Reg. No. : | | | | | | | | | | | |

T 3099

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2008.

Fourth Semester

Bio - Technology

BT 1253 — CHEMICAL THERMODYNAMICS AND BIO-THERMODYNAMICS

(Regulation 2004)

Time : Three hours Maximum : 100 marks

Any missing data can be suitably assumed.

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. What is physical significance of virial coefficients?

2. What is compressibility factor?

3. What is partial molar property?

4. Define fugacity and fugacity coefficient for a real gas.

5. What is the difference between bubble and dew point?

6. What are the characteristics of an ideal solution?

7. Is the Gibbs free energy change of a chemical reaction related to the work done by the system? Give an example.

8. What is the effect of pressure on the rate of conversion at equilibrium for a gas phase reaction?

9. What do you understand by the principle of increase in entropy?

10. Differentiate between available and unavailable energy.

PART B — (5 × 16 = 80 marks)

11. (a) (i) Show $dH = C_p\,dt + \left(V - \frac{(C_p - C_v)k}{\beta}\right)dp$. (8)

(ii) 1.5 kg of air at 8 bar occupies a volume of $2m^3$. It is heated at constant pressure until the volume is doubled. Calculate the work done, change in internal energy and heat added. (8)

Or

(b) (i) Prove the following relation where μ is Joule - Thomson coefficient

$$\left(\frac{\partial C_p}{\partial P}\right)_T = -\mu\left(\frac{\partial C_p}{\partial T}\right)_p - C_p\left(\frac{\partial u}{\partial T}\right)_p. \quad (8)$$

(ii) The vapour pressures of ethyl benzene at 347.2° k and 460° k are 0.133 bar and 3.325 bar respectively. Estimate the enthalpy of vapourization of ethyl benzene. (8)

12. (a) (i) Explain the tangent - intercept method for determination of partial molar properties. (8)

(ii) The volume of a solution formed from $MgSO_4$ and 1.0 kg of water fits the expression.

$$V = 1.00121\times10^{-3} + 34.69\times10^{-6}\,(m - 0.070)^2$$

Where m is the molarity of the solution? Calculate the partial molar volume of the salt and solvent when m = 0.05 mol/kg. (8)

Or

(b) (i) The activity coefficient of n-propyl alcohol in a mixture of water (1) and alcohol (2) at 298°k referred to the pure liquid standard state is given below :

x_B	0	0.01	0.02	0.05	0.10	0.2
γ_B	12.5	12.3	11.6	9.92	6.05	3.12

Find γ_A in the solution containing 10% (mole) n-propyl alcohol. (8)

(ii) Calculate the heat effects when 1.0 k mole of water is added to a solution containing 1 k. mole of sulphuric acid and 3 k. mole of water. The process is isothermal and occurs at 298°k

Data :

Heat of mixing for $H_2SO_4\,(3H_2O)$ = –49000 kJ/k. mole H_2SO_4

Heat of mixing for $H_2SO_4\,(4H_2O)$ = –54100 kJ/k. mole H_2SO_4 (8)

13. (a) (i) Two substances A and B are known to from ideal liquid solutions. A vapour mixture containing 50 mole % A and 50 mole % B is at 311°k and 101.3 Kpa. This mixture is compressed isothermally until condensation occurs. At what pressure condensation occurs and what is the composition of the liquid that forms? The vapour pressures of A and B are 142 Kpa and 122 Kpa respectively. (8)

(ii) Show that Van-Laar equation is consistent with Duhem's equation. (8)

Or

(b) (i) Calculate the bubble point of a 5% liquid solution of methane at 37.8°C. The other component is propane. The value of K is given below.

K at 37.8°C

Component :	21.1 kg/cm^2	24.6 kg/cm^2	28.1 kg/cm^2
Methane :	8.1	6.5	5.8
Propane :	0.74	0.63	0.61

(8)

(ii) The activity coefficient for component 1 in a binary solution can be represented by $1n\gamma_1 = 4x_2^2 + 6x_2^3 + 8x_2^4$. Determine an expression for $1n\gamma_2$. (8)

14. (a) (i) Calculate the equilibrium constant at 298°k of the reaction.

$N_2 + 3H_2 \rightarrow 2NH_3$

Given that free energy of formation of ammonia at 298°k is – 16500 J/mol. (8)

(ii) A gaseous mixture containing 30% Co, 50% H_2 and rest inert gas is sent to a reaction chamber for methanol synthesis. The following reaction occurs at 635° k and 310 bar.

$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$

Assuming that gas mixture behaves like an ideal solution, calculate percent conversion of CO given that

$K_f = 5 \times 10^{-5}$ and $K\varphi = 0.35$. (8)

Or

(b) (i) 1 mol of carbon at 298°k reacts with 2 mol oxygen to form an equilibrium mixture of CO_2, CO and O_2 at 3000°k and 1 bar. If the equilibrium constant is K = 0.328, determine the equilibrium compositions. (8)

(ii) Carbon-di-oxide is reduced by graphite according to the equation

$C(S) + CO_2(g) \rightarrow 2CO(g)$

Calculate the effect of pressure on the degree of conversion of pure CO_2 at 1000°k assuming total pressure of 1, 2 and 3 bar. Gas mixture may be treated as ideal gas and an equilibrium constant value of K = 1.778 may be assumed. (8)

15. (a) (i) In a tubular counter - flow heat exchanger 0.3 kg/s of water is heated from 40 to 80°C. Hot gases enter at 200°C and leave at 100°C. C_p for gases = 1. kJ/kg°k . The atmospheric temperature is 35°C. Find the loss of available energy due to this heat transfer. Calculate the entropy generated due to irreversible heat transfer.(8)

(ii) Explain the working of Rankine power cycle. (8)

Or

(b) (i) 900 kJ of energy was transferred from a work reservoir to heat reservoir at 97°C. Determine

(1) The amount of entropy generation

(2) The amount of lost work

(3) The available energy

The surrounding is at 27°C (8)

(ii) In order to maintain a space at a constant temperature of –12°C, heat has to be continuously removed from the space at the rate of 1050 kJ/min. If the ambient temperature is 15°C Calculate

(1) COP

(2) The minimum work required

(3) The refrigeration load in tonnes. (8)