NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF CHEMICAL AND TEXTILE ENGINEERING
CHEMICAL ENGINEERING PROGRAM

PI217 – THERMODYNAMICS FOR CHEMICAL ENGINEERING II

I. GENERAL INFORMATION

CODE	**:**	PI217 Thermodynamics for Chemical Engineering II
SEMESTER	**:**	7
CREDITS	**:**	3
HOURS PER WEEK	**:**	4 (Theory – Practice)
PREREQUISITES	**:**	PI216 Thermodynamics for Chemical Engineering I PI523 Calculations in Chemical Engineering I
CONDITION	**:**	Compulsory

II. COURSE DESCRIPTION

This theoretical-practical course prepares students for the application of thermodynamic principles for analyzing solutions, their equilibrium states, vapor-liquid equilibrium, phase equilibrium and equilibrium in chemical reactions. Student apply mathematical models for obtaining phase equilibrium curves, as well as the speed of chemical reactions.

III. COURSE OUTCOMES

At the end of the course, students:

1. Identify, understand and analyze the variables defining solution and their equilibrium states.
2. Calculate phase equilibrium variables of unit operations and unit processes.
3. Apply and integrate mathematical models for obtaining phase equilibrium curves, as well as the speed of a reaction of different reaction order.
4. Apply the Clausius-Clapeyron equation and Gibbs fundamental equation for analyzing phase equilibrium in single and binary component systems.

IV. LEARNING UNITS

1. THERMODYNAMICS OF SOLUTIONS

Mixtures and solutions / Concentration / Molecular structure of solutions / Phase diagram / Fugacity rule of Lewis / Fugacity coefficient / Critical pressure / Activity coefficient / Super-saturation / Undercooling and overheating / Heat of solution / Freezing mixtures / Vapor-pressure depression / Freezing-point depression / Boiling-point increase / Osmotic pressure / Thermochemical data of solutes / Gas reactions under high pressures /

2. VAPOR-LIQUID EQUILIBRIUM

Introduction / Pure systems / Multi-component systems / Vapor pressure / Concentration dependence / Temperature dependence / Activity coefficient models / Gamma-Phi formulation / Vapor-liquid equilibrium diagrams / Distillation / Fractional distillation / Raoult law / Dalton law / Henry law.

3. PHASE EQUILIBRIUM

Phase equilibrium in one-component system / Phase diagrams / Gibbs fundamental equation / Clapeyron equation / Critical point and supercritical fluids / Clausius-Clapeyron equation / Phase equilibrium in two-component system / Phase rule / Interpretation of phase diagrams / Inverse Lever law / Microstructure development.

4. EQUILIBRIUM IN CHEMICAL REACTIONS

Reactants concentrations / Reaction rate / Forward reaction and reverse reaction / Dynamic equilibrium / Concentration quotients / Metastable mixtures / Multiple criteria / Effect of temperature / Effect of electric and magnetic fields / Types of equilibrium / Mass balance equations / Polybasic acids / Solution and precipitation / Minimization of free energy.

V. LABORATORIES AND PRACTICAL EXPERIENCES

- Vapor-liquid equilibrium
- Single phase equilibrium
- Binary phase equilibrium
- Equilibrium in chemical reactions

VI. METHODOLOGY

This course is carried out in theory and practical sessions. In theory sessions, the instructor introduces concepts and applications of the same. In practical sessions, problems are solved and their solution is analyzed in order to relate the theory with its application. The introduction and development of the course are carried out with the available multimedia resources for the presentation of slides and videos; internet access to use interactive pages (applets), online videos. Student active participation is promoted throughout the course.

VII. EVALUATION FORMULA

The average grade PF is calculated as follows:

PF = (EP + EF + PP) / 3

EP: Mid-Term Exam EF: Final Exam
PP: Average grade of practical work

VIII. BIBLIOGRAPHY

1. **CENGEL, YUNUS A. AND BOLES, MICHAEL. A.**
   Thermodynamics (Spanish)
   McGraw-Hill Interamerican Editorial 2nd Edition (2006)

2. **MORAN, J. MICHAEL AND SHAPIRO, HOWARD N.**
   Fundamentals of Industrial Thermodynamics (Spanish)
   Reverté Editorial 2nd Edition, Spain (2005)

3. **PERRY, JOHN**
   Chemical Engineer's Handbook (Spanish)
   UTEHA Editorial, Mexico (2002)