Course code	Course Name	L-T-P-Credits	Year of Introduction
CH204	CHEMICAL ENGINEERING THERMODYNAMICS	3-1-0-4	2016

Prerequisite : Nil

Course Objectives

To understand the concepts and applications of chemical engineering thermodynamics

Syllabus

Basic Concepts and Definitions, Laws of Thermodynamics, Some applications of the Laws of Thermodynamics, Entropy, PVT behaviour of pure substances, Equations of State, Thermodynamic properties of pure fluids, Fugacity and Activity of Pure fluids, Properties of Solutions, Ideal and Non ideal solutions, Property change of mixing, Excess Properties, Gibbs Duhem equation, Phase equilibrium criteria, Phase rule for non-reacting system, Vapour Liquid Equilibria concepts, VLE diagrams, Activity coefficient models, Liquid-Liquid Equilibria, Chemical Reaction Equilibria, Equilibrium Constant, Phase rule for reacting system

Expected Outcome

At the end of the course the students will be able to

1. Apply the laws of thermodynamics to analyse chemical engineering problems
2. Compute the properties of ideal/real gases and mixtures/solutions
3. Analyse processes using mass, energy and entropy balances
4. Evaluate composition of vapor-liquid equilibrium for ideal and non-ideal systems
5. Determine equilibrium constant and mole fraction of reaction mixture under give conditions

Text books:

1. Smith J. M. & Van Ness H.V., Introduction to Chemical Engineering Thermodynamics, McGraw Hill
2. Narayanan K. V., A Textbook of Chemical Engineering Thermodynamics, 2nd Edn., Prentice-Hall of India, 2013

References:

- Stanley I. Sandler, Chemical and Engineering Thermodynamics, 2nd Edn., John Wiley & Sons, USA, 1989
- Kyle B.G., Chemical and Process Thermodynamics, Prentice-Hall of India
- Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Scope of Thermodynamics, Thermodynamic Systems-Closed, open and isolated system - intensive and extensive properties - path and state functions - reversible and irreversible process –Zeroth law of Thermodynamics- First Law of Thermodynamics- Energy Balance for Closed Systems-Limitations of First Law- Second Law of	9	15%

	Thermodynamics-Carnot's principles -Definition of Entropy-Calculation of entropy change in processes involving ideal gases-Definition of availability and exergy – entropy generation in steady flow processes-Third law of Thermodynamics-Energy balance of open systems-Flow through pipe, nozzles, compressors, throttling, refrigeration, liquefaction.		
II	P-V and P-T diagram of pure substances. Equations ofstate for real gases- van der Waal's, Redlich Kwong, Peng Robinson and Virial equations. Principle of corresponding states- generalized compressibility chart- Fundamental Property Relations-Maxwell's Equations- Clausius-Clapeyron equation - entropy-heat capacity relationships - equations for entropy, internal energy and enthalpy in terms of measurable quantities- Joule-Thomson coefficient – Gibbs Helmholtz equation- -fugacity and activity of pure fluids - selection of standard state - effect of temperature and pressure on fugacity and activity-residual properties-thermodynamic diagrams.	9	15%
FIRST INTERNAL EXAMINATION			
III	Definition of partial molar properties-chemical potential - definition - effect of temperature and pressure on fugacity-fugacity in solution - ideal solution - Lewis-Randall rule-Raoult's law - Henry's law - activity and activity coefficients in solutions - effect of temperature and pressure on activity coefficients - Gibbs-Duhem equations – criterion of phase equilibria - criterion of stability - phase equilibrium in single component systems - phase equilibria in multicomponent systems - phase rule for non-reacting systems - Duhem's theorem	9	15%
IV	Vapour-liquid equilibrium - phase diagram for binary solutions - VLE in ideal solutions - non-ideal solutions - positive and negativedeviation - azeotropes - VLE at low pressures-Application of activity coefficient equations in equilibrium calculations - activity coefficient models such as Wohl's equation - van Laar equation - Wilson equation -NRTL, UNIQUAC and UNIFAC models - calculation of activity coefficients using Gibbs - Duhem equations - consistency tests for equilibrium data - Redlich-Kister method -coexistence equation	9	15%
SECOND INTERNAL EXAMINATION			
V	Vapour-liquid equilibrium at high pressures – vaporization equilibrium constants - bubble point, dew point and flash	10	20%

	calculations in multi component systems- vapour-liquid equilibrium in partially miscible and immiscible systems - phase diagrams - principles of steam distillation – phase equilibrium considerations in steam distillation - liquid-liquid equilibrium - binary and ternary equilibrium diagrams - use of triangular diagrams for ternary equilibrium		
VI	Chemical reaction equilibria-extent of reaction-equilibrium constant - standard free energy change - feasibility of reaction -effect of temperature on equilibrium constant – evaluation of equilibrium constant - equilibrium conversion in gas-phase reactions - effect of pressure and other parameters on conversion - pressures of decomposition in gas-solid reaction - simultaneous reactions - phase-rule for reacting systems	10	20%
END SEMESTEREXAMINATION			

Evaluation Scheme

- **Internal Evaluation: Total Marks: 50**
  - (i) *Total Marks for Assignment/Seminar/Project/Case study or any other appropriate tool used for the evaluation of the course outcomes:* **10**
    A minimum of above two tools shall be used. If more than 2 tools are used, proportionate change shall be made in the marks so that the total contribution of marks for item (i) above remains at 10.
  - *(ii) Marks for Tests: Two tests each carrying 40% weightage shall be conducted with total contribution of* **40 marks**.

- **External Evaluation :** University Examination
  Maximum Marks : 100
  Exam Duration : 3 Hours

Question Paper Pattern:

There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.

(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.

(2 x15= 30 Marks)

There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.

(2 x20= 40 Marks)