CBE:3105 Chemical Engineering Thermodynamics
Spring 2017

COURSE DESCRIPTION:

Chemical Engineering Thermodynamics reviews the principles of thermodynamics and concentrates on applying them to various unit operation and chemical processes important to chemical engineers. Based on this background, prediction of material properties will be examined and phase equilibria and chemical equilibrium will be applied to mixtures and reacting systems.

PREREQUISITE: ENGR:2130 Fundamental of Thermodynamics
If you have not completed the prerequisite course, please contact the instructor immediately.

LECTURES: Time: 12:30 - 1:30 PM Monday Wednesday Friday
Place: 3505 SC

DISCUSSION & PROBLEM SOLVING SESSION
Time: 6:30 – 7:20 PM Monday
Place: 3505 SC

INSTRUCTORS: Primary Instructor,
Prof. Charles Stanier; Office 4122 SC; Phone (319) 335-1399;
charles-stanier@uiowa.edu,
Office Hours: Location 4122 SC. Times To Be Posted on Course Website.

TEACHING ASSISTANTS: Madeline Hess, Madeline-hess@uiowa.edu
Madison Murhammer, Madison-murhammer@uiowa.edu

Office Hour times and locations: To Be Posted on Course Website

COURSE LEARNING GOALS:

1. By the end of the course, the student will understand and be able to apply the laws of thermodynamics to open and closed systems.
2. By the end of the course, the student will have acquired a fundamental knowledge of thermodynamic properties of pure substances.
3. By the end of the course, the student will have acquired a fundamental knowledge of thermodynamic properties of solutions in single and multiphase systems.
4. By the end of the course, the student will have acquired a fundamental knowledge of vapor-liquid equilibrium and be able to solve VLE problems using simple models (e.g. Raoult's or modified Raoult's laws) and more complex models (gamma-phi formulation).
5. By the end of the course, the student will be able to apply thermodynamic principles to steady-state flow processes such as nozzles, turbines and pumps.
6. By the end of the course, the student will have acquired a fundamental knowledge of chemical reaction equilibrium and be able to determine the equilibrium composition in equilibrium reaction systems.

7. By the end of the course, the student will have had opportunities to further his or her professional development through practicing written, oral and graphical communication skills; working successfully within an assigned team and understanding the nature of teamwork; and successfully using modern computer tools to solve engineering thermodynamic problems.

WEBSITE: http://icon.uiowa.edu The site will contain the course calendar, class notes, assignments, announcements, etc.

TEXT: Introduction to Chemical Engineering Thermodynamics, Seventh Edition, J. M. Smith, H. C. VanNess, M. M. Abbott, 2005

COURSE GRADING:

3 Midterm Exams	45%
Final	20%
Project	7%
Assignments	12%
In class quizzes	6%
Clicker questions	5%
Engagement score (based on attendance and completion of assignments – see "Engagement Requirement" below)	5%

Grades are calculated separately for each category of assessment above. For the exams, quizzes, and project, grades are calculated by two methods and students receive the higher of the two grades. Method one uses the absolute grade scale below. Method 2 uses a curve formula $Z = (x-\mu)/s$ where instructor chosen values of μ and s are used to calculate a normalized performance. The value of μ is chosen by the instructor that corresponds to approximately a B+ on the exam or quizzes. This is sometimes adjusted up (down) to account for particularly good (below expectation) performance of the class on specific exams. For the categories of assignments and attendance, the absolute scale below is used.

90-100%	A
80-90%	B
70-80%	C
60-70%	D

COURSE COMPONENTS:

Exams. All exams may have both open and closed book sections. 3 exams will be given throughout the semester at approximately equal intervals. Each of these exams will be two hours long and given outside of typical class times, most likely on Wednesday evenings (6:30-8:00 PM). The final exam will be comprehensive and given during finals week. The date for the final exam will be published by the registrar's office sometime later during the semester.

Midterm evening exam dates. 6:30 to 8:00 PM
(Locations to be announced, and date/times to be confirmed)

Thur Feb 16
Thur Mar 23
Thur Apr 27

Office Hours. Office hours are an important component to learning in this course. Both instructor and TA office hours are held weekly for 1 or 2 hours. All students should take advantage of office hours during the semester.

ICON/Canvas. Extensive postings regarding the course will be on Course Website, including calendar information, study aids for exams, and announcements.

Textbook. Students should independently read the textbook chapters covered in the class, note any questions, review all example problems, and bring up their questions regarding the textbook in class, in discussion section, or in office hours. The lectures are not a replacement for reading the textbook.

Discussion Sections. Teaching assistant will work example problems during the discussion section. Students may be asked to work in small groups on problems as well. Attendance of discussion section falls under the engagement requirement of the course (see below).

Student Response Devices / Clickers. Student response devices are mandatory and will be used during most class periods. Please register your response devices (clickers) on ICON. The student response devices will be used to (1) gage attendance and (2) test students on concepts recently introduced in the textbook or reading. The attendance / student response grade will be weighted as follows: ½ for attendance and for attempting clicker problems; ½ for correctly completing the clicker problems.

Electronic Communication: The course management system discussion board can be used for anonymous or attributed questions, notifications can be set to send you an email when the discussion board is updated, and a daily digest of discussion board activity can be emailed from the course management system to you.

Engagement Requirement. All students are required to engage with the material by working the homework problems, asking questions, reading the textbook, and attending lectures, discussion sections, and/or office hours. The instructors and TA will help students engage using the following system:

- Based on instructor discretion (instructor will use attendance, pretest results, quiz scores, participation, completion of assignments, and quality of completed assignments, etc.) each student will be classified as follows:
    - Instructor-monitored engagement (2 sessions per week required)
    - Instructor-monitored engagement (1 sessions per week required)
    - Student-monitored engagement (0 sessions per week required)

  A "session" is attendance of a discussion section, attendance of office hour, completion of a test reflection, or turning in of an assignment 48 hours (or more) early for TA or instructor feedback followed by a meeting to discuss the assignment. With instructor or TA prior permission, working of practice problems, reworking of

an assignment or quiz and meeting with an instructor or TA to discuss the work will also count as a "session."

Classification of students will be reevaluated periodically. Level of engagement will be weighted heavily in considering whether to reduce the number of required "sessions" or to move from instructor- to student-monitored engagement.

Homework. Homework assignments will be given throughout the semester, on approximately a weekly basis. Each assignment will be distributed at least one week before the date they are due. These assignments will build on concepts discussed in class and in the book. Students are encouraged to begin assignments early to allow time to ask questions before they are due. Assignments will be collected at the beginning of class on the due date. Late homework may be accepted with prior approval of the instructor. Unstapled homework will not be accepted; homework with ragged edges (torn from spiral notebook) will not be accepted. And homework that is illegible or of marginal legibility will not be accepted.

In grading homework (and exam) problems, emphasis will be on a correct approach to the problem. Discussion of homework problems with classmates is permitted; however, copying of solutions is not. Homework will be used in two manners: one, all homework will be graded on whether a significant attempt was made at solving the problems (50% or more of credit). In addition, one problem will be graded in detail on most (but probably not all) of the assignments (up to 50% of credit).

Policy on dropping of exams. If the average of your problem set grade is **85%** or higher, then the lowest exam score (possibly including the final, see below) will be dropped, and the average of your highest three tests will replace your lowest test score! In computing this score, the lowest detailed homework score will be dropped.

For dropping the final exam, there are two additional requirements:

- For students to drop the final exam (or to skip the final exam completely), they must have a 70% or higher average on any quizzes that have material taught after midterm 3. The instructor will announce when the quizzes begin to cover material that is beyond midterm 3.
- For students to drop the final exam (or to skip the final exam completely), perfect attendance after midterm 3 is required.

Always include the proper units throughout your calculations and in the final answer. Credit will not be given for answers without the proper units. Lay out your problem neatly and place a box around the final answer for your problem.

Quizzes. Up to 8 quizzes will be given throughout the semester. They will be based on recent lectures and homework. Each quiz will be announced the class period beforehand unless class attendance warrants unannounced quizzes. No quizzes will be dropped, and make up quizzes will not be given. Missed quizzes due to an excused absence will not be used in the calculation of the individual student's grade. Missed quizzes due to unexcused absence will receive a zero. See minimum quiz grade requirement above (in exam exemption section).

Project. The project will consist of a group report and presentation on an industrial relevant chemical thermodynamic process. Connections to elements in the course must be included.

Guidelines on Academic Misconduct and Other Matters

- Cheating on hour exams, midterms, or final exams will result in an F in the course. Examples of cheating include but are not limited to looking at your neighbor's exam papers, discussing problems during an exam, or copying answers from another exam paper.
- Cheating on a quiz will result in a zero for the quiz portion of the class (e.g. a zero for all quizzes in the class). Examples of cheating include but are not limited to looking at your neighbor's quiz papers, discussing problems during a quiz, or copying answers from another exam paper.
- Any use of a solution manual (including electronic) for the textbooks used in this course is considered academic misconduct and is not appropriate. Any use of previous year homework solutions, or completed assignments from previous years, or exams (other than those provided on the Spring 2017 course website) is defined as academic misconduct.
- Looking at the exam or quizzes of others, even if nothing is copied from them, is academic misconduct. Any communication with others (verbal, electronic, gestures, etc.) is academic misconduct.
- **Direct copying of homework is academic misconduct and will in sanctions.** Detailed problems will be intercompared as a detection of copying from other students or from a solution manual. Copying from other students or from a solution manual is academic misconduct. Penalties for this misconduct are up to the instructor and can be up to a zero on all homework assignments, and referral to the dean's office.
- Appropriate collaboration on homework – individual assignments.
    - Collaboration is encouraged. Appropriate collaboration on homework is working together on the assignment, without viewing the work of others until you have completed the assignment independently.
    - DO's
        - Collaborate by posting questions to a class discussion board, if one exists
        - Work together
        - When assisting a friend, ask them questions that will help them test their understanding and develop the solution logic themselves.
        - Verbally compare intermediate and final answers
        - Work with others as a tutor would work with a student – help them learn the material and not just complete the problem
        - Create your own spreadsheets to solve computer-aided problems, even if working as a group
        - Help your teammates understand and develop the skills of problem setup, equation selection, and determination of negligible/non-negligible terms
    - DON'T (these are academic misconduct)
        - Look at or copy the written work of other students before you are fully complete with the problem or problem set
        - Show your written work to others before they are finished with the problem set
        - Copy spreadsheets and computer programs
        - Give out copies of spreadsheets and computer programs
        - Use previous year solutions or solution manuals
        - Give out answers
- Appropriate collaboration on group assignments

    - DO's
        - Be honest about your contribution to the work – when completing surveys or talking with the instructor or students
    - DO NOT
        - Claim credit for work you didn't do. If you didn't contribute at all to a group project, then your name shouldn't be on the report or presentation. Let the instructor know.
- If academic misconduct is suspected by the instructor, College of Engineering policies will be used to investigate and (if needed) take action in terms of repercussions against the student. See http://www.engineering.uiowa.edu/current-students/academic-misconduct.php
    - A discussion with the suspected student will be held. If the suspicion of academic misconduct cannot be cleared by the discussion, it will (possibly after discussion at a CBE Department faculty meeting), be documented in writing, a zero will be assigned to the appropriate portion of the class (attendance, quiz, or homework), and the documentation will be submitted to the Dean of Engineering office. The student may appeal to the dean's office. For 2nd offenses, the Dean's office may take additional actions against the student (cancellation of the student's registration, disciplinary probation, suspension from the College, or recommendation of expulsion from the University)
- Cheating lowers the morale of all students, and makes grading less fair. If you are aware of cheating, use of solution manuals, or academic misconduct, please report it to the instructor. Please be specific if possible. Your report can be made anonymously if you like (print it out and slip it under my office door, for example). If you are a "whistleblower" of this type, your name will not be released. Disciplinary action will not be taken directly based on your evidence, but scrutiny by the TA and instructor will increase.

Additional Policies

Accommodations for Disabilities. If you feel that you may need an accommodation based on the impact of a disability please contact Prof. Charles Stanier privately to discuss your specific needs. You may also contact the Office of Student Disability Services (319/335-1462) to discuss the accommodations that are available for students with documented disabilities.

Policy on Make-up Assignments. A student may request to turn in an assignment late in the case of an illness or unavoidable situation. Students should get prior approval from the instructor to reschedule the assignment if there is a professional schedule conflict.

Policy on Cross Enrollments. This course is given by the College of Engineering. This means that class policies on matters such as requirements, grading, and sanctions for academic dishonesty are governed by the College of Engineering. Students wishing to add or drop this course after the official deadline must receive the approval of the Dean of the College of Engineering. Details of the University policy of cross enrollments may be found at:
http://www.uiowa.edu/~provost/deos/crossenroll.doc.

Complaint Policy. If you feel that we have treated you unfairly or acted unprofessionally or otherwise failed to meet our responsibilities as instructors, please bring the matter to our attention so that we can work together to resolve the problem. If you remain unsatisfied you may contact (choose one) the chair of our department, [Alan Guymon, 335-1400]. If your concerns have still not been resolved at that point, you may submit a written complaint to the Associate Dean for Academic Programs, 3100 SC (335-5764) (for undergraduates), the Graduate College, 205 Gilmore Hall, 335-2137 (for graduate students).

Policy on Sexual Harassment. Sexual harassment is illegal and will not be tolerated. The course will follow guidelines set forth in University of Iowa policies.

CHEMICAL ENGINEERING THERMODYNAMICS

COURSE OUTLINE

1. **Introduction/Course overview** [1.5 lectures, S&VN Chapter 1]
    a. Class Data
    b. Course Components
    c. Work, Energy, Heat

2. **The First Law and Other Basic Concepts** [2.5 lectures, S&VN Chapter 2]
    a. Joule's Experiments, Internal Energy
    b. The First Law of Thermodynamics
    c. Energy Balance For Closed Systems
    d. Thermodynamic State and State functions
    e. Equilibrium
    f. The Phase Rule
    g. The Reversible Process
    h. Constant V and Constant P Processes
    i. Enthalpy, Heat capacity
    j. Mass and Energy Balances for Open Systems

3. **Volumetric Properties of Pure Fluids** [3 lectures, S&VN Chapter 3]
    a. PVT Behavior of solutions
    b. PV Curve
    c. Critical Behavior
    d. Single Phase
    e. Equation of States, Ideal Gas
    f. Virial Equations
    g. Cubic Equations of State
    h. Corresponding states
    i. Thermodynamic Relations for Ideal Gases

4. **Heat Effects** [1.5 lectures, S& VN Chapter 4]
    a. Sensible Heat
    b. Latent Heat
    c. Heat of Reaction

5. **Second Law of Thermodynamics** [3 lectures, S& VN Chapter 5]
    a. Statements of the 2nd law
    b. Heat Engine
    c. Carnot Cycle
    d. Entropy
    e. Entropy Change for an Ideal Gas
    f. More on 2nd Law
    g. Entropy Balance for Open Systems
    h. Ideal Lost Work
    i. Third Law
    j. Statistical Thermodynamics

6. **Thermodynamic Properties of Fluids [**3 lectures S& VN Chapter 6]
    a. Phase rule, Thermodynamic Relationships
    b. Maxwell Equations
    c. More Thermo Relationships
    d. Residual Proprties
    e. Two Phase Systems
    f. Thermo diagrams/Tables
    g. Generalized Correlations of Thermodynamic Properties for Gases

7. **Thermodynamics of Flow Processes** [1 lecture, S& VN Chapter 7]
    a. Duct flow of compressible fluids
    b. Turbines
    c. Compression Processes
    d. Pumps

8. **Heat to Work** [1 lecture, S& VN Chapter 8]
    a. Steam Power Plant
    b. Internal Combustion engines

9. **Vapor Liquid Equilibrium [**3 lectures, S& VN Chapter 10]
    a. Equilibrium
    b. Phase Rule/Duhem's Theorum
    c. VLE behavior
    d. Simple VLE models – Raoult's law VLE calculations
    e. Problem solving Strategies
    f. Henry's Law
    g. Modified Raoult's law
    h. Azeotrope
    i. VLE from K-value
    j. Flash calculations

10. **Solution Thermodynamics** [2.5 Lectures S& VN Chapter 11]
    a. Fundamental Properties
    b. Chemical Potential and Phase Equilibria
    c. Partial Properties
    d. Ideal Gas Mixture
    e. Fugacity and Fugacity Coefficient
    f. General Correlations for Fugacity coefficient

11. **Solution Thermodynamics VLE and Mixing** [1.5 Lectures S& VN Chapter 12]
    a. Liquid Properties from VLE data
    b. Excess Gibbs free Energy
    c. Data Reduction
    d. Property Changes of Mixing
    e. Enthalpy of Mixing

12. **Chemical Reaction Equilibria** [1.5 Lectures S& VN Chapter 13]
    a. Reaction Coordinate
    b. Reaction Equilibrium
    c. Single Phase Reactions