



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Chemical Engineering

Subject Code: BE04005041

Subject Name: Chemical Engineering Thermodynamics-II

w.e.f. Academic Year:	2024-25
Semester:	4
Category of the Course:	Professional Core Courses

Prerequisite:	Chemical Engineering Thermodynamics-I
Rationale:	This subject introduces the concepts of fugacity, activity coefficient and other important thermodynamic properties and its evolution for pure components and solutions. Starting with ideal gas mixtures and ideal solutions, the concepts of bubble and dew points are introduced to enable flash calculations and design of process components. Subsequently, various levels of non-ideality and complexity are introduced. The course also provides fundamental insight into the underlying thermodynamic principles of phase equilibria and reaction equilibria to solve complex problems.

Course Outcome:

After Completion of the Course, Students will be able to:

No	Course Outcomes
01	Understand the fundamental thermodynamic principles for phase equilibria and chemical reaction equilibria.
02	Apply principles of partial molar properties for predicting thermodynamic properties.
03	Analyze the equilibrium composition of mixtures under phase and chemical-reaction equilibria.
04	Evaluate the equilibrium conversion and product composition for the different types of chemical reactions

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
L	T	P	PBL*	TH		Theory		Tutorial / Practical			
						ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
45	15	00	30	90	03	70	30	20	30	00	150

- **Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.**

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination



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Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	<p>PHASE EQUILIBRIA:</p> <p>VAPOUR/LIQUID EQUILIBRIUM(VLE): Introduction, The Nature of Equilibrium, The Phase Rule; Duhem's Theorem, VLE- Qualitative Behaviour, Azeotropic Mixtures, Retrograde condensation, Simple Models for Vapour/Liquid Equilibrium, Raoult's Law, Dew point and Bubble point Calculations with Raoult's Law, Henry's law, VLE by Modified Raoult's Law, VLE from K-Value Correlations, Flash Calculations, The Gamma / Phi Formulation of VLE,</p> <p>An introduction to Equilibrium and stability, liquid-liquid equilibrium (LLE), solid-liquid equilibrium, Vapor-Liquid-liquid equilibrium (VLLE), Solid-Liquid equilibrium (SLE), Solid-Vapor equilibrium (SVE) etc..</p>	15	33
2	<p>SOLUTION THERMODYNAMICS:</p> <p>THEORY Fundamental Property Relation, The Chemical Potential as a Criterion for Phase Equilibria, Partial Properties, Equations Relating Molar and Partial Molar Properties , The Partial Molar Gibbs Energy and the Generalized Gibbs-Duhem Equation, Partial Properties in Binary Solutions, Relations among Partial Properties, The Ideal Gas Mixture model, The Partial Molar Gibbs Energy and Fugacity, Fugacity and Fugacity Coefficient: Pure Species and for Species in Solution, The Ideal Solution Model, The Lewis/Randall Rule, Excess Properties, The Excess Gibbs energy and activity coefficient, nature of excess property</p> <p>APPLICATIONS Liquid-Phase Properties from VLE Data, Composition Dependence of Liquid-Phase Fugacities for Species in a Binary Solution, Excess Gibbs Energy, Data Reduction, Thermodynamic Consistency by Integral or Area Test Method, Models for the Excess Gibbs Energy, Margules Equations, Van-Laar Equations, Local Composition Models such as NRTL Equation, UNIQUAC Equation, UNIFAC Method</p>	18	40



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3	<p>CHEMICAL REACTION EQUILIBRIA: The reaction coordinates, Application of equilibrium criteria to chemical reactions, The standard Gibbs free energy change and the equilibrium constant, Effect temperature on equilibrium constant, Evaluation of the equilibrium constant, Relation of equilibrium constant to composition for gas phase and liquid phase reactions, calculation of equilibrium conversion for single reaction, The phase rule and Duhem's theorem for reacting systems, introduction to multi-reaction equilibria</p>	12	27
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Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	20	20	10	5	0

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze; E: Evaluate and C: Create and above Levels (Revised Bloom's Taxonomy)

Reference Books:

1. Smith J.M, Van-Ness H.C., Abbott M.M, "Introduction to Chemical Engineering Thermodynamics", the McGraw Hill Companies, Inc., USA, 7th Ed., 2005.
2. Elliot J. R. and Lira C.T., "Introductory Chemical Engineering Thermodynamics", Prentice Hall, 1999.
3. Hougen O.A., Watson K.M., and Ragatz R.A., "Chemical Process Principles Part, II" Thermodynamics, John Wiley 1970.
4. Perry's Chemical Engineers Handbook, 7th edition, McGraw Hill, USA 2000.
5. K.V. Narayanan "A Text book of Chemical Engineering Thermodynamics", Prentice Hall of India
6. Stanley I. Sandler, "Chemical, Biochemical and Engineering Thermodynamics", Wiley India Pvt. Ltd., 4th ed., 2007.
7. B.G. Kyle, "Chemical Process Thermodynamics", 2nd Ed., Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
8. J.M. Prausnitz, R.N. Litchenthaler, Molecular Thermodynamics of fluid phase Equilibria, 3rd Edition, Prentice Hall.
9. Stanley M. Walas, Phase-Equilibria in Chemical Engineering, Wiley India Private Limited

List of Tutorials: Numerical/problems based on topics of each theme of content.



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Major Equipment: None

List of Open Source Software/learning website:

1. Students can refer to video lectures available on the web sites including NPTEL.
2. Students can refer to the CDs which are available with some reference books for the solution of problems using softwares. Students can develop their own programs for the solutions of problems.
3. XSEOS—an Open Software for Chemical Engineering Thermodynamics

Suggested Activities for Students: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide.

List of suggested activities for Problem Based Learning:

Sr. No.	Description	No. Of hours	Total Hrs.
1	Students will have to undergo industrial visit related to any one of the content mentioned in syllabus and submit the report for the same.	Visit = 5 hrs Report Preparation = 5 hrs	10
2	Students will have to undergo technical video based learning related to subject and have to present it or prepare a report of that learning.	Duration of video = 5 hrs Report Preparation = 5hrs	10
3	Students will have to submit assignment work assigned to them. Numerical base assignment is preferable.	5 assignments of 2 hrs each.	10
4	Problem solving/Coding using C, C++, Python, SCILAB, MATLAB, MS-EXCEL or any other relevant software	5 small coding based assignment of 2 hrs each.	10
5	Self learning on-line course.	Min. Duration of the course should be 10 hrs	10
6	Discussion on research paper based on relevant subject. Summarize research paper and evaluation critical parameters	5 research papers can be included. Each one has 5 hrs	25
7	Students will have to prepare poster, chart or PowerPoint presentation on technical topic	Duration of each activity = 6 hrs	12



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	related to subject content.	Max. two topic can be considered.	
8	Student will have to do Group Discussion on emerging, Trending technical topics based on subject.	Preparation and discussion on one topic	5
9	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/any other issue	Duration=15h for industrial exposure Problem identification and tentative solution =10h	25
Max. Hours to be allotted			60
