155:309 Chemical Engineering Thermodynamics II Fall 2017

Lectures: Monday & Wednesday, 8:40 a.m. –10:00 a.m.
BME-102, Busch

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Course Description: In this course, students will learn and apply the principles and methods of thermodynamics to analyze and solve equilibrium thermodynamics problems encountered in chemical and biochemical engineering. The course provides opportunities for students to (i) analyze and interpret thermodynamic data, (ii) identify, formulate, and solve chemical engineering thermodynamics problems, and (iii) apply advanced thermodynamic techniques and tools necessary for engineering practice.

Students will learn advanced thermodynamic methods and computational techniques to model properties of fluids and their mixtures, phase equilibrium, and chemical reaction equilibrium relevant to chemical, petrochemical, and pharmaceutical industries. Understanding of these topics is required for later courses and essential for development of a career in chemical engineering.

Knowledge, Abilities, and Skills Students Should Gain From This Course:

Students who have successfully completed this course will be able to: 1) understand the principles of physical and chemical equilibrium; 2) employ thermodynamic models to estimate equilibrium properties of fluid mixtures relevant to design of separation processes based on liquid-vapor, liquid-liquid and liquid-solid equilibrium; 3) apply engineering techniques and computational tools to calculate and predict thermodynamic properties.

The material covered in this course (155:309) forms the foundational basis for the topics of phase equilibrium, fugacity, and chemical reaction equilibrium. Thermodynamics plays an important role in chemical engineering science and applications including 155:324 Design of Separation Processes, 155:427 and 155:428 Chemical & Biochemical Engineering Design & Economics. Thermodynamics is one of the pillars of chemical engineering.

Textbook (required):

M. D. Koretsky, "Engineering and Chemical Thermodynamics," John Wiley & Sons, NJ, 2nd edition (2013)

Suggested textbook (not required):

S. I. Sandler, "Using ASPEN Plus in Thermodynamics Instruction – A Step-by-Step Guide," John Wiley & Sons, NJ (2015)

Assessment:

Attendance: 5%, Homework & Project: 35%, Exams 60%

Weekly Homework:
Homework assignments will be handed out at least one week in advance of their due dates. Homework will be collected before class starts on the due date. Late homework will not be accepted. Any homework that is not submitted will receive the grade of zero.

Course Content:
Thermodynamic properties of mixtures; ideal gas and ideal solution models; partial fugacity of gaseous and liquid phases; properties change of mixing and partial molar properties; excess functions and activity coefficients for non-ideal solutions; phase equilibrium and phase diagrams; phase equilibrium calculations; colligative properties; chemical reaction equilibrium.

1. **REVIEW OF THERMODYNAMIC CONCEPTS** chapters 4 and 5
   Inter-molecular forces; equation of states; thermodynamic web; calculation of changes of thermodynamic properties for pure substances.

2. **PHASE EQUILIBRIUM OF PURE SUBSTANCES** chapter 6
   Gibbs energy; pure species phase equilibrium; Clapeyron equation and Clausius-Clapeyron equation, phase transitions.

3. **THERMODYNAMIC PROPERTIES OF MIXTURES** chapter 6
   Thermodynamic properties of mixtures; Properties change of mixing; Partial molar properties; Mixture property relations; Models for gas mixtures – ideal gas mixture and ideal gaseous solution models; Models for liquid solutions – ideal liquid solution, non-ideal solutions; Thermodynamic properties of gaseous and liquid mixtures.

4. **PHASE EQUILIBRIUM INVOLVING MIXURES** chapter 7
   Condition of phase equilibrium; Partial fugacity and partial fugacity coefficient; Partial fugacity of gaseous mixtures; Calculation of fugacity using mixture equations of states; Partial fugacity of liquid solutions; Excess properties; Activity and activity coefficients; Determination of activity coefficients from experimental data; Excess Gibbs energy and activity coefficient models; Standard states; Lewis fugacity rule and Henry's law.

5. **APPLIED PHASE EQUILIBRIUM** chapter 8
   Vapor-liquid equilibrium; Phase diagram; Raoult's law and modified Raoult's law; Bubble point, dew point and flash calculations; Azeotropes; Liquid-liquid equilibrium; Vapor-liquid-liquid equilibrium; Solid-liquid equilibrium; Solid-solid equilibrium; Colligative properties

6. **CHEMICAL REACTION EQUILIBRIUM** chapter 9
   Standard Gibbs energy of reaction; Equilibrium constant and its temperature dependence; relation of equilibrium constant to compositions involving gas and condensed phases; multi-reaction equilibria.

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As an academic community dedicated to the creation, dissemination, and application of knowledge, Rutgers University is committed to fostering an intellectual and ethical environment based on the principles of academic integrity. Academic integrity is essential to the success of the University's educational and research missions, and violations of academic integrity constitute serious offenses against the entire academic community. This academic integrity policy is designed to guide students as they prepare assignments, take examinations, and perform the work necessary to complete their degree requirements.

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- properly acknowledge and cite all use of the ideas, results, or words of others
- properly acknowledge all contributors to a given piece of work
- make sure that all work submitted as his or her own in a course or other academic activity is produced without the aid of unsanctioned materials or unsanctioned collaboration
- obtain all data or results by ethical means and report them accurately without suppressing any results inconsistent with his or her interpretation or conclusions
- treat all other students in an ethical manner, respecting their integrity and right to pursue their educational goals without interference. This requires that a student neither facilitate academic dishonesty by others nor obstruct their academic progress
- uphold the canons of the ethical or professional code of the profession for which he or she is preparing.

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