharePoint.
    d. Resubmissions are worth 100% of the initial point value and late cut does not apply.
    e. Late initial submissions and problems with scores less than 4/10 are not eligible for a re-grade.
    f. You must identify in writing what you did wrong.
    g. You must make corrections to your work and verify the correction.
    h. If available, approved solutions can be used as a reference (see note 4 below).
4. Solutions will be posted by the instructor when all cadet work has been received. For the purposes of resubmission, you may use approved solutions to identify mistakes in your work. However, simply copying the instructor solution for resubmission will not change your grade. You must make corrections to your work and identify in writing what you did wrong. Approved solutions will not be posted until all cadet work has been received.

WRITING ASSIGNMENTS. You will have a writing assignment in this course. The writing assignment is designed to assist you with self-reflection on skills learned in our program, as well as for you to assess your own intellectual growth in this area. You will be asked to prepare a resume explaining your skills as a chemical engineer. Grades on this assignment depend on your ability to describe the material and projects in your academic courses and the skills you acquired as a result. The grade is iterative. That is, you will make a submission, receive feedback, and then make a resubmission. The resubmission allows you to make corrections and expand your professional skill set over the course of the semester, hopefully improving your grade.

CLASSROOM POLICY. Classroom activity will include interactive discussions, execution of classroom problems, homework problems, or other pertinent topics. Review sessions are scheduled at appropriate times during the semester to re-enforce classroom concepts and to allow time for discussion of concepts. You may use the review sessions to ask questions and work on homework problems. Classroom activities are organized and facilitated by the instructor. Discussions between cadets on topics not related to class will result in a COR.

COMPUTER USAGE DURING CLASS TIME. This class is conducted in the computer lab in Bartlett Hall. Computers are provided to assist you with assignments in this class. During class time, any computer activity not related to CH365 is prohibited. This includes but is not limited to emailing, texting, web surfing, and typing assignments for other classes. If you are observed using computers inappropriately, this will result in an immediate COR and possible deduction of points from your grade. I do not discourage you from bringing personal laptops to class, but I do not maintain laptop software or assist cadets with networking issues. Because of this, ***lab computers are required for exams and laptops are prohibited.*** Use of personal laptops during class time for any activity unrelated to CH365 is also prohibited. This policy will be strictly enforced.

CAPSTONE PROJECT. There is a capstone design project for this course. This project will require you to use an advanced thermodynamic method to replicate calculations in Aspen+ and CHEMCAD. The assignment will be posted on lesson one and is due lesson 40. You are cautioned that this project cannot be completed in one day. There will be parts that you can do early in the semester, and there are parts that will require much more work and study. You are encouraged to read through the assignment, plan how you will achieve the objectives, and begin working now. More information on the capstone project can be found on the course website.

ADDITIONAL INSTRUCTION (AI). AI in this course is encouraged. My policy on AI is that I maintain an open door for CH365 students provided I am not otherwise engaged. You may stop in without an appointment, and if I am available, I will meet with you. If I am not available, I will ask you to leave. I strongly encourage the use of appointments where feasible. Appointments work to your advantage since they will guarantee my presence, one-on-one attention, and priority over walk-ins.