First Semester 2018-2019
Instruction Division
Course Handout (Part II)

Date: 02/08/2018

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	**:**	Banasri Roy
Instructors (Tutorial)	**:**	Ajay Kumar Pani Banasri Roy Venkata Vijayan S

1. Course Description

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. [Review of work, heat, reversible and irreversible processes, First Law applications to closed and open systems, Second Law, Entropy, and applications related to power and refrigeration, Heat effects, Availability and Exergy analyses, Equations of state and generalized correlations for PVT behaviour, Maxwell relations and fluid properties estimation; Residual and excess properties, Partial molar quantities; Gibbs-Duhem Equation, Fugacity and Activity Coefficient models, Vapour-Liquid equilibria]

2. Scope & Objective

- Develop ability to analyze heat, energy, and work requirement/transfer for physical and chemical processes
- Determination of equilibrium constants, free energy, and other essential conditions for physical and chemical changes.
- Analyze essential conditions (temperature, pressure, composition, etc.) for the physical and chemical changes.
- Apply thermodynamic principles in estimation/calculation of power input/output, efficiency, etc., of industrial processes used for converting heat in to other form of power (electrical, mechanical, etc.).
- Application of thermodynamic principals for understanding the criterion (ΔG, equilibria constant) of chemical reaction at equilibria, degree of conversion, composition and effect of P, inert gas addition, excess reactants, products on conversion.

3. Recommended Text Book (TB)

T1: Smith, J M, H C Van Ness and M M Abbott, (Adapted by: B I Bhatt), Introduction *to Chemical Engineering Thermodynamics (7th ed.)*, Tata McGraw Hill, special Indian Edition 2010.

Reference Books (RB)

RB1: Rao, Y V C, *Chemical Engineering Thermodynamics*, Universities Press, 1997.

RB2: Narayanan K V, *A Textbook of Chemical Engineering Thermodynamics*, Prentice Hall of India, 2nd ed., 2013.

RB3: Sandler, Stanley I., *Chemical, Biochemical and Engineering Thermodynamics*, 4th Edition, Wiley (India Pvt. Ltd. : Wiley Student Edition), 2006.

RB4: Cengel, Y A and M A Boles, *Thermodynamics: An Engineering Approach (SI Units),* 8th Edition, Tata McGraw Hill Education (India) Pvt. Ltd., (5th Reprint, 2016!)

4. Course Plan

The following course plan is tentative. Changes according to the class need may occur

Module: Lecture No.	**Topics to be Covered in Lecture (L) & Tutorial (T) Sessions**	**Reference Ch./Sec. #**	**Learning Outcome**
M1:1 Introduction	**L1:** Scope and Objectives of course, Course structure, work, heat, energy, temperature.	T1: 1.1- 1.9	Understand 1. Scope and objectives, and structure of course **2.** Basics: work, heat, energy, temperature.
M2: 2 - 3 First Law of Thermodynamics & Basic Concepts	**L2:** First law, Energy balance for closed system, State and state functions, Equilibrium, Phase rule, Reversible process, Const-V and Const-P processes.	T1: 2.1-2.9	1. Identify different forms of energies, 2. Understand applications of 1st law 3. Use state functions for energy calculations of practical thermodynamic problems
	L3: Enthalpy, Heat capacity, Mass and energy balance for open systems.	T1: 2.10-2.12	
	T1: Exercise problems on 1st law & basics of thermodynamics.	T1: Ch1 & Ch2 Problems	
M3: 4 – 7 Volumetric Properties of Pure Fluids	**L4:** PVT behavior of pure substances, Virial equations.	**T1:** 3.1-3.2	Calculate/analyze work & energy requirement/transfer for pure fluids in simple industrial processes
	L5: Ideal gas, Applications of Virial equations.	**T1:** 3.3-3.4	
	L6: Applications of Virial equations, Cubic equations of	**T1:** 3.4-3.5	

	state.		
	L7: Generalized correlations for gases and liquids.	**T1:** 3.6-3.7	
	T2: Exercise problems on Volumetric Properties of Pure Fluids.	T1: Ch3 Problems	
M4: 8 – 9 Heat Effects	**L8:** Sensible heat effects, Latent heat of pure substances Standard heats of reaction, formation and combustion, Temperature dependence of ΔH.	**T1:** 4.1-4.6	1. Calculate/analyze the requirement/transfer of heat energies and related parameters of fluids applicable in simple chemical processes 2. Utilize heat effects of reactions for defining operation conditions of industrial processes
	L9: Heat effects of industrial reactions.	**T1:** 4.7	
	T3: Exercise problems on Heat Effects.	T1: Ch3 Problems	
M5: 10 – 12 Second Law, Entropy and Third Law	**L10:** Statements of second law, Heat engines, Thermodynamic temperature scale, Entropy, Entropy change for an ideal gas, Mathematical statement of the second law.	**T1:** 5.1-5.6	1. Understand applications of 2nd law, importance of idea of entropy 2. Calculate entropy change and different works (ideal, actual, and lost) and related properties for the simple industrial processes.
	L11: Entropy balance for open Systems, calculation of ideal work.	**T1:** 5.7-5.8	
	L12: Lost work, Third law of thermodynamics, Entropy from the microscopic view point.	**T1:** 5.9-5.11	
	T4-T5: Exercise problems on Second Law, Entropy and Third Law.	T1: Ch3-4 Problems	
M6: 13 – 17 Thermodynamic Properties of Fluids	**L13:** Property relations for homogeneous phases.	**T1:** 6.1	1. Estimate/calculate heat and work quantities for the simple and homogeneous fluids in industrial processes. 2. Estimate/calculate actual thermodynamic properties (pressure, volume, free energy, enthalpy, etc.,) for the simple and homogeneous fluids in industrial processes.
	L14: Residual properties and Residual properties calculation by equations of state.	**T1:** 6.2-6.3	
	L15: Residual properties calculation by equations of state.	**T1:** 6.3	
	L16: Two-phase systems, Thermodynamic diagrams and tables.	**T1:** 6.4-6.6	
	L17: Generalized property	**T1:** 6.7	

	correlations for gases.		
	T6-T7: Exercise problems on Thermodynamic Properties of Fluids.	T1: Ch5-6 Problems	
M7: 18 - 20 Applications of Thermodynamics to Flow Processes	**L18:** Duct flow of compressible fluid.	**T1:** 7.1	1. Estimate/calculate heat, work, enthalpy, entropy, free energy etc., for the flowing fluids in simple industrial process structure and equipment. This chapter will help students to understand fluid flow and related processes addressed in Fluid Mechanics (CHE F212) course.
	L19: Duct flow of compressible fluid.	**T1:** 7.1	
	L20: Turbines, Compression processes.	**T1:** 7.1-7.2	
	T8-T9: Exercise problems on Applications of Thermodynamics to Flow Processes	T1: Ch7 Problems	
M8 & M9: 20+ Production of Power from Heat I Refrigeration & Liquefaction	Steam power plant, Internal-Combustion engines, Jet engines; Rocket engines I Carnot refrigerator, Vapour-Compression cycle, Choice of refrigerant, Absorption refrigeration, Heat pump, Liquefaction processes	Chapters 8 & 9 **Assignments**	Apply thermodynamic principles in estimation/calculation of power, efficiency, etc., of industrial processes used for 1. Converting heat in to other form of power (electrical, mechanical, etc.). 2. Refrigeration & liquefaction
M10: 21 – 24 Introduction to Vapour/Liquid Equilibrium	**L21:** Nature of equilibrium, Phase rule; Duhem's theorem.	**T1:** 10.1-10.2	Apply thermodynamic principles in estimation/calculation of temperature, pressure, phase compositions, of simple VLE equilibrium systems. This chapter will help students to understand mass transfer related (distillation, adsorption, extraction, drying, etc.,) simple industrial processes addressed in Separation Processes I (CHE F244) and Separation Processes II
	L22: VLE: Qualitative behaviour, Simple models for VLE.	**T1:** 10.3-10.4	
	L23: VLE by Modified Raoult's law.	**T1:** 10.3-10.5	
	L24: VLE from K-value correlations.	**T1:** 10.6	
	T10-T11: Exercise problems on Vapour/Liquid Equilibrium.	T1: Ch10 Problems	

			(CHE F313) courses.
M11: 25 - 28 Basic Concepts of Solution Thermodynamics: Theory	**L25**: Fundamental property relation, Chemical potential and Phase equilibrium, Partial properties.	**T1:** 11.1-11.3	Apply thermodynamic principles in estimation/calculation of enthalpy, entropy, free energy, temperature, pressure, volume, compositions, etc., of simple gas mixture and liquid solutions.
	L26-27: Ideal gas mixture model, Fugacity coefficients of pure species, Fugacity coefficients of Species in solution.	**T1:** 11.4-11.6	
	L28: Ideal gas mixture model, Fugacity coefficients of pure species, Fugacity coefficients of Species in solution.	**T1:** 11.4-11.6	
	T12-T13: Exercise problems on Basic Concepts of Solution Thermodynamics: Theory	T1: Ch11 Problems	
M12: 29 – 33 Solution Thermodynamics: Applications	**L29**: Liquid-phase properties from VLE data.	**T1:** 12.1	Apply thermodynamics of simple VLE equilibrium systems in estimation/calculation of changing free energy, enthalpy, entropy, volume, etc., due to mixing
	L30: Liquid-phase properties from VLE data, Activity coefficients from VLE data, Models for Excess Gibbs energy.	**T1:** 12.1-12.2	
	L31: Property changes of mixing.	**T1:** 12.3	
	L32: Property changes of mixing, Heat effects of mixing processes.	**T1:** 12.3-12.4	
	L33: Heat effects of mixing processes.	**T1:** 12.4	
	T14-T15: Exercise problems on Solution Thermodynamics: Applications.	T1: Ch12 Problems	
M13: 34 – 40 Chemical Reaction Equilibria	**L34**: The reaction coordinate, Application of equilibrium criteria to chemical reactions.	**T1:** 13.1-13.2	• Apply thermodynamic principles in estimation/calculation of reaction rate, equilibrium conversion • Effect of temperature, pressure, and phase
	L35: The standard Gibbs-Energy changes and equilibrium constant (K), effect of T on K.	**T1:** 13.3-13.4	
	L36: Evaluation of K, Relation of K to composition.	**T1:** 13.5-13.6	

	L37-38: Equilibrium conversion for single reactions, Phase rule & Duham theorem, multireaction equilibrium.	**T1:** 13.7-13.9	compositions on reaction rate, equilibrium conversion
	L39-40: Fuel cell	**T1:** 13.10	
	T16-T17: Exercise problems on Solution Thermodynamics: Applications.	T1: Ch13 Problems	

5. Evaluation Scheme

EC No.	Evaluation Component (EC)	Duration	Weightage (Marks/ %)	Date/Time	Remarks
1	Mid Semester Test	1.5 hrs	75/25	13/10 2:00 - 3:30 PM	OB/CB
2	Tutorial Tests (5 out of 7)	-	60/20	-	CB/OB
3	Assignments		30/10	-	OB
4	Class Participation (5 out of 7)	-	30/10		CB/OB
5	Comprehensive Exam	3 hrs	105/35	12/12 FN	CB/OB

CB = Close Book **OB** = Open Book

Chamber consultation hour will be announced in the class.

- The **notices,** if any**,** concerning the course will be displayed on the NALANDA only.
- **Make-up** will be granted for **genuine cases only**. Certificate from authenticated doctor, say from the Medical Center, must accompany make-up application (*only prescription or vouchers for medicines will not be sufficient*). Prior permission of IC is compulsory.
- **No** make-up will be granted for the **tutorial**, assignments, and **class participation** tests**.**

Instructor-in-charge | **CHE F213**