LOK JAGRUTI UNIVERSITY (LJU)

INSTITUTE OF ENGINEERING & TECHNOLOGY

Department of Chemical Engineering (708)

Bachelor of Engineering (B.E.) – Semester – III

Course Code:	**017083301**
Course Name:	**Thermodynamics II**
Category of Course:	Professional Core Course (PCC)
Prerequisite Course:	Thermodynamics I

Teaching Scheme				
Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Credit**	**Total Hours**
4	**1**	**0**	**5**	**50**

Syllabus

Unit No.	Topic	Prerequisite Topic	Successive Topic	Teaching Hours
01	**Thermodynamic Property Relations**			**4 (8%)**
	1.1 Classification of Thermodynamic Properties	Introduction to Thermodynamics (017082201-Unit-1)		
	1.2 Mathematical Prerequisites			
	1.3 Free Energy Functions			
	1.4 Fundamental Property Relations	Fundamental Concepts of Thermodynamics (017082201-Unit-2)		
	1.5 Maxwell's Relations	Entropy Change (017082201-Unit-8)		
	1.6 Clapeyron Equation			
	1.7 Residual Property, Introduction			
02	**VLE for Ideal Solution**			**7 (14%)**
	2.1 Criteria of Equilibrium, Introduction		Concept of Vapor-Liquid Equilibria (017083503-Unit-2.1)	
	2.2 Criteria for Phase Equilibrium	Phase, Components, Degree of freedom (017081101- Unit-5.2) Phase Transformations (017082101- Unit-7.1)		
	2.3 Phase Rule for Non-reacting Systems	Homogeneous Mixture and Heterogeneous Mixture (017082201-Unit-2.2) Property of Thermodynamic System : Intensive and Extensive (017082201-Unit-2.4)		
	2.4 VLE Diagram for Binary Mixture			
	2.5 Vapour-Liquid Equilibrium: Raoult's Law		Solutions: Vapour pressure using Raoult's law (017083401-Unit-3.1)	
	2.6 Methodology for Bubble Point Calculations			
	2.7 Methodology for Dew Point Calculation			
03	**VLE for Non Ideal Solutions**			**5 (10%)**
	3.1 Deviations from Raoult's Law		Deviation from Ideality (017083503-Unit-3.3)	
	3.2 Non Ideal Solution			
	3.3 Azeotrope Formation			
	3.4 Minimum Boiling Azeotrope		Minimum and Maximum Boiling Azeotropic Mixtures (017083503-Unit-3.4)	
	3.5 Maximum Boiling Azeotrope			
	3.6 Effect of Pressure on Azeotrope			
	3.7 K value Correlation			
	3.8 VLE for High Pressure			
04	**Phase Equilibrium Diagram**			**5 (10%)**
	4.1 Phase Diagram for Single Component		P-X-Y & T-X-Y Diagrams (017083503-Unit-2.2)	
	4.2 Liquid-Liquid Equilibrium			
	4.3 Ternary Liquid-Liquid Equilibrium			
	4.4 Solid-Liquid Equilibrium			
	4.5 Solid-Vapour Equilibrium			
	4.6 Retrograde Condensation	P-V-T Behavior of Pure Substance (017082201-Unit-5)		
05	**Solution Thermodynamics**			**8 (16%)**
	5.1 Partial Molar Properties			
	5.2 Chemical Potential			
	5.3 Fugacity and Fugacity Coefficients			
	5.4 Fugacity in Solutions			
	5.5 Activity and Activity Coefficients			
	5.6 Activity in Solutions			
	5.7 Gibbs–Duhem Equations			
06	**Property Change of Mixing**			**4**

	6.1 Gibbs Theorem for Ideal Gas Mixture Model			**(8 %)**
	6.2 Entropy Change of Mixing	Statements of Second Law of Thermodynamics (017082201-Unit-9.1)		
	6.3 Gibbs Free Energy Change of Mixing			
	6.4 Enthalpy Change of Mixing			
	6.5 Volume Change of Mixing			
07	**Ideal Solution Model**			**3 (6%)**
	7.1 Lewis–Randall Rule			
	7.2 Raoult's Law and Ideal Solution	Equation of State (017082201-Unit-6)	Solutions: Vapour pressure using Raoult's law (017083401-Unit-3.1)	
	7.3 Henry's Law and Dilute Solution		Gas Mixtures, Gas-Liquid Mixtures using Henry's Law (017083401-Unit-3.3)	
	7.4 Excess Property			
08	**Chemical Reaction Equilibria**			**7 (14%)**
	8.1 The Reaction Coordinates			
	8.2 Criteria of Chemical Reaction Equilibrium			
	8.3 Equilibrium Constant and Standard Free Energy Change	Heat Effects (017082201-Unit-7)	Equilibrium constants (017083601-Unit-4.2)	
	8.4 Effect of Temperature on Equilibrium Constant			
	8.5 Effect of Pressure on Equilibrium Constant			
	8.6 Other Factors Affecting Equilibrium Conversion			
	8.7 Liquid-phase Reactions			
	8.8 Heterogeneous Reaction Equilibria			
	8.9 Phase Rule for Reacting Systems	Phase, Components, Degree of freedom (017081101- Unit-2.9) Gibb's Phase Rule for Non reacting System (017082201-Unit-2.9)		
09	**Activity Coefficient Model**			**4 (8%)**
	9.1 Wohl's Equation			
	9.2 Margules Equation			
	9.3 Van Laar Equation			
	9.4 Local Composition Model, NRTL equation			
	9.5 Universal Group Model, UNIQUAC & UNIFAC method			
10	**Thermodynamic Consistency Test of VLE Data**			**3 (6%)**
	10.1 Using Slope of ln γ Curves			
	10.2 Using Data at the Mid-point			
	10.3 Redlich–Kister Method			

Proposed Theory + Practical Evaluation Scheme by Academicians
(% Weightage Category Wise and it's Marks Distribution)

L:	**4**	**T:**	**1**	**P:**	**0**

Note: In Theory Group, Total 4 Test (T1+T2+T3+T4) will be conducted for each subject.
Each Test will be of 25 Marks.
Each Test Syllabus Weightage: Range should be 20% - 30%

Group (Theory or Practical)	Group (Theory or Practical) Credit	Total Subject Credit	Category	% Weightage	Marks Weightage
Theory	**5**	**5**	MCQ	30%	30
Theory			Theory Descriptive	10%	10
Theory			Formulas and Derivation	30%	30
Theory			Numerical	30%	30
Expected Theory %	**100%**		**Calculated Theory %**	**100%**	**100**
Practical	**0**		Individual Project	0%	0
Practical			Group Project	0%	0
Practical			Internal Practical Evaluation (IPE)	0%	0
Practical			Viva	0%	0
Practical			Seminar	0%	0
Expected Practical %	**0%**		**Calculated Practical %**	**0%**	**0**
Overall %	**100%**			**100%**	**100**

Course Outcome	
	Upon completion of the course students will be,
1	Capable in Vapor-Liquid Equilibrium (VLE) Analysis for Ideal Solutions Using Thermodynamic Property Relations
2	Able to Analyze and Predict Phase Equilibrium for Non-Ideal Solutions and Complex Systems
3	Skilled in Analyzing Solution Thermodynamics and Predicting Property Changes after Mixing in Ideal Solutions
4	Able to Analyze Chemical Reaction Equilibriums, Use Activity Coefficient Models, and Conduct Thermodynamic Consistency Tests for VLE Data.
Suggested Reference Books	
1	A text book of Chemical Engineering Thermodynamics, K. V. Narayanan, Prentice-Hall of India Pvt. Ltd.
2	Introduction to Chemical Engineering Thermodynamics, J. M. Smith, H. C. Vanness, M. M. Abbott, The McGraw-Hill Companies, Inc.
3	Introduction to Chemical Engineering Thermodynamics, Gopinath Halder, Prentice-Hall Of India Pvt. Ltd.
4	Thermodynamics: An Engineering Approach, Yunus Cengel , Michael Boles, The McGraw-Hill Companies, Inc.
5	Introduction to Thermodynamics, Y.V.C. Rao, Wiley Eastern Limited.
6	Chemical and Process Thermodynamics, B.G. Kyle, Prentice-Hall Inc.

List of Open Source Software/Learning website	
1	https://nptel.ac.in
2	https://www.coursera.org
3	https://www.edx.org