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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

September / October 2023 Supplementary Examinations

Programme: B.E. **Semester: IV**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 19CH4DCTD2 **Max Marks: 100**
Course: Process Engineering Thermodynamics-II **Date: 21.09.2023**

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

UNIT - I

1 a) Define and explain the significance of Helmoltz free energy and Gibb's free energy. **04**

b) Derive the Maxwell relations from fundamentals. **10**

c) Carbon tetrachloride boils at 349.75 K at 1 bar. If its latent heat of vaporization is 194.8 kJ/kg, what would be the boiling point of carbon tetrachloride at 2 bar? **06**

OR

2 a) Prove the following relations starting from the fundamentals. **10**

(i) $\left(\frac{\partial S}{\partial T}\right)_P = C_p/K$

(ii) $C_p - C_V = \beta^2 V\, T/Ķ$

b) Explain the significance of Joule-Thomson coefficient and prove that it is zero for ideal gases. **05**

c) What are the different types of thermodynamic diagrams? Explain any one of them with the field of application. **05**

UNIT - II

3 a) State and explain the applicable range and significance of Lewis-Randall rule and Henry's law. **05**

b) Calculate the fugacity of CO at 50 bar and 400 bar, if the following data are applicable at 273 K. **10**

P, bar	25	50	100	200	400	800
Z	0.989	0.0.979	0.974	1.0196	1.2482	1.8057

c) Derive Gibb's-Helmholtz equation. Prove that Gibbs free energy is a generating function. **5**

OR

4 a) What are partial molar properties? How does this equation reduce to Gibb's-Duhem equation? **08**

b) The volume of a mixture of two organic liquids 1 and 2 are represented by the following equation. **07**

$$V = 110.0 - 17.1x_1 - 2.5x_1^2$$

where V is the volume in m^3/mol at 300 K and 1 bar. Obtain the expressions for the partial molar volumes and also determine the following.

i. The partial molar properties of component 1 and 2 at $x_1 = 0.4$

ii. The pure component volumes (V_1 and V_2)

c) Obtain equations for any two energy property change of mixing ideal gases to form an ideal solution. **05**

UNIT - III

5 a) Draw and explain the dew and bubble point diagrams. **06**

b) The binary system, acetone (1)-acetonitrile (2) conforms closely to Raoult's law. Using the vapour pressure data, plot P-x_1 and P-y_1 at 323 K. The vapor pressures of acetone and acetonitrile at 323 K are 81.97 kPa and 33.79, kPa respectively. **09**

c) What is the criterion of thermodynamic equilibrium in multicomponent systems? Derive the expression. **05**

UNIT – IV

6 a) What are the high boiling and low boiling azeotropes? Explain any one with the help of T-x,y and equilibrium diagram. **06**

b) Explain any two methods for testing the consistency of VLE data. **06**

c) Water (1) and hydrazine (2) system forms an azeotrope containing 42.5% (mol) water at 393 K and 101.3 kPa. **08**

i. Evaluate the van Laar's constants. The vapour pressure of water a 393 K is 199.62 kPa and that of hydrazine is 124.76 kPa.

ii. Calculate the activity coefficients for a solution containing 20% hydrazine.

UNIT - V

7 a) Define extent of reaction. Derive an expression to relate the extent of reaction and the mole fraction of components involved in the reaction. **05**

b) Derive an equation to relate equilibrium constant and standard free energy change of reacting system. **05**

c) n-butane is isomerized to i-butane by the action of catalyst at moderate temperature. It is found that the equilibrium is attained at the following compositions. **10**

Temperature, K	Mole %, n-butane
317	31
391	43

Assuming that the activities are equal to mole fractions, calculate the standard free energy of the reaction at 317 K and 391K and average value of heat of reaction over this temperature.

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