

C 3086

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2007.

Fourth Semester

Biotechnology

BT 1253 — CHEMICAL THERMODYNAMICS AND
BIOTHERMODYNAMICS

(Regulation 2004)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define the terms 'state function' and 'path function'.
2. Show that the Joule–Thomson coefficient is zero for ideal gases.
3. Define chemical potential and its significance.
4. How is the activity coefficient related to the excess free energy?
5. Why does immiscibility occur in liquid solutions?
6. Define coexistence equation and its applications.
7. Define equilibrium constant of a chemical reaction and how it is related to K_f and K_p .
8. Define Van't Hoff equation.
9. One ton of refrigeration – What it means?
10. Define net value and gross value of heat of combustion.

PART B — (5 × 16 = 80 marks)

11. (a) (i) Calculate the change in enthalpy, entropy and internal energy when 1 mol liquid water at 273 K and 1 bar is converted into steam at 473 K and 3 bar. List the assumptions used. Data : At 1 bar the specific heat of steam is $C_p = 37.002 - 8.00 \times 10^{-3} T + 9.24 \times 10^{-6} T^2$, where C_p is in KJ/K mol and T is in K. Enthalpy of vaporization at 373 K = 40.6 KJ/K mol. (10)

- (ii) Derive the relationship between entropy and heat capacity. (6)

Or

- (b) (i) Show that for ideal gases $C_p - C_v = R$. (4)

- (ii) Derive Maxwell relations. (12)

12. (a) (i) Discuss Gibb's – Duhem equations and its various forms. (10)

- (ii) The partial molar volumes of acetone and chloroform in an mixture in which mole fraction of acetone is 0.5307 are $74.166 \times 10^{-6} \text{ m}^3/\text{mol}$ and $80.235 \times 10^{-6} \text{ m}^3/\text{mol}$ respectively. What is the volume of 1 kg of the solution? (6)

Or

- (b) (i) Explain in detail about the concept of fugacity. (10)

- (ii) Calculate the fugacity of liquid water at 303 K and 10 bar if the saturation pressure at 303 K is 4.241 kPa and the specific volume of liquid water at 303 K is $1.004 \times 10^{-3} \text{ m}^3/\text{kg}$. (6)

13. (a) (i) What is meant by a tie line? How does the tie line help in determining the amount of liquid and vapor in equilibrium? (6)

- (ii) An experimental determination of a VLE state for ethanol – toluene system gave the following results. Vapor pressure at 45°C : Ethanol = 173 mm Hg, Toluene = 75.4 mm Hg, $x_1 = 0.3$, $y_1 = 0.634$, $P^T = 183 \text{ mm Hg}$. Calculate

(1) the liquid phase activity coefficient

(2) does the liquid phase exhibit positive or negative deviation from ideal solution behavior?

Or

- (b) (i) Describe the methods used for testing the thermodynamic consistency of experimentally determined vapor-liquid equilibrium data for binary systems. (12)

- (ii) Compare Dew point and bubble point temperature. (4)

14. (a) (i) A gas mixture containing 25% CO, 55% H₂ and 20% inerts is used for methanol synthesis at 300 bar 623 K. If the gas coming from the catalyst chamber is in chemical equilibrium with respect to the reaction, $\text{CO} + 2\text{H}_2 \rightarrow \text{CH}_3\text{OH}$. What percent of carbon monoxide would have been converted, if the equilibrium constant is 1.4×10.4 ? (10)
- (ii) Write the effect of temperature on equilibrium constant. (6)

Or

- (b) Acetic acid is esterified as per the reactions $\text{CH}_3\text{COOH}(\text{l}) + \text{C}_2\text{H}_5\text{OH}(\text{l}) \rightarrow \text{CH}_3\text{COOC}_2\text{H}_5(\text{l}) + \text{H}_2\text{O}(\text{l})$ at 100°C.

Given : $\Delta H^\circ_{298} = 13100 \text{ J}$

$\Delta F^\circ_{298} = 9270 \text{ J}$.

Assuming ΔH° is a constant, find equilibrium constant at 100°C. What is the composition at 100°C? (16)

15. (a) (i) Discuss the properties of a refrigerant. (6)
- (ii) Explain with a schematic diagram the working of an absorption refrigeration system. (10)

Or

- (b) (i) Derive an expression for the efficiency of a Carnot cycle. (10)
- (ii) A Carnot refrigerator is used to maintain a space at 0°C while the outside temperature is 25°C. Find the C.O.P. mass of refrigerant required and power required if the capacity is one ton. (6)