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Question Paper Code: R4905

B.E. / B.Tech. DEGREE EXAMINATION, APRIL / MAY 2025

Fourth Semester

Chemical Engineering

R21UCH402 – CHEMICAL ENGINEERING THERMODYNAMICS-I

(Regulations R2021)

Duration: Three hours

Maximum: 100 Marks

Answer ALL Questions

PART A - (10 x 1 = 10 Marks)

1. At absolute zero, which of the following is true? CO1-U
(a) All molecular motion stops. (b) Water freezes.
(c) Snow melts. (d) Gases have a maximum volume.
2. In Joule's experiment, which of the following was primarily demonstrated? CO1- U
(a) The conversion of thermal energy into mechanical work.
(b) The independence of heat and temperature.
(c) The creation of energy from nothing.
(d) The relationship between heat and pressure.
3. Which of the following is true for the compressibility factor at low temperatures and high pressures? CO1-U
(a) $Z = 1$ for all gases. (b) $Z > 1$ for most gases.
(c) $Z < 1$ for most gases. (d) $Z = 0$ for all gases.
4. The relationship between pressure, volume, and temperature for an ideal gas is given by which law? CO1-U
(a) Boyle's law (b) Charles' law (c) Ideal gas law (d) Gay-Lussac's law

5. Which of the following is an example of excess property in thermodynamics? CO1-U
 (a) Excess enthalpy (b) Excess entropy
 (c) Excess Gibbs free energy (d) All of the above
6. The change in entropy during the mixing of two ideal gases is: CO1-U
 (a) Zero (b) Positive
 (c) Negative (d) Depends on the temperature only
7. The activity coefficient of a component in a mixture indicates: CO1-U
 (a) The ratio of the fugacity of the component to its partial pressure.
 (b) The deviation of the component's behavior from ideal solution behavior.
 (c) The chemical potential of the component.
 (d) The partial molar volume of the component.
8. The change in Gibbs free energy upon mixing two ideal gases is: CO1-U
 (a) Zero. (b) Positive.
 (c) Negative. (d) Dependent on the temperature and pressure.
9. The standard free energy change (ΔG°) of a reaction is related to the equilibrium constant (K) by the equation: CO2-App
 (a) $\Delta G^\circ = -RT \ln K$ (c) $\Delta G^\circ = -RT \ln (1/K)$
 (b) $\Delta G^\circ = RT \ln K$ (d) $\Delta G^\circ = RT \ln (1/K)$
10. If the equilibrium constant (K) is much greater than 1, the reaction: CO3-Ana
 (a) Favors the products. (b) Favors the reactants.
 (c) Is at equilibrium. (d) Cannot proceed.

PART – B (5 x 2= 10 Marks)

11. Distinguish between the behavior of an ideal gas and a real gas using the compressibility factor from compressibility charts. CO3-Ana
12. Illustrate a graph representing the P-V-T behavior of a pure fluid. CO2-App
13. How is enthalpy change related to the heat of mixing for two substances? CO2-App
14. Why is it important to understand phase equilibrium in the context of distillation processes? CO5-App

15. Name the factors that affect the equilibrium composition of a homogeneous chemical reaction. CO4-Ana

PART – C (5 x 16= 80Marks)

16. (a) Apply the First Law of Thermodynamics to explain Joule's experiment. Discuss how this experiment demonstrates the conversion of mechanical work into heat energy and supports the principle of energy conservation in thermodynamic systems. CO2- App (16)

Or

- (b) Apply the Carnot cycle to explain the theoretical maximum efficiency of a heat engine. Discuss the limitations of real-world engines. CO2- App (16)

17. (a) Derive the equation of state for an ideal gas and a real gas. Discuss how the real gas equation accounts for deviations from ideal behavior at high pressures and low temperatures. CO3- Ana (16)

Or

- (b) Construct the mathematical representation of the P-V-T behavior of a pure fluid. Derive the equation of state and explain how pressure, volume, and temperature interact in different fluid phases. CO3- Ana (16)

18. (a) (i) Distinguish between excess properties and ideal solution behavior. How are excess properties, such as excess Gibbs free energy, used to describe real mixtures? CO3- Ana (8)

- (ii) Dissect the Gibbs-Duhem equation into its constituent parts and analyze how it establishes relationships between the chemical potentials of different components in a mixture. CO3- Ana (8)

Or

- (b) (i) Examine the relationship between fugacity and partial molar Gibbs free energy. Analyze their roles in influencing the equilibrium of a chemical reaction in mixtures. CO3- Ana (8)

- (ii) Analyze the function of excess properties in thermodynamics and explore how they are used to characterize deviations from ideal behavior in mixtures. CO3- Ana (8)

19. (a) Discuss the thermodynamic principles governing first-order phase transitions, including the concepts of latent heat and Gibbs free energy. CO1- U (16)

Or

- (b) Explain Schreinemaker's analysis and its application in constructing phase diagrams. CO1- U (16)

20. (a) Consider the reaction $\text{N}_2 (\text{g}) + 3\text{H}_2 (\text{g}) \rightleftharpoons 2\text{NH}_3 (\text{g})$. Derive the expression for the equilibrium constant in terms of concentrations. Explain how the reaction's equilibrium constant would change with variations in temperature and pressure. CO5- App (16)

Or

- (b) How does the concept of Gibbs free energy (ΔG) relate to the equilibrium constant? Derive the equation that connects ΔG° and K . Explain how to interpret the values of ΔG° and K for spontaneous and non-spontaneous reactions. CO5- App (16)