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**FIRST SEMESTER 2023-2024**

# Course Handout Part II

Date: 11-08-2023

In addition to part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

Course No. : CHE F213

Course Title : Chemical Engineering Thermodynamics

Instructor-in-Charge : Dr. Ramendra Kishor Pal

**Course Description**:

Development and applications of the combined first and second laws; relations between state properties; chemical equilibria in reacting and non-reacting systems; statistical concepts, and brief exposure to irreversible thermodynamics; extensive problem assignments throughout.

**Scope & Objective**:

This course aims to comprehensively treat thermodynamics from a chemical engineering viewpoint. The most important problems the chemical engineer must be able to cope with will be emphasized, viz. heat and work requirements for many physical and chemical processes, determination of equilibrium constants for chemical reactions and the transfer of chemical species between phases.

*Learning objectives:*

* Students will be able to estimate the energy requirements for various processes taking place in chemical engineering and evaluate the feasibility of a process.
* Students will be able to predict the PVT behaviour for various substances which deviate from ideal behaviour
* Students will be able to predict the phase behaviour of ideal and non-ideal systems
* Students will be able to study the reaction equilibrium

**Text Book**:

J. M. Smith, H.C. Van Ness, M. M. Abbott, and M. T. Swihart, “Introduction to Chemical Engineering, Thermodynamics”, McGraw Hill, 8th ed., 2020.

**Reference Books**:

YVC Rao, “Chemical Engineering Thermodynamics”, Universities Press, 1997.

KV Narayanan, “A Textbook of Chemical Engineering Thermodynamics”. Prentice Hall of India, 2001.

Jefferson W. Tester, Michael Modell, “Thermodynamics and Its Applications”, Prentice Hall, 1997.

K. D. Dahm, D. P. Visco Jr., Jayant Singh, “Fundamentals of Chemical Engineering Thermodynamics”, Cengage Learning, 2015

**Course Plan**:

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| **Lecture No.** | **Learning Objectives** | **Topics to be covered** | **Chapter in the Text Book** |
| 1 | Introduction | Scope and Objectives of course, methodology | Chap. 1 |
| 2 – 4 | First Law of Thermodynamics: Basic Concepts | First law, Closed System, State and State functions  Equilibrium, Phase rule, Reversible Process, Const-V and Const-P Processes Enthalpy, heat capacity, First law for Open systems | 2.1 to 2.12 |
| 5 – 8 | Volumetric Properties of Pure Fluids | PVT behaviour of pure substances, Virial Equations, Ideal gas, Applications of Virial Equations, Cubic Equations of State, Generalized correlations for gases and liquids | 3.1 to 3.7 |
| 9 – 11 | Heat Effects:  Heat of reaction | Sensible heat effects, Latent heat  Standard heats of reaction, formation, combustion  Temperature dependence of ΔH°, heat effects of industrial reactions**.** | 4.1 to 4.7 |
| 12 – 16 | Second Law: Entropy and Third Law | Statements of second law, Heat engines, Thermodynamic temperature Scale, Entropy, ΔS for an ideal gas, Entropy balance for Open Systems, Ideal work, Lost work, Third law **.** | 5.1 to 5.10 |
| 17 – 21 | Thermodynamic Properties of Fluids | Property relations for homogeneous phases, Residual properties and their calculations by cubic equations  Two-phase systems, thermodynamic diagrams and tables  Generalized property correlations for gases**.** | 6.1 to 6.7 |
| 22 – 24 | Applications of Thermodynamics to Flow Processes | Duct flow of compressible fluids, Expansion Processes, Compression Processes. | 7.1 to 7.3 |
| 25 – 28 | Introduction to vapour/liquid Equilibrium | Nature of Equilibrium, Phase rule, Duhem’s theorem  VLE; Qualitative behaviour, Simple models for VLE  VLE by Modified Raoult’s law, K-value correlations | 10.1 to 10.6 |
| 29 – 33 | Basic concepts of Solution Thermodynamics: Theory | Fundamental Property Relation, Chemical potential and Phase equilibrium, Partial Properties, Ideal gas mixtures, Fugacities of pure species, Fugacities of Species in solution, Generalized Correlations, Ideal Solution, Excess Properties | 11.1 to 11.9 |
| 34 – 37 | Solution Thermodynamics: Applications | Liquid-phase properties from VLE data, Activity coefficients from VLE data, Models for Excess Gibbs energy, Property changes of Mixing, Heat effects of Mixing processes | 12.1 to 12.4 |
| 38 – 42 | Chemical Reaction Equilibria | Reaction coordinate, Equilibrium criteria for chemical reactions, Equilibrium constants and their variation with temperature, Evaluation of Equilibrium constants, Relation of Equilibrium Constants with Compositions,  Equilibrium conversions for Single Reactions, Phase Rule and Duhem’s theorem for Reacting Systems and Multireaction Equilibria | 13.1 to 13.9 |

**Evaluation Scheme**:

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| **Component** | **Duration** | **Weightage (%)** | **Date & Time** | **Nature of Component** |
| Tutorial Tests (2 best of 3) | Will be discussed in Tutorial Sessions | 20 | TBA | Open Book |
| Continuous Evaluations | Will be discussed during lecture hours and tutorial sessions | 10 | TBA | Open Book |
| Mid Semester Exam | 1.5 h | 25 | 09/10 - 9.30 - 11.00AM | Open Book |
| Comprehensive Exam | 3 h | 45 | 06/12 FN | Open Book |

**NOTE:** A total of three tutorial tests will be conducted. Two best of three will be considered.

**Chamber Consultation Hour:** At 1 PM every Saturday (Chamber: **D 321**).

**Notices:** Will be updated via CMS

**Make-up Policy:** Make-up will be granted only for genuine cases with valid justification and only with prior permission from Instructor-in-charge.

**Academic Honesty and Integrity Policy**: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Dr. Ramendra Kishor Pal

**INSTRUCTOR-IN-CHARGE**