CHEMICAL ENGINEERING THERMODYNAMICS **Course Code : 314308**

Programme Name/s : **Chemical Engineering**
Programme Code : **CH**
Semester : **Fourth**
Course Title : **CHEMICAL ENGINEERING THERMODYNAMICS**
Course Code : **314308**

I. RATIONALE

Diploma chemical engineer deals with industrial processes, where laws of thermodynamics play a vital role. The concepts and laws of thermodynamics develop an ability in diploma chemical engineers to evaluate heat and work interaction involved in industrial chemical processes.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Apply basic concepts, laws, and principles of thermodynamics to calculate heat and work requirements for physical and chemical changes in various chemical engineering processes.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Use basic concepts of thermodynamics for given chemical processes.
- CO2 - Apply first law of thermodynamics to improve the chemical process.
- CO3 - Apply second law of thermodynamics to describe entropy of system.
- CO4 - Use P-V-T graphical representation of fluids for different process.
- CO5 - Apply concept of chemical equilibrium in chemical process.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
314308	CHEMICAL ENGINEERING THERMODYNAMICS	CET	DSC	4	2	-	-	6	3	03	30	70	100	40	50	20	-	-	-	-	150

Total IKS Hrs for Sem. : Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Enlist different types of system TLO 1.2 Differentiate between extensive and intensive properties of system TLO 1.3 Identify state and path function TLO 1.4 State zeroth law of thermodynamics for given situation/system TLO 1.5 Explain thermodynamic equilibrium	**Unit - I Basic Concept of Thermodynamics** 1.1 Introduction to thermodynamics: System, boundary and surrounding 1.2 Classification of system: Homogeneous and heterogeneous, closed, open, isolated, and adiabatic 1.3 Properties: Extensive and intensive, concept of energy, heat, work and power, simple numerical (based on heat and work) 1.4 Function: State and path function. (work and heat as path function) 1.5 Process: Isobaric, isothermal, isochoric, adiabatic, reversible, irreversible, quasi static and cyclic process 1.6 Types of equilibrium: Stable, unstable, metastable, mechanical, chemical, thermal, and thermodynamic equilibrium 1.7 Zeroth law of thermodynamics and its application	Lecture Using Chalk-Board Presentations

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 State first law of thermodynamics TLO 2.2 Explain internal energy and enthalpy TLO 2.3 Write relation between heat capacity at constant volume and heat capacity constant pressure TLO 2.4 Derive an expression for work done for given process	**Unit - II First Law of Thermodynamics** 2.1 First law of thermodynamics: Mathematical equation and its application 2.2 Internal energy, standard enthalpy changes, temperature dependence of enthalpy. Simple numerical on enthalpy calculation 2.3 Relation between heat capacity at constant volume (Cv) and heat capacity at constant pressure (Cp) 2.4 Derivation for work done for following processes: Isobaric process, isochoric/isometric, isothermal, adiabatic and polytropic process (simple numerical on determination of Q, W, ΔU & ΔH for the above processes)	Lecture Using Chalk-Board Presentations
3	TLO 3.1 Explain second law of thermodynamics TLO 3.2 Describe basic concepts of second law of thermodynamics TLO 3.3 Write mathematical expression of Clausius inequality TLO 3.4 Calculate entropy change for given system TLO 3.5 State third law of thermodynamics	**Unit - III Second Law of Thermodynamics** 3.1 Second law of thermodynamics. (Kelvin-Plank statement, Clausius statement) and its application, limitations of first law of thermodynamics 3.2 Basic concepts: heat reservoir, heat engine and heat pump or refrigerator, thermal efficiency and Coefficient of Performance (C.O.P), entropy 3.3 Clausius inequality statement and mathematical expression 3.4 Entropy change of an ideal gas. Phase change, ideal gas processes, adiabatic, mixing, and isothermal mixing (numerical on entropy change) 3.5 Third law of thermodynamics and its application	Lecture Using Chalk-Board Presentations
4	TLO 4.1 Explain P-V-T behaviour of pure fluids TLO 4.2 Draw P-H (Pressure-Enthalpy), T-S (Temperature-Entropy), H-T (Enthalpy – Temperature) and H-S (Enthalpy – Entropy) diagram for given chemical process TLO 4.3 Explain phase diagram for water system TLO 4.4 Use Vander Waals equation to calculate volume of real gas TLO 4.5 Calculate degree of freedom for given system	**Unit - IV Pressure-Volume-Temperature(P-V-T) Behaviour of Pure Fluids** 4.1 1 P-V-T behaviour of pure fluids: Graphical presentation of different thermodynamic processes on P-H (Pressure-Enthalpy), T-S (Temperature-Entropy), H-T (Enthalpy – Temperature) and H-S (Enthalpy – Entropy) diagram. Phase diagram for water system 4.2 Ideal gas and equation of state 4.3 Equations of state for real gas: Vander Waals and Virial equation, numerical on Vander Waals equation only. Compressibility factor 4.4 Degree of freedom, Gibb`s phase rule, numerical 4.5 Fugacity and fugacity coefficient	Lecture Using Chalk-Board Presentations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 Explain chemical equilibria for the given system TLO 5.2 Apply Le-Chatelier's principle for given system TLO 5.3 Write relation between ΔG & K TLO 5.4 Explain variation of equilibrium constant with temperature based on Van't Hoff's equation	**Unit - V Chemical Equilibria** 5.1 Concept of chemical equilibria, equilibrium constant for gaseous mixture, derivation and numerical 5.2 Gibbs free energy change and feasibility of chemical reaction from free energy change. Le-Chatelier's principle 5.3 Chemical potential, law of mass action, relation between Gibbs free energy(ΔG) & equilibrium constant (K) 5.4 Van't Hoff's equation, variation of equilibrium constant with temperature for exothermic and endothermic reaction, numerical (based on Van't Hoff's equation)	Lecture Using Chalk-Board Presentations

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Calculate heat of given system	1	* Numerical based on heat (Q)	2	CO1
LLO 2.1 Calculate work of given system	2	* Numerical based on work (W)	2	CO1
LLO 3.1 Calculate internal energy of given system	3	* Numerical based on internal energy	2	CO2
LLO 4.1 Derive an expression for work done for given reversible process.	4	Derive an expression for work done for isobaric process, isochoric/isometric, isothermal, adiabatic and polytropic reversible process	2	CO1 CO2
LLO 5.1 Apply first law of thermodynamics to calculate ΔU for given process	5	* Numerical on ΔU using first law of thermodynamics	2	CO1 CO2
LLO 6.1 Apply first law of thermodynamics to calculate ΔH for given process	6	Numerical on ΔH using first law of thermodynamics.	2	CO1 CO2
LLO 7.1 Explain relation between Cp, Cv and R	7	*Derivation between Cp, Cv and R	2	CO2
LLO 8.1 Calculate entropy changes for adiabatic mixing of given system	8	Numerical on entropy changes for adiabatic mixing	2	CO3
LLO 9.1 Explain concept of Entropy LLO 9.2 Calculate entropy changes for ideal gas	9	*Numerical on entropy changes of for ideal gas	2	CO3
LLO 10.1 Explain concept of Entropy LLO 10.2 Calculate entropy changes for given system	10	Numerical on entropy changes for isothermal mixing	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 11.1 Explain thermodynamic diagram	11	* Plot the curve of P-V-T (pressure-volume-temperature), T-S (temperature-entropy), H-T (enthalpy – temperature), P-H (pressure-enthalpy) and H-S (enthalpy – entropy)	2	CO4
LLO 12.1 Use Vander Waals equation to calculate volume of real gas	12	Numerical on Vander Waals equation	2	CO4
LLO 13.1 Explain phase rule LLO 13.2 Calculate degree of freedom for given system	13	*Numerical on Gibb's phase rule	2	CO4
LLO 14.1 Explain equilibrium constant for gaseous mixture	14	* Derivation for the equilibrium constant (Kp & Kc) and (Kp & Ky)	2	CO5
LLO 15.1 Calculate effect of temperature on equilibrium constant using Van't Hoff's equation LLO 15.2 Apply Le-Chatelier's principle to solve numerical	15	* Numerical on Van't Hoff's equation and Le-Chatelier's principle	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

-NA-

- -NA-

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	-NA-	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification

Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Basic Concept of Thermodynamics	CO1	10	4	4	4	12
2	II	First Law of Thermodynamics	CO1,CO2	14	6	4	6	16
3	III	Second Law of Thermodynamics	CO2,CO3	14	4	6	6	16
4	IV	Pressure-Volume-Temperature(P-V-T) Behaviour of Pure Fluids	CO4	12	4	4	6	14
5	V	Chemical Equilibria	CO5	10	4	4	4	12
Grand Total				**60**	**22**	**22**	**26**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Tutorial of 50 Marks

Two Class Test of 30 Marks

Summative Assessment (Assessment of Learning)

- End Semester Exam of 70 Marks

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	2	1	-	1	-	1			
CO2	2	2	1	1	2	-	1			
CO3	2	2	1	1	2	-	1			
CO4	2	2	2	1	2	-	1			
CO5	2	2	2	-	1	-	1			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	K. V. Narayanan	A Textbook of Chemical Engineering Thermodynamics	Prentice Hall India Pvt., Limited, ISBN: 9788120317321, 8120317327
2	Joseph Mauk Smith, Hendrick C. Van Ness, Michael M. Abbott, M. T. Swihart	Introduction to Chemical Engineering Thermodynamics	McGraw-Hill, ISBN: 9780071270557, 0071270558

Sr.No	Author	Title	Publisher with ISBN Number
3	Stanley I. Sandler	Chemical and Engineering Thermodynamics	Wiley, ISBN: 9780471017745, 0471017744
4	Y. V. C. Rao	Chemical Engineering Thermodynamics	Sangam Books, ISBN:9788173710483, 8173710481
5	P. K. Nag	Engineering Thermodynamics	Tata McGraw Hill, ISBN: 9780070591141, 0070591148

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://archive.nptel.ac.in/courses/103/103/103103144/	Video Lectures, Transcripts
2	https://archive.nptel.ac.in/courses/103/106/103106070/	Video Lectures
3	https://archive.nptel.ac.in/courses/103/104/103104151/	Video Lectures
4	https://unacademy.com/course/part-1-thermodynamics-chemical-engineering/PPQGVSG1	Video Lectures
5	https://unacademy.com/course/part-ii-chemical-engineering-thermodynamics-cet-ii/XO43QVZQ	Video Lectures
6	https://nptel.ac.in/courses/103101004	Video Lectures

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students