Spring 2019

CHE 342-002: Chemical Engineering Thermodynamics II

Gennady Gor

1. **ChE 342 - Chemical Engineering Thermodynamics II**
2. **Credits and contact hours:** 3-0-3 (3 lecture hr/wk - 0 lab hr/wk - 3 course credits)
3. **Course Coordinator or Instructor:** Gennady Gor
4. **Textbook:** Fundamentals of Chemical Engineering Thermodynamics, Kevin D. Dahm, Donald P. Visco, Cengage Learning, (2014). ISBN: 1111580707
5. **Specific course information**
    a. **Description:** The principles and methods developed in Chemical Engineering Thermodynamics I are extended to multicomponent systems, and used to treat phase and chemical equilibrium as well as such applications as chemical reactors and refrigeration systems.
    b. **Prerequisites:** ChE 230, Math 211 (or Math 213), Chem 236
    c. **Required, Elective, or Selective Elective** - Required
6. **Specific goals for the course**
    a. A student should be able to:
        1. Calculate efficiencies for reversible and practical cycles, such as Carnot, Rankine & Brayton
        2. Calculate heat absorption and heat rejection rates for cycles
        3. Calculate work of turbines & pumps
        4. Analyze internal combustion engines & gas turbine engines
        5. Analyze refrigeration cycles & liquefaction processes
        6. Apply Raoult's law and Henry's law to solve thermodynamics problems
        7. Predict behavior from liquid/vapor phase diagrams including azeotropes
        8. Carry out bubble and dew point calculations for a given mixture
        9. Calculate partial properties of binary solutions, such as partial molar volumes
        10. Calculate activity coefficients using correlating equations such as Margules and Lan Laar
        11. Determine VLE using ideal gas and ideal solution models
        12. Analyze appropriate models for calculating phase equilibrium
        13. Interpret phase diagrams of binary systems
        14. Calculate vapor-liquid equilibria for non-electrolyte systems
        15. Predict equilibrium compositions of mixtures under phase equilibria
        16. Apply concepts of equilibria of multi-component, multi-phase systems to the evaluation and design of separation processes, such as distillation
        17. Estimate the fugacity coefficients for given mixtures
        18. Analyze ideal gas/solution models that reflect behavior of real mixtures based on concepts of excess free energy and chemical potential
    b. This course explicitly addresses the following student outcomes: 1
7. **Topics**
    1. Heat Engines
    2. Refrigeration Processes
    3. Vapor-Liquid Equilibrium
    4. Solution Thermodynamics
    5. Solution Thermodynamics Applications
    6. Chemical Reaction Equilibria

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Instructor: Dr. Gennady Gor, Assistant Professor
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Class: Tuesday, Thursday, 4:00-5:20 PM; Room: Kupfrian Hall 206
Office Hours: Tuesday 9:00-10:00 AM; Thursday 2:30-3:30 PM; Room: Tiernan Hall 373

Course Description and Requirements

This course will cover heat engines, refrigeration, thermodynamics of mixtures, phase equilibrium and chemical-reaction equilibrium. Solid knowledge of chemical engineering thermodynamics including these topics is necessary to succeed in more advanced chemical engineering courses. In particular, the current course is a pre-requisite for ChE 349 Kinetics and Reactor Design and ChE 360 Separation Processes I.
Pre-Requisites: ChE 230, Math 211 (or Math 213), Chem 236

Course Objectives

Taking this course, a motivated student will learn to:

- Use the laws of thermodynamics to analyze basic power and refrigeration cycles.
- Apply both fundamental and practical knowledge of thermodynamics to the design of basic power and cooling cycles.
- Apply concepts of thermodynamic to solutions.
- Determine equilibrium compositions of chemical reaction products and two-phase liquid/vapor mixtures.

Learning Materials

Textbook Required: Fundamentals of Chemical Engineering Thermodynamics, Kevin D. Dahm, Donald P. Visco (2014). ISBN: 1111580707
Additional: Introduction to Chemical Engineering Thermodynamics, Seventh Edition, J.M. Smith, H.C. Van Ness and M.M. Abbott, McGraw-Hill (2005). ISBN: 0-07-310445-0

Other Learning Material: The textbook is the main source for preparing for classes and reading the textbook before each class is necessary. Additional materials will be posted on Moodle.
Calculator: A high-end calculator (TI-83, TI-84 or TI-84SE) is required for solving exam problems.
Software: Use of Matlab, Python or other computational software is strongly recommended for working on homework assignments.

Course Outline

	Date	**Topic** (preliminary, subject to minor changes)
1.	Jan. 22	Recollection of Thermo I and PChem.
2.	Jan. 24	Carnot Cycle (PV and TS diagram).
3.	Jan. 29	Rankine Cycle.
4.	Jan. 31	Vapor Compression Refrigeration Cycle.
5.	Feb. 5	PH-diagrams. Examples.
6.	Feb. 7	Examples on Refrigeration.
7.	Feb. 12	Basics of Liquefaction. Joule-Thomson Process.
8.	Feb. 14	Liquefaction. Linde and Claude Processes.
9.	Feb. 19	Midterm 1.
10.	Feb. 21	Phase Equilibrium for Pure Components: Gibbs Free Energy.
11.	Feb. 26	Phase Equilibrium for Pure Components: Vapor Pressure.
12.	Feb. 28	Chemical Potential and Fugacity.
13.	Mar. 5	Fugacity from EOS. Poynting Method.
14.	Mar. 7	Introduction to Mixtures.
15.	Mar. 12	Properties of Mixing. Partial Molar Properties.
16.	Mar. 14	Partial Molar Properties of Binary Mixtures.
17.	Mar. 26	Pxy and Txy Diagrams. Raoult's law. Bubble and Dew Points Calculations.
18.	Mar. 28	Dew T calculation. Two-component PT Flash. Lever Rule.
19.	Apr. 2	Midterm 2.
20.	Apr. 4	Three-component Flash. Modified Raoult's Law. VLE Calculation Based on it.
21.	Apr. 9	Phase Equilibrium for Mixtures. Mixture Fugacity.
22.	Apr. 11	Raoult's and Henry's Laws from Mixture Fugacities.
23.	Apr. 16	Fugacity from Generalized Correlations and Virial EOS.
24.	Apr. 18	Gibbs Free Energy Models. One- and Two-parameter Margules Equation.
25.	Apr. 23	Data Reduction Procedure Using Margules Equation.
26.	Apr. 25	Wilson and Van Laar Equations. Thermodynamic Consistency. Integral Test.
27.	Apr. 30	Basics of Chemical Reactions Equilibrium.
28.	May 2	P and T Effects on Reaction Equilibrium. Van't Hoff Equation.

Assessment and Grading

Homework: Homework assignments will be given regularly, at least once a week. The assignments will be posted on Moodle. The homework (including both reading and problems assignments) must be completed by Tuesday's class of the week following the assignment, unless otherwise is explicitly stated. Most of the homework will not be graded, unless explicitly announced. The homework material will be included in quizzes.

Quizzes: Regular quizzes will be given based on the homework material, including both concepts and problems. The quizzes will not be announced in advance, so please be prepared to have a quiz during every class. No make-up quizzes will be allowed. All quizzes will be closed book with no material allowed. The quizzes will often take place at the beginning of the class, so being on time is strongly encouraged.

Exams: There will be two midterm exams (1.5 hours long) and one final exam (2.5 hours long). All exams will be closed book, however a handwritten sheet (double-sided, letter size) with materials

used to prepare for midterm exams will be allowed. For the final exam two sheets are allowed. Shared or copied preparation sheets, as well as use of any electronic materials will be considered as a violation of academic integrity.

Homeworks and Quizzes	25%
Midterm #1	20%
Midterm #2	25%
Final Exam	30%
	100%

Percent	Grades
above 85%	A
above 80%	B+
above 75%	B
above 70%	C+
above 65%	C
above 55%	D
below 55%	F

Important Dates

- Midterm exam #1: February 19, 2019
- Midterm exam #2: April 2, 2019
- Final exam: between May 10 and 16, 2019
- Withdraw Deadline: April 8, 2019

Policies

NJIT Honor Code: The NJIT Honor Code will be upheld and any violations will be brought to the immediate attention of the Dean of Students.
Special Needs: If you need accommodations due to a disability please contact Chantonette Lyles, Associate Director of Disability Support Services, Fenster Hall Room 260 to discuss your specific needs. A Letter of Accommodation Eligibility from the Disability Support Services office authorizing your accommodations will be required.
Lectures

- Attendance is strongly recommended. Attendance sheet has to be signed at the beginning of each class. The examples discussed in the class are not necessarily from the main textbook and therefore missing a class will have consequences for preparation to quizzes and exams.
- The classes start at 4:00, and the students must be in class by that time. Being late to class may have consequences for the grade, since many of the classes will start from quizzes.
- Electronic devices other than calculators (laptops, tablets, cell-phones etc.) are not permitted during the classes. No audio or video recording is allowed.
- Cellphones should be turned off during both lectures and exams and not allowed under any circumstances.
- Laptops will be permitted only if necessary for class activities.
- No eating any time during the classes.

Course materials, office hours and correspondence

- The course Moodle page is the main platform for delivering information about the course. All relevant course materials and assignments will be posted on Moodle, so a student should check it regularly.
- The students have to upload a professional-looking head shot for their Moodle profile.
- The students are strongly encouraged to attend Office Hours held bi-weekly. Long questions, which require derivations will be discussed only during the Office Hours and will not be answered by email. Questions regarding grades can be discussed only during the Office Hours.
- E-mail and Moodle correspondence is intended only for quick questions. Questions which require a detailed discussion should be discussed in person during the Office Hours.
- All correspondence should be conducted in a professional style, using formal English.
- To assure quick response to your emails, please add "ChE342" in the subject of your emails.
- The instructor reserves the right not to respond to emails if the email does not have a greeting or a signature.

Exams, Quizzes, Homeworks and Grades

- A letter grade is based on the final score, calculated using an Excel spreadsheet in accordance with the Tables given in this syllabus. The assigned letter grade is final and cannot be negotiated.
- A student can dispute the exam scores within a week after the announcement of the score. Exam scores can be disputed during the official Office Hours, not during class time or via email.
- The graded exams must be returned within a week to be saved for the department course assessment initiative. If a student does not return the exam, the grade for this exam is zeroed.
- Students will get zero for not coming to quizzes, exams, or any other course activity. If students miss an exam due to extreme circumstances (such as a medical problem), they need to notify the instructor via email before the beginning of the exam, and bring proof of the circumstance to the Dean of Student's office. Only in the case of official approval from the Dean of Student's office, may a make-up be given at the discretion of the instructor.
- A student must show as many details when solving a problem during an exam of a quiz. Not showing the work will cause losing points even if the final answer is correct.
- Partial credits can be given for solving the exams problems.
- No partial credit will be given if there is not enough details to follow.
- The final answer should be always evaluated with respect to its reasonability. No partial credit will be given if the final answer is wrong and unreasonable, and it is not stated.
- There will be no partial credits for the questions/problems on quizzes.
- Each quiz or homework is worth 2.5% of the overall grade. However, there will be 12 homeworks/quizzes, not just 10. Therefore, even missing 2 quizzes (or getting zeros on them) one still can get the full 25%.
- If a student misses a quiz due to a legitimate reason (absence approved by the Dean of Students), this quiz is excluded from the calculation, and the weights of the quizzes are scaled proportionally.
- Student handwriting must be legible in order to receive points.
- A student coming to dispute a grade has to bring completed homework sheets. No discussion of grades will be held without completed homework.