K. K. Wagh Institute of Engineering Education & Research, Nashik

(An Autonomous Institute From A.Y. 2022-23)

WINTER-2025	
Exam Seat No.:	
Academic Year: 2025-2026	Semester: IV
Class: SY	Program: B.Tech
Branch Code: CHE	Pattern: 2022
Name of Course: Thermodynamics	Course Code: CHE222014
Max. Marks: 60	Duration: 2.30 Hrs.

Instructions: Candidates should read carefully the instructions printed on the Question Paper and on the cover page of the Answer Book, which is provided for their use.

1. This question paper contains 02 page(s).
2. Answer to each new question is to be started on a new page.
3. Assume suitable data wherever required, but justify it.
4. Draw the neat labelled diagrams, wherever necessary.
5. The last columns indicates the Course Outcome of the Question/sub-question.

		Marks	CO
Question No. 1			
1a)	Explain heat capacities (Cp, Cv). Derive the relation between Cp and Cv for ideal gases.	(6)	CO1
Question No. 2			
2a)	Explain the significance of the critical point of a pure substance and illustrate fluid behavior near the critical region using a PV diagram.	(6)	CO2
Question No. 3			
3a)	Derive the relation for a total property of a mixture in terms of partial molar properties, showing that $M^t = \sum_i n_i \bar{M}_i$.	(8)	CO3
	OR		
3b)	Derive the thermodynamic property relations for the Helmholtz free energy A and the Gibbs free energy G starting from their definitions. Show the complete derivations for: a) $dA = -SdT - PdV$ b) $dG = -SdT + VdP$	(8)	CO3
3c)	A total volume of 1.5 m^3 is required to produce a liquid mixture that is 25 mol% acetone and 75 mole% benzene. The molar volume of pure acetone is 73×10^{-6} m^3/mol and that of pure benzene is 89.4×10^{-6} m^3/mol. The partial molar volume of acetone and benzene are 75.1×10^{-6} m^3/mol and 87.9×10^{-6} m^3/mol respectively. Calculate the volumes of pure acetone and pure benzene that must be mixed to prepare 1.5 m^3 of the solution.	(8)	CO3
	OR		
3d)	Derive the Lewis Randall Rule.	(8)	CO3
Question No. 4			
4a)	Describe the concept of degrees of freedom and illustrate how the phase rule is used to calculate it for a non-reacting system.	(8)	CO4

OR

4b) A water (1)–acetic acid (2) mixture at 298 K and a total pressure of 18×10^3 Pa, the liquid mole fraction is $x_1 = 0.35$ and the vapor mole fraction is $y_1 = 0.675$. The saturation pressures for pure water (1) and acetic acid (2) at 298 K are 17.5×10^3 Pa and 7.5×10^3 Pa, respectively. Calculate the activity coefficient for water in the liquid phase and find G^E/RT. (8) CO4

4c) Describe the criteria for phase equilibrium. (8) CO4

OR

4d) Benzene (1) and toluene (2) form an ideal solution. The vapor pressures of benzene and toluene are 95.1 kPa and 28.4 kPa, respectively. Calculate: (8) CO4

(i) x_1 and y_1 at 360 K and P = 70 kPa.

(ii) P and x_1 at 360 K and y_1 =0.3

Question No. 5

5a) A gas mixture containing 1 mol CO and 1 mol water vapour is undergoing following reaction at a temperature of 1100K and a pressure of 1 bar. (8) CO5

$$CO_{(g)} + H_2O_{(g)} \rightarrow CO_{2\,(g)} + H_{2\,(g)}$$

The equilibrium constant for the reaction is K = 1. Calculate the fractional dissociation of steam assuming that the gas mixture behaves ideally.

OR

5b) How does temperature influence the equilibrium constant? Use the Van't Hoff equation to explain the impact of increasing temperature on endothermic and exothermic reactions. (8) CO5

5c) What is the concept of chemical equilibrium, and what criteria must be satisfied for it to occur? (8) CO5

OR

5d) In the reaction $C_2H_4 + H_2 + O_2 \rightarrow C_2H_5OH$, starting with an initial mixture of 2 mol ethylene, 3 mol hydrogen, 1 mol oxygen, and 4 mol ethanol, how would you express the mole fraction of each component in terms of the extent of reaction? (8) CO5

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