



# GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Metallurgy

Subject Code: BE03021011

Subject Name: Metallurgical Thermodynamics

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	Professional Core Course

<b>Prerequisite:</b>	Nil
<b>Rationale:</b>	Metallurgical thermodynamics focuses on the energy changes and equilibrium conditions in metallurgical processes. It is used to study chemical reactions, phase equilibria, and elemental distribution in metallurgical processes. Metallurgical Extraction processes involve use of Ellingham diagram for choice of reducing agent, free energy and enthalpy calculations maintaining reducing conditions etc.

## Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Identify different system and thermodynamic processes	15
CO-2	Apply thermodynamic laws for metallurgical applications.	55
CO-3	Calculate enthalpy and entropy of reaction	30

## 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)	PBL (I)	ESE (V)	
45	0	60	15	120	04	70	30	20	30	50	200

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

## Content:

Sr. No.	Content	Total Hrs	% Weightage
1	Introduction: thermodynamic terms, Ideal Gas, Energy and Work, Extensive and Intensive Properties, Zeroth law of thermodynamics.	04	09
2	First Law of Thermodynamics, Internal Energy, Enthalpy, Heat Capacity, Reversible Processes	06	12
3	Second Law of Thermodynamics, Entropy and equilibrium, Reversibility, Statistical Interpretation of Entropy, Boltzmann Equation, Auxiliary Functions Enthalpy, Free Energy, Chemical Potential, Maxwell's Equations,	14	31



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	Gibbs-Helmholtz Equation		
4	Enthalpy as a Function of Temperature and Composition, Third Law of Thermodynamics, Phase Equilibrium in a One-Component System, Equilibrium between Vapor and Condensed Phase, and between condensed phases, Raoult's Law and Henry's Law, Activity, Gibbs-Duhem Equation, Properties of Ideal and Non-ideal Solutions, Regular Solutions	15	36
5	Ellingham Diagrams, The Gibbs Phase Rule, Phase Diagrams of some Binary Systems	06	12
	<b>Total</b>	<b>45</b>	<b>100</b>

## Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	30	50	5	0	0

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

## Reference Books:

1. Introduction to Thermodynamics of Materials, 5th Edition, David R Gaskell, Taylor & Francis, 2016.
2. Metallurgical Thermodynamics, Kinetics and Numericals, S.K.Dutta and Prof. A.B.Lele
3. Introduction to Materials and Metallurgical Thermodynamics by A. Ghosh published by PHI
4. Problems in Metallurgical Thermodynamics and Kinetics by G. S. Upadhyaya and R. K. Dube published by Pergamon Press

## List of Experiments:

1. Introduction to materials thermodynamics and basic terminologies.
2. To understand Zeroth law of thermodynamics and its applications.
3. To study First law of thermodynamics, Hess Law & Kirchoff's law.
4. To solve problems based on 1st law of thermodynamics.
5. To study 2nd law of thermodynamics and concept of entropy and free energy.
6. To solve problems based on 2<sup>nd</sup> law of thermodynamics.
7. To derive specific heat and relation between  $C_p$  and  $C_v$ .
8. To study 3rd law of thermodynamics, Raoult's law, Henry's law and Solutions.



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- To apply Gibb's phase rule to phase diagram.
- To apply Ellingham Diagram for extractive metallurgy.

## List of Open Source Software/learning website:

I. <http://nptel.iitm.ac.in/>

II. <http://ocw.mit.edu/>

## • List of suggested activities for Problem Based Learning:

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Industry/Research laboratory visit	Visit = 5hrs., Report preparation = 5hrs. Total = 10hrs.	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2.	Technical Video based learning related to the subject	Duration of video = 5hrs. Report preparation = 5hrs. Total = 10hrs.	Report /presentation based on the video learning outcomes.
3.	Assignment writing. Numericals based assignment is preferable.	5 assignments of 4hrs. each. Total = 20hrs.	Based on the correctness of submitted assignment.
4.	Problem solving/Coding using C, C++, MATLAB, Python, SCILAB, modeling and Analysis software or any other software	5 small coding-based assignment of 2hrs. each. Total = 10hrs.	Based on the coding solution submitted.
5.	Self-learning online course	Minimum duration of the course should be 10hrs.	Examination based assessment at the end of course. Based on the certificate produced.
6.	Identification and solution of Complex problem	Maximum 2 problems. Study of the problem and solution finding, Total = 10hrs.	Based on the depth of the solution submitted.
7.	Videos on Industrial safety/Disaster Management aspects	Duration of video = 5hrs. Report preparation = 5hrs. Total = 10hrs.	Based on quiz/report submitted



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	based on subject		
8	Technical paper reading and summarization of research papers based on relevant subject	5 research papers = 20 hrs.	Summarize research paper and evaluation critical parameters
9.	Poster/chart/power point preparation on technical topics	Duration = 6 hrs.	Based on poster/chart preparation and presentation skills
10	Working/non-working model on technical topics	Working = 12 hrs. Non- working = 8 hrs.	Based on inter department/external evaluation
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/sustainability/any other issue	Duration = 15 hrs. for industrial exposure  Problem identification and tentative solution = 10 hrs. Total = 20 hrs.	Based on evaluation of critical problems and solutions
12	Group Discussion on emerging/trending technical topics based on subject	Duration = Min. 1 hr.per subject. Max. 3 hrs. per subject	Based on performance in group discussion, technical depth, knowledge etc.
13.	Real world case studies-based learning	Duration of data collection/study = 5hrs. Report preparation = 5hrs. Total = 10hrs.	Based on in-depth study, technical depth, data collected, fact finding, etc.
14.	Application/Software development	Duration = 10 hrs.	Depending on the complexity of the Application/Software
15.	Research paper publication	Duration = 10 hrs.	Based on submission of proof of publication
16.	Upgradation/Reverse engineering studies of existing equipment of the laboratory	Duration 10 hrs.	Based on the performance of the equipment
17.	Expert lecture/session	Duration 3 hrs. For attending the lecture/session– 2 hrs. and for report writing 1 hr.	Based on the proof of attendance and report submitted
18.	Annotated Video Explanation of Concept/Problem	10h (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
19.	Patent Search and	10h (Search + Report)	Based on number of



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	Innovation Identification	Gap		relevant patents analyzed and identification of innovation scope.
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Note:

- All the suggested activity should be related to the subject.
- The number of hours are suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
- Rubrics for the evaluation can be prepared by the faculty.
- Subject teacher can add the relevant activities other than those listed above, with the consent of head of the department and DQAC.
- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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