GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3130405
Semester – III
Concepts of Themodynamics and Bioenergetics

Type of course: Engineering Science

Prerequisite: Basic Knowledge of Chemistry and Biochemistry

Rationale: The basic aim of this subject is to provide a clear understanding to the students about the laws of thermodynamics, its allied concepts and calculation of various quantities which predict the behavior of various systems. Bioenergetics is important to understand energy metabolism and energy transfer in living systems

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	**T**	**P**	**C**	**Theory Marks**		**Practical Marks**		
				ESE (E)	**PA (M)**	**ESE (V)**	**PA (I)**	
3	1	0	4	70	30	0	0	100

Contents:

Sr. No.	Topics	Teaching Hrs.
1	**Introduction** Basic concepts – systems, surroundings, processes, properties (extensive/intensive), components (single/multi), phases (G/L/S), ideality, zeroth, first law of thermodynamics and their consequences (T, U, S).	6
2	**[A] Thermodynamic functions** The thermodynamic functions H, A and G, concept of chemical potential, equations for a closed system, Maxwell's relations, thermodynamic analysis of processes – lost work, irreversibility, thoughts on Classical and Statistical Thermodynamics in the context of Biological Processes and Systems. **[B] Thermodynamics of solutions:** Partial molar properties, fugacity, ideal and non-ideal solutions, excess properties of mixtures, activity coefficient, Gibbs-Duhem equation	8
3	**Thermodynamic properties of pure fluids** Review of ideal gas, non-ideal gas, PVT behaviour, virial and cubic equations of state, generalized correlations, residual properties, estimation of thermodynamic properties using equations of state	6

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4	**Second law of thermodynamics:** Statements, heat engines, concept of entropy, entropy changes, third law of thermodynamics	6
5	**Phase and Reaction Equilibria** Phase rule, criteria for phase equilibria, VLE for pure component, VLE for multi-component system, Equilibrium criteria for homogenous reactions, evaluation of equilibrium constant, effect of temperature and pressure on equilibrium constant, calculation of equilibrium conversion and yields for single and multiple reactions.	6
6	**Metabolic Concepts:** Elucidation of metabolic pathways, logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; unifying themes of metabolic pathways.	3
7	**Biochemical Energetics** Energy yielding and energy requiring reactions, Calculations of Equillibrium Concentrations, Oxidation Reduction Reactions, Metabolism and ATP yield, Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F_1 -F_0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane., Active Transport, Enthalpy and Entropy, Activation Energy.	13

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	20	15	30	25	0

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

Reference Books:

1. "Introduction to Chemical Engineering Thermodynamics"; J. M. Smith, H. C.Van Ness, M. M. Abbott, the McGraw-Hill Companies, Inc.

2. "Chemical, Biochemical and Engineering Thermodynamics"; S.I. Sandler, Wiley India Edition.

3. "A text book of Chemical Engineering Thermodynamics"; K. V. Narayanan, Prentice-Hall of India Pvt. Ltd.

4. "Chemical and Process Thermodynamics"; B.G. Kyle, Prentice-Hall Inc.

5. "Introduction to Thermodynamics"; Y.V.C. Rao, 2nd Edition, Wiley Eastern Limited.

6. Biochemical calculations by Irwin Seigel, Publisher John Wiley & Sons.

7. NPTEL videos of the same subjects

Course Outcome:

Sr. No.	CO Statement	Marks % Weightage
CO-1	To develop a fundamental understanding of the basic principles of thermodynamics and calculations.	25%
CO-2	To examine and select pertinent data, and solve energy transformations problems.	25%
CO-3	To give examples of important application of thermodynamics laws in Bio processes	25%
CO-4	To develop understanding energy metabolism in biochemical reactions	25%

LIST OF TUTORIALS:

1. Tutorials based on thermodynamics basic functions and properties

2. Tutorials based on properties of pure fluids and solutions

3. Tutorials based on equilibria of reaction

4. Tutorials based on bio energetics

List of Open Source Software/learning website:

1) NPTEL

2) MIT Open course lecture