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DEPARTMENT OF CHEMICAL ENGINEERING
College of Engineering
University of the Philippines Diliman, Quezon City

COURSE SYLLABUS
ChemE 123 Chemical Engineering Thermodynamics II

A. Course Catalogue Description

1. **Course Number:** ChemE 123
2. **Course Title:** Chemical Engineering Thermodynamics II
3. **Course Description:** Thermodynamic properties of homogeneous mixtures; phase and reaction equilibria; calculations involving equilibrium models as applied to chemical engineering systems
4. **Prerequisite:** ChemE 106 Mathematical Methods in Chemical Engineering II and ChemE 122 Chemical Engineering Thermodynamics I
5. **Semester Offered:** Second Semester
6. **Course Credit:** 3u
7. **Number of Hours:** 3h
8. **Meeting Type:** lecture
9. **Course Goals:** To provide an adequate knowledge of solution thermodynamics and chemical reaction equilibria in different chemical engineering processes

B. Rationale

This course covers the principles of phase equilibrium, including the different thermodynamic models used to quantitatively define multiphase fluid systems and real fluids in chemical engineering processes. It also covers the discussion on chemical reaction equilibrium and how the different thermodynamic variables affect the extent of conversion of the reactants into products.

C. Course Outline

1. Course Outcomes (CO)

Upon completion of the course, students must be able to:

- **CO 1.** solve vapor-liquid equilibrium problems for both ideal and non-ideal solutions;
- **CO 2.** derive phase equilibrium, chemical equilibrium, and other thermodynamic property relations from fundamental property relations using concepts of physical chemistry and techniques in calculus;
- **CO 3.** analyze the effect of operating variables on chemical reaction conversion for process development and reactor design; and
- **CO 4.** use spreadsheets, computer programming, and numerical computing software in vapor-liquid equilibrium calculations, phase equilibrium diagrams construction, and equilibrium conversion of multi-reaction systems determination.

Course Outcomes and Relationship to Program Learning Objectives

Course Outcomes	Program Learning Objectives*				
	A	B	C	D	E
Solve vapor-liquid equilibrium problems for both ideal and non-ideal solutions					
Derive phase equilibrium, chemical equilibrium, and other thermodynamic property relations from fundamental property relations using concepts of physical chemistry and techniques in calculus					
Analyze the effect of operating variables on chemical reaction conversion for process development and reactor design					
Use spreadsheets, computer programming, and numerical computing software in vapor-liquid equilibrium calculations, phase equilibrium diagrams construction, and equilibrium conversion of multi-reaction systems determination					

* **A** Equip students with strong technical education in chemical engineering necessary to succeed in their chosen careers and to become responsive citizens.
B Develop the students' ability to effectively communicate technical information to any audience.
C Train students to function in multidisciplinary teams, manage projects, and take leadership roles in their respective fields.
D Engage students in research, innovation, and life-long learning to identify opportunities, and address issues and challenges in their respective spheres of influence.
E Instill in students a strong commitment to the ethical practice of their profession; to health, safety, and environment; and to service to society.

2. Course Content

Lecture Topics	No. of Hours
Introduction to vapor-liquid equilibrium (VLE) 1. Nature of equilibrium 2. Phase rule and Duhem's Theorem 3. Qualitative behavior 4. Models for VLE	6
Solution thermodynamics 1. Chemical potential and phase equilibria 2. Partial properties 3. Ideal gas mixture	6
Long Examination 1	
4. Fugacity and fugacity coefficients 5. Ideal solution model 6. Excess properties 7. Property changes and heats of mixing 8. Models for excess properties	16.5

Lecture Topics	No. of Hours
Long Examination 2	
Topics in phase equilibria 1. Gamma-phi formulation of VLE 2. Equilibrium and stability 3. Liquid-liquid equilibrium 4. Vapor-liquid-liquid equilibrium 5. Solid-liquid equilibrium	9
Chemical reaction equilibria 1. Reaction coordinates 2. Gibbs energy change and equilibrium constants 3. Temperature effect on equilibrium constants 4. Evaluation of equilibrium constants 5. Composition and equilibrium constants 6. Phase & Gibbs-Duhem Rule for reacting systems 7. Equilibrium conversions for single reactions 8. Multi-reaction equilibria	10.5
Long Examination 3	
Total number of hours	**48**

3. Course Coverage

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
1-2	1,2,4	**Introduction to vapor-liquid equilibrium (VLE)** 1. Nature of equilibrium 2. Phase rule and Duhem's Theorem 3. Qualitative behavior 4. Models for VLE	How can phase rules be applied to determine the number of independent variables required to solve VLE problems? How can applicable VLE models be determined to solve a particular problem? How can phase equilibrium diagrams be utilized to determine pressure, temperature, and composition at equilibrium of a certain system?	lecture, classwork	problem set/quiz
3-10	1,2,4	**Solution thermodynamics** 1. Chemical potential and phase equilibria 2. Partial properties 3. Ideal gas mixture	What is chemical potential? What are partial properties? How can partial properties be related to solution properties and pure species properties?	lecture, classwork	problem set/quiz
					Long Examination 1

Week	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
		4. Fugacity and fugacity coefficients 5. Ideal solution model 6. Excess properties Property changes and heats of mixing 7. Models for excess properties	What is fugacity? What are activity coefficients? How can excess properties be used in determining activity coefficient models?		
					Long Examination 2
10-13	1,2,4	**Topics in phase equilibria** 1. Gamma-phi formulation of VLE 2. Equilibrium and stability 3. Liquid-liquid equilibrium 4. Vapor-liquid-liquid equilibrium 5. Solid-liquid equilibrium	What are the equations used in determining thermodynamic stability multiphase systems?	lecture, classwork	problem set/quiz
13-16	1,2,3	**Chemical reaction equilibria** 1. Reaction coordinates 2. Gibbs energy change and equilibrium constants 3. Temperature effect on equilibrium constants 4. Evaluation of equilibrium constants 5. Composition and equilibrium constants 6. Phase & Gibbs-Duhem Rule for reacting systems 7. Equilibrium conversions for single reactions 8. Multi-reaction equilibria	What are the effects of temperature, pressure, and initial composition on the equilibrium conversions of chemical reactions? What is Gibb's Phase Rule for reacting systems?	lecture, classwork	problem set/quiz
					Long Examination 3

4. Course Requirements

1. Long examinations (3)
2. Problem sets
3. Quizzes

REFERENCES:

Dy, T. R. N. (2013). Water hyacinth-derived biopolyols for polyurethane production using crude glycerine as liquefaction solvent (Master's thesis). University of the Philippines Diliman.

Sandler, S.I. (2017). Chemical, Biochemical and Engineering Thermodynamics. 5th Ed. NJ: John Wiley and Sons Inc.

Smith, J. M., Van Ness, H. C. and Abbott, M. M. (2018). *Introduction to Chemical Engineering Thermodynamics* 8th Ed. NY: McGraw-Hill Co., Inc.