



K. K. Wagh Institute of Engineering Education & Research, Nashik
(An Autonomous Institute From A.Y. 2022-23)

SUMMER-2024	
Exam Seat No.:	
Academic Year: 2023-2024	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 2 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 and level of Blooms Taxonomy of the Question/sub-question.

Question No. 1 Attempt following Question

- 1a) Discuss the Zeroth Law of Thermodynamics and explain the difference between reversible and irreversible process. (6) CO1

Question No. 2 Attempt following Question

- 2a) Show that work done in constant temperature = $RT \ln (P_1/P_2)$. (6) CO2

Question No. 3 Attempt following Question

- 3a) a) Prove the Maxwell's equations. (8) CO3

$$\text{I. } \left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$$
$$\text{II. } \left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$$

OR

- 3b) Define Activity, Activity Coefficient and show that the activity and mole fraction in an ideal solution are identical. (8) CO3
- 3c) The partial pressure of acetone (A) and chloroform (B) measured at 298K are reported below: (8) CO3

x_A	0	0.2	0.4	0.6	0.8	1.0
\bar{p}_A (bar)	0	0.049	0.134	0.243	0.355	0.457

p_B^- (bar)	0.386	0.288	0.187	0.108	0.046	0
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Calculate the activity and activity coefficient of acetone in chloroform based on Lewis-Randall rule.

OR

- 3d) A 30% by mole methanol-water solution is to be prepared. How many cubic meters of pure methanol (molar volume, $40.727 \times 10^{-6} \text{ m}^3/\text{mol}$) and pure water (molar volume, $18.068 \times 10^{-6} \text{ m}^3/\text{mol}$) are to be mixed to prepare 2 m^3 of the desired solution? The partial molar volume of methanol and water in a 30% solution are $38.632 \times 10^{-6} \text{ m}^3/\text{mol}$ and $17.765 \times 10^{-6} \text{ m}^3/\text{mol}$, respectively. (8) CO3

Question No. 4 Attempt following Question

- 4a) Derive the equation for Raoult's law and Modified Raoult's law form Vapour Liquid Equilibrium. (8) CO4

OR

- 4b) State the Duhem's theorem? What is its significance in establishing the state of the system? (8) CO4

- 4c) Explain the T-x-y diagram in detail. (8) CO4

OR

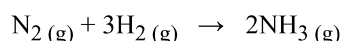
- 4d) The vapor-liquid state of an ethanol (1) – toluene (2) system at 318 K and $24.4 \times 10^3 \text{ Pa}$ is $x_1 = 0.30$, $y_1 = 0.634$. The saturation pressure of pure ethanol (1) and toluene (2) at 313 K are $23.06 \times 10^3 \text{ Pa}$ and $10.06 \times 10^3 \text{ Pa}$, respectively. Determine the liquid phase activity coefficient and value of G^E/RT for the liquid phase. (8) CO4

Question No. 5 Attempt following Question

- 5a) Derive the relation $\Delta G^0 = -RT \ln K$. (8) CO5

OR

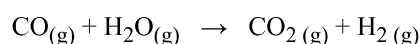
- 5b) The standard heat of formation and standard free energy of formation of ammonia at 298 K are $-46,100 \text{ J/mol}$ and $-16,500 \text{ J/mol}$ respectively. Calculate the equilibrium constant for the reaction at 500 K assuming that the standard heat of reaction is constant in the temperature range 298K to 500K. (8) CO5



- 5c) What is the effect of temperature on equilibrium constant? Using Van't Hoff equation predict the effect of increasing the temperature on endothermic and exothermic reactions. (8) CO5

OR

- 5d) A gas mixture containing 2 mol CO, 1 mol steam and 1 mol CO_2 undergoing the following reaction: (8) CO5



Derive expression for the mole fraction of the components present in the reaction mixture in terms of the extent of reaction.

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