Register No.: .... Name: ....

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

FOURTH SEMESTER B.TECH DEGREE EXAMINATION (S), AUGUST 2023
CHEMICAL ENGINEERING
(2020 SCHEME)

Course Code : **20CHT202**

Course Name: **Chemical Engineering Thermodynamics**

Max. Marks : 100 **Duration: 3 Hours**

PART A

(Answer all questions. Each question carries 3 marks)

1. What are the statements of Second law of thermodynamics?
2. State Clausius inequality statement.
3. What is the significance of Vander Waals constants 'a' and 'b'?
4. What is meant by derived thermodynamic properties? Give examples.
5. What is Raoult's law and its applicability?
6. Define activity and activity coefficient.
7. Differentiate between positive and negative azeotropic mixtures.
8. Highlight the difference between activity composition models and local composition models?
9. Mention the effect of pressure on reaction equilibrium constant?
10. Elucidate the term "feasibility of a reaction".

PART B

(Answer one full question from each module, each question carries 14 marks)

MODULE I

11. a) A system consisting of a gas confined in a cylinder is undergoing the series of process before it is brought back to the initial conditions. Step 1: A constant pressure process when it receives 50 J of work and gives up 25 J of heat. Step 2: A constant volume process when it receives 75 J of heat. Step 3: An adiabatic process. Determine the change in internal energy during each step and the work done during the adiabatic process. (7)

    b) A steel casting at a temperature 725 K and weighing 35 kg is quenched in 150 kg oil at 275 K. If there are no heat losses, determine the change in entropy. The specific heat (C_P) of steel is 0.88 kJ/kg K and that of oil is 2.5 kJ/kg K. (7)

OR

12. Water at 425 K is pumped from a storage tank at the rate of 25 m^3/h. The motor for the pump supplies work at the rate of 2 hp. The water passes through a heat exchanger, where it gives up heat at the rate of 42000 kJ/min and is delivered to a second storage tank at an elevation of 20 m above the first tank. What is the temperature of the water delivered to the second storage tank? Assume that the enthalpy of water is zero at 273 K and the specific heat of water is constant at 4.2kJ/kg K. (14)

MODULE II

13. Derive the Maxwell relations from the fundamentals. (14)

OR

14. a) Explain the phase change curves, triple point and critical point of a pure metal using Pressure-Temperature diagram. (7)

    b) Define Joule Thomson coefficient and prove it is equal to zero for ideal gases. (7)

MODULE III

15. Derive the Gibbs Duhem equation relating the molar and partial molar property. (14)

OR

16. a) Prove that if Raoult's law is valid for one constituent of a binary mixture over the whole concentration range it must also apply to the other component. (7)

    b) Prove that multiple phases at the same T and P are in equilibrium when chemical potential of each species is the same in all places. (7)

MODULE IV

17. Water (Component 1) - Hydrazine (Component 2) system forms an azeotrope containing 58.5 mole % hydrazine at 393K and 101.3 KPa. Calculate the equilibrium vapor composition for a solution containing 20 mole % hydrazine. The relative volatility of water with reference to hydrazine is 1.6 and may be assumed to remain constant in the temperature range involved. The vapor pressure of hydrazine at 393K is 124.76Kpa. (14)

OR

18. Explain the bubble point curve and dew point curve using a neat boiling point curve. How does the tie line help in determining the amount of liquid and vapour in equilibrium? (14)

MODULE V

19. Estimate the standard free energy change and equilibrium constant at 700 K for reaction (14)

$$N_2(g) + 3H_2(g) \leftrightarrow NH_3(g),$$

Given that the standard heat of formation and standard free energy of formation of ammonia at 298 K to be 46,100 J/mol and -16,500 J/mol respectively. The specific heat (J/mol K) data are given as functions of temperature (K)

N_2 $27.27 + 4.93\times10^{-3}$ T

H_2 $27.01+ 3.51\times10^{-3}$ T

NH_3 $29.75 + 25.11\times10^{-3}$ T

OR

20. a) n-Butane is isomerized to i-butane by the action of catalyst at moderate temperatures. It is found that the equilibrium is attained at the following composition. (10)

Temperature, K	mol %, n-butane
317	31.00
391	43.00

Assuming that activities are equal to the mole fractions, calculate the standard free energy of the reaction at 317 K and average value of heat of reaction over this temperature range.

b) What is the effect of temperature on equilibrium constant? (4)

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