Model Question

V Semester Chemical Engineering

13.505 Chemical Engineering Thermodynamics (H)

CHEMICAL ENGINEERING BRANCH

(2013 SCHEME)

Part A

(Answer all questions from Part A)

1. Explain the thermodynamics state function and path function.
2. State and explain Vander wall's equation of state and write its constant.
3. State and explain the law of corresponding states and the usefulness of acentric factor
4. Explain phase rule for non reacting system.
5. Define chemical potential. How it is useful in expressing the criterion of phase equilibrium?
6. Define excess free energy and explain its relation to activity coefficient. Show that the rate of change of chemical potential of a substance is equal to its partial molar volume in the solution
7. Describe the tangent intercept method to determine the partial molar properties in a binary system
8. What are azeotropes? With proper phase diagrams explain maximum and minimum boiling azetropes?
9. Derive the relationship between the mole fraction of the component and extent of the reaction.
10. Write the effect of inerts on Equilibrium constant. (10x2=20 Marks)

Part B

Module I

11. Derive the following using Jacobian method

(a) $\frac{\partial u}{\partial T}$ ¿ ¿ ¿

(b) $\left(\frac{\partial u}{\partial p}\right) v = Cp\frac{k}{\beta} - Tv\beta$

(c) $\left(\frac{\partial u}{\partial v}\right)_T = \frac{T\beta}{K} - p$

(20marks)

OR

12. (a) At 20°C, the value of PV for oxygen may be approximated at pressures upto 100 atm by the equation

$PV = 1.07425 - 0.53\,X\,10^{-3}\,P + 0.15\,X\,10^{-6}\,P^2$

where P is in Atmospheres. Calculate, The fugacity of Oxygen at 90 atm and 20°C

(10marks)

(b) Explain

(i) Chemical Potential

(ii) Activity Coefficient

(iii) Fugacity coefffient

(iv) Mollier diagram (10 marks)

Module II

13. (a) Derive Gibbs Duhem equation and explain its application (10marks)

(b) In a binary mixture at azetropic condition prove that the composition is same throughout the phases. (10 marks)

OR

14 (a) Discuss in detail the applicability Wilson and Van laar equation for non ideal solution models (10marks)

(b) At atmospheric pressure ethyl acetate and ethyl alcohol form an azeotrpe mixture containing 53.9% of ethyl acetate boiling at 71.8 deg C. Calculate the vapour composition of a mixture containing 45% Ethyl acetate,

Vapour pressure of Ethyl Alcohol at 71.8 deg C= 636 mm Hg

Vapour pressure of Ethyl acetate at 71.8 deg C= 587 mm Hg
(10marks)

Module III

15 (a) Discuss the criteria of stability and show that for a stable liquid phase, the fugacity of each component in a binary mixture always increases with increase in concentration at constant T and P. (14 mark)

(b) Explain Roult's law and Henry's law (6 marks)

OR

16(a) Benzene and Toluene form an ideal solution. Draw the bubble point and dewpoint line for entire composition range for a total pressure of 760 mmHg.

Temperature ^{0}C	80^{0}C	90 ^{0}C	100^{0}C	110.9^{0}C
V.P of benzene	760 mmHg	1078 mmHg	1344 mmHg	1748 mmHg
VP of Toluene	300 mmHg	431 mmHg	559 mmHg	760 mmHg

(10 marks)

(b) Explain the usefulness of Triangular diagram in Liquid- Liquid equilibria in extraction operations (10 marks)

Module IV

17. Estimate the equilibrium constant for the reaction at 600 K

$$C_2H_{4(g)} + H_2O(g) \rightarrow C_2H_5OH(g)$$

ΔG at 298K = -2030 cal/(gm mole)

ΔH_f 298K for $C_2H_5OH(g) = -56240\, cal/(gm.mol)$

ΔH_f 298K for $C_2H_{4(g)} = -12496\, cal/(gm.mol)$

ΔH_f 298K for $H_2O(g) = -57798\, cal/(gm.mol)$

(20 marks)

18 (a) Discuss the feasibility of a chemical Reaction (6 marks)

(b) Explain the effect of Pressure on equilibrium composition (6 marks)

(c) Discuss the effect of Equlibrium constant (8 marks)