SRI VENKATESWARA COLLEGE OF ENGINEERING

COURSE DELIVERY PLAN - THEORY

Department of Biotechnology	LP: BT22403 Rev. No: 00 Date: 23.01.24
B.E/B.Tech/M.E/M.Tech : B.Tech (Biotechnology) Regulation: 2022 PG Specialisation : - Sub. Code / Sub. Name : BT22403 –Chemical and Biochemical Thermodynamics Unit : I	

Unit Syllabus: THERMODYNAMIC LAW AND PROPERTIES OF FLUIDS 9 hrs

First Law of Thermodynamics, a generalized balance equation and conserved quantities, Volumetric properties of fluids exhibiting non ideal behavior; Maxwell's relations and applications, Estimation of thermodynamic properties using equations of state; calculations involving actual property exchanges, Residual Properties.

Objective: This unit aims to explore the laws and application of thermodynamics, types of energy, and property of fluids in biochemical systems.

Session No *	Topics to be covered	Ref	Teaching Aids
1	Introduction to Thermodynamics, Classification of Thermodynamic properties.	T1 – Ch.1; Pg. 1-15 T5 – Ch.2; Pg. 16-30	LCD
2	Volumetric properties of pure fluids-PVT behavior.	T1 – Ch.1; Pg. 64-78	LCD
3	Virial equation and its application, various correlations, Simple problems.	T1 – Ch.1; Pg. 79-98	LCD
4	Residual properties-Gibbs energy, Thermodynamic diagrams.	T1 – Ch.6; Pg. 199-219 T2- Ch.6; Pg. 257-262 R1- Ch.6; Pg. 229-239	LCD
5	Clapeyron equation, Entropy heat capacity equations.	T2 – Ch.6; Pg.213-220	LCD
6	Effect of temperature, pressure and volume on U, H and S, CP-CV relationship, Problems.	T2 – Ch.6; Pg. 220-232	LCD
7	Joule-Thomson Coefficient, Gibbs-Helmholtz Equation.	T2 – Ch.6; Pg. 233-235 T4 – Ch.11; Pg. 429-431	BB/LCD
8	Problems involving actual property exchanges.	T2 – Ch.6; Pg. 244-256	BB/LCD
9	Maxwell's relations and applications	T2 – Ch.6; Pg.211-213	BB/LCD
Content beyond syllabus covered (if any): -NIL-			

* Session duration: 50 minutes

SRI VENKATESWARA COLLEGE OF ENGINEERING

COURSE DELIVERY PLAN - THEORY

Sub. Code / Sub. Name: BT22403 –Chemical and Biochemical Thermodynamics

Unit : II

Unit Syllabus : SOLUTION EQUILIBRIA 9 hrs

Partial molar properties, concepts of chemical potential and fugacity, Ideal and non-ideal solutions, Concepts and applications of excess properties of mixtures, Activity coefficient, Gibbs Duhem equation.

Objective: This unit aims to gain knowledge in solution thermodynamics and its concepts of chemical potential, fugacity, activity coefficient and Gibbs Duhem equation.

Session No *	Topics to be covered	Ref	Teaching Aids
10	Partial molar properties-physical meaning of partial molar properties, determination of partial molar properties.	T1 – Ch.11; Pg. 381-390 T2 – Ch. 7; Pg. 273-283 R1 – Ch. 9; Pg. 333 – 342	LCD
11	Chemical potential, Effect of temperature and pressure on Chemical potential.	T1- Ch.11; Pg. 380-381 T2 – Ch.7; Pg. 284-287 R1- Ch. 9; Pg. 343-346	LCD
12	Fugacity and Fugacity coefficient for pure species and species in solution, generalized correlations for Fugacity coefficient.	T1-Ch.11; Pg. 394 - 410 T2- Ch.7; Pg. 288-292	LCD/BB
13	Problems involving Fugacity and Fugacity coefficient.	R1 – Ch.9; Pg. 353 – 359	LCD/BB
14	Ideal and non-ideal solutions, Raoult's law, Henry's law, Problems.	T1-Ch.10; Pg. 350-362 T2-Ch.7; Pg.292-295	LCD/BB
15	Concepts and applications of excess properties of mixtures	T1-Ch.11; Pg. 413-429 T2-Ch.7; Pg. 317-319 R1-Ch.9; 366 – 370	LCD
16	Activity, Activity coefficient, Effect of temperature and pressure on Activity coefficient, Problems.	T2- Ch.7; Pg. 296-301	LCD/BB
17	Activity Coefficient Problems.	R1-Ch.9; Pg. 347 – 349	BB
18	Gibbs Duhem Equation and problems related to it.	T2-Ch.7; Pg. 302-307 R1-Ch.9; Pg. 349-352	LCD/BB

Content beyond syllabus covered (if any): - NIL-

* Session duration: 50 mins

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COURSE DELIVERY PLAN - THEORY

Sub. Code / Sub. Name: BT22403 –Chemical and Biochemical Thermodynamics

Unit : III

Unit Syllabus : PHASE EQUILIBRIA 9 hrs

Criteria for phase equilibria, VLE calculations for binary and multi component systems, Phase diagrams, Azeotropes and its types, Activity Coefficient Equations, Liquid-liquid equilibria.

Objective: This unit provides information on VLE and Liquid-liquid phase equilibria

Session No *	Topics to be covered	Ref	Teaching Aids
19	Criteria of Phase Equilibria-Constant U and V, Constant T and V, Constant P and T.	T2 – Ch.8; Pg. 330 -332 R1-Ch.10; Pg. 383 – 386	LCD
20	Criterion of stability, Vapor-liquid equilibria, Problems.	T2- Ch.8; Pg.332-340 R1-Ch.10; Pg. 387- 390	LCD/BB
21	Vapor-liquid equilibria for multicomponent system, Problems	T2-Ch.8; Pg. 386-394 R1-Ch.10; Pg. 391 – 395	LCD/BB
22	Phase diagrams for Binary solutions	T2- Ch.8; Pg. 387-393	LCD, Blended Learning
23	VLE in ideal solutions, Duhem Margules Equation,	T2- Ch.8; Pg. 394-400	LCD
24	Antoine Equation probems	T2- Ch.8; Pg. 401-405	LCD
25	Azeotropes, Types of Azeotropes	T2- Ch.8; Pg. 408-410	LCD
26	VLE at low pressures, Activity Coefficient equations	T2- Ch.8; Pg. 413-418	BB
27	Binary liquid-liquid equilibria, Diagrams	T2-Ch.8; Pg.457- 460 R1-Ch.11; Pg.449 – 453	LCD

Content beyond syllabus covered (if any): -NIL-

* Session duration: 50 mins

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COURSE DELIVERY PLAN - THEORY

Sub. Code / Sub. Name: BT22403 –Chemical and Biochemical Thermodynamics
Unit : IV

Unit Syllabus : CHEMICAL REACTION EQUILIBRIA 9 hrs

Equilibrium criteria for homogeneous chemical reactions, Evaluation of equilibrium constant, Effect of temperature and pressure on equilibrium constant, Calculation of equilibrium conversion and yields for single and multiple reactions.

Objective: This unit helps to gain knowledge in chemical reaction equilibrium concepts like equilibrium constant, equilibrium conversion for single, multiple, homogeneous and heterogeneous reactions

Session No *	Topics to be covered	Ref	Teaching Aids
28	Reaction Stoichiometry, Problems	T2- Ch. 9; Pg. 426- 429	LCD/BB
29	Criteria of Chemical Reaction Equilibrium, Equilibrium Constant, Standard Gibbs Free energy	T2- Ch. 9; Pg. 429- 431 T1-Ch.13; Pg. 484-488 R1 – Ch.12; Pg. 470 – 474	LCD/BB
30	Equilibrium constant, effect of temperature and pressure on equilibrium constant, Problems.	T1-Ch.13; Pg. 489- 492 T2-Ch.9; Pg. 436-449 R1-Ch.12; Pg. 475-476	LCD/BB
31	Effect of Pressure on Equilibrium constant and conversion, Problems	T2- Ch.9; Pg. 446 – 450	LCD/BB
32	Other factors affecting Equilibrium Conversion, Presence of Inert Materials	T2- Ch.9; Pg. 450 – 454 R1-Ch.12; Pg. 493- 496	LCD/BB
33	Other factors affecting Equilibrium Conversion, Presence of Excess of Reactants	T2- Ch.9; Pg. 455 – 456	LCD/BB
34	Other factors affecting Equilibrium Conversion, Presence of Excess of Products	T2- Ch.9; Pg. 457– 459	LCD/BB
35	Heterogenous Reaction Equilibria	T2-Ch.9; Pg. 461- 465	LCD/BB
36	Simultaneous Reactions, Phase rule for reacting systems	T2-Ch.9; Pg. 466-470	LCD/BB

Content beyond syllabus covered (if any): -NIL-

* Session duration: 50 mins

Sub. Code / Sub. Name: BT22403 –Chemical and Biochemical Thermodynamics

Unit : V

Unit Syllabus : THERMODYNAMIC CYCLES AND BIOTHERMODYNAMICS 9 hrs

Carnot cycle, Refrigeration cycle, Thermodynamics of microbial growth, Stoichiometry, Thermodynamics of maintenance, Calculation of the Operational Stoichiometry of a growth process at different growth rates, including Heat using the Herbert-Pirt relation for Electron donor, thermodynamics and stoichiometry of product formation.

Objective: This unit provides knowledge in thermodynamic description of microbial growth and product formation models like Herbert-Pirt model and Compromise model

Session No *	Topics to be covered	Ref	Teaching Aids
37	Carnot cycle	T2 – Ch.5; Pg. 151-162 R2 – Ch.5; Pg. 164-180 Video 1	LCD, Animated videos
38	Refrigeration cycle	T4 – Ch.14; Pg. 617-626 Video 2 & 3	LCD, Animated videos
39	Thermodynamics of microbial growth	T3 – Ch.11; Pg. 01-20 R3; Pg. 517-533	LCD
40	Stoichiometry, thermodynamics of maintenance	T3- Ch.9; Pg. 01-32 R3; Pg. 517-533	LCD
41	Non-growth components and models for microbial maintenance	T3 – Ch.10; Pg. 01-18	LCD
42	Herbert Model & Pirt Model	R3; Pg. 517-523 R4; Pg. 01-08	LCD
43	Compromise Model	R3; Pg. 524-527 R4; Pg. 01-08	LCD
44	Relationship between three models	R3; Pg. 528-531 R4; Pg. 01-08	LCD/BB
45	Overall maintenance coefficient and Multi-Parameter Sensitivity analysis, Implications of microbial ecology modeling	R3; Pg. 532-533 R4; Pg. 01-08	LCD/BB

Content beyond syllabus covered (if any): Cellular respiration

* Session duration: 50 mins

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REFERENCES:

TEXT BOOK (TB):

1. Smith J.M., Van Ness H.C., Abbot M.M. Chemical Engineering Thermodynamics. 7th Edition. McGraw-Hill, 2010.
2. Narayanan K.V. A Text Book of Chemical Engineering Thermodynamics. Eastern Economy Ed, PHI, 2015.
3. Christiana D.Smolke. The Metabolic pathway engineering handbook fundamentals, CRC Press Taylor & Francis Group, 2010.
4. Nag P.K. Engineering Thermodynamics, 6th Edition, McGraw Hill Education, 2017.
5. Pandey G.N, Chaudhari J.C. Chemical Engineering Thermodynamics, Khanna Publishers, 2004.

REFERENCE BOOK (RB):

1. Gopinath Halder. Introduction to Chemical Engineering Thermodynamics, PHI, 2009.
2. Sandler S.I, Chemical and Engineering Thermodynamics, John Wiley, 1989.
3. Urs von Stockar, Thomas Maskow, Jingsong Liu, Ian W.Marison, Rodrigo Patino. Thermodynamics of microbial growth and metabolism: an analysis of the current situation (2006) Journal of Biotechnology, 121, 517-533.
4. Gangsheng Wang, Wilfred M.Pos. A theoretical reassessment of microbial maintenance and implications for microbial ecology modeling (2012) FEMS Microbiol Ecol, 81, 610-617.

ANIMATED VIDEO LINKS:

1. Carnot cycle - https://youtu.be/ELR1Hx4qymo?si=9Fc1F0agizX5WF3w
2. Refrigeration cycle - https://youtu.be/LqDhdQ-9KcQ?si=TNMhSZfeKBFz9lS6
3. Air conditioner working principle - https://youtu.be/GzEMdQk1QTk?si=dE5Y82W8X6jekGX-

BLENDED LEARNING VIDEO

1. Phase diagrams for Binary solutions - https://www.youtube.com/playlist?list=PLODKZZeKAWb8-X2nbdiO304TFKBZeWg8b/BT22403-Phase

	Prepared by	Approved by
Signature	P.K. Praveen 20.1.25	20/1/25
Name	Dr. P.K. PRAVEEN KUMAR	Dr. E. NAKKEERAN
Designation	PROFESSOR	PROFESSOR & HOD
Date	20.01.2025	20.01.2025
Remarks *: The same lesson plan will be followed in subsequent semester.		
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