

**L 1036**

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2006.

Fourth Semester

Bio-Technology

BT 1253 — CHEMICAL THERMODYNAMICS AND BIO-THERMODYNAMICS

(Regulation 2004)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. State the two fundamental laws of thermodynamics.
2. What is the purpose of the bomb calorimeter?
3. State Hess Law.
4. What is quasistatic process?
5. What is a physical interpretation of enthalpy?
6. State Gibbs Duhem equation.
7. Give an explanation of the effect of the pressure and temperature on a first order reaction.
8. Explain the concept of fugacity.
9. Explain law of mass action.
10. Define activity co-efficient.

PART B — (5 × 16 = 80 marks)

11. (i) Show that van't Hoff formula may be written in the form  $\Delta P = cRT/(\mu)$  where  $c$  is the concentration and  $(\mu)$  is the molecular weight of the solute.
- (ii) Find the osmotic pressure of a solution of sucrose  $C_{12}H_{22}O_{11}$  in water at  $18^\circ\text{C}$ .

$\Delta T, k$

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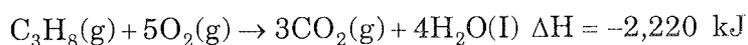
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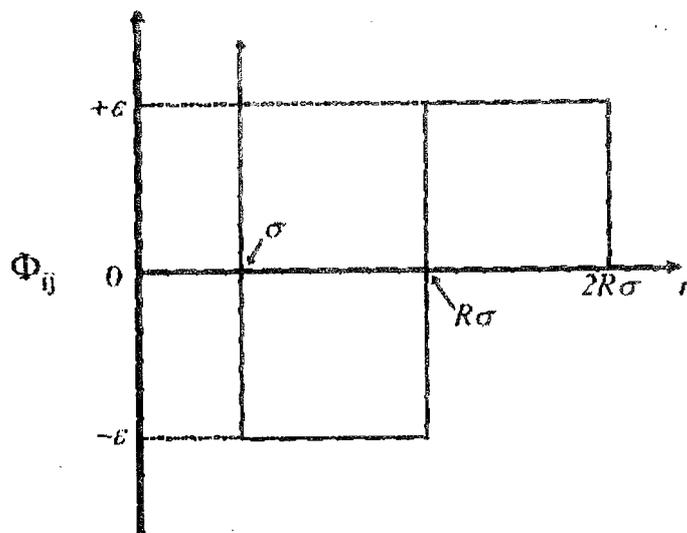
12. (a) Consider a weak solution concentrate ( $c \ll 1$ ) of the solute in equilibrium in a uniform gravitational field. By including the contribution of the gravitational potential energy in the chemical potential, derive a formula for the variation of the concentration with height.

Or

- (b) Propane burns in air producing energy according to the following balanced thermochemical equation :



- (i) How much energy is produced when 5.000 g of propane is burned?
- (ii) If this 5.000 g sample of propane were burned inside a calorimeter containing 1.000 kg of water at  $25.00^\circ\text{C}$ , what would the final temperature of the water be (the specific heat capacity of water is  $4.184 \text{ J/g}\cdot\text{K}$ )?
13. (a) A set of different polyatomic, multi-polar molecules all have similar intermolecular potential functions for their binary interactions, as described approximately by the functional form shown in the figure below



Develop an expression  $B(T)$ , the second virial coefficient, for a particular pure component species.

Or

- (b) The equilibrium constant  $K$ , for the formation of a deuterium atom from two hydrogen atoms can be defined by the equations  $2H = DK = P_d/P_H * P^0$ .

The equation for the temperature dependence of  $K$  is  $\log_{10}K = 20.260 + 1.5 \log_{10}T + 7.04 * 10^9/T$

- (i) Calculate  $K$  at a temperature of  $10^8$  K
- (ii) Calculate  $\Delta H_m^0$  and  $\Delta S_m^0$  at the same temperature.
14. (a) Explain the criteria for stability of binary mixture of liquids using suitable equations.

Or

- (b) Prove that  $\partial L_{m1}/\partial T = C_{pm,1} - C_{Pm,1}^*$ . Given that  $L$  is the relative partial molar enthalpy.
15. (a) If fugacity function is defined by the equation  $\mu_i = \mu_i^0 + RT \ln (f_i/f^0)$ .

Show that for a solution of two components :

$$X_1(\partial \ln f_1/\partial X_1)_{P,T} = X_2(\partial \ln f_2/\partial X_2)_{P,T}$$

Or

- (b) MITY Industries is trying to decide where to make its next investments and has been approached by Colossal Technology Inc. (CTI), which claims that it has a new approach for generating motive power from hydrogen that is inherently more efficient than the traditional Internal Combustion (IC) engines that are in use today in our automobiles and trucks. In their scheme, pressurized pure hydrogen at 500 bar, 25°C is electrochemically oxidized with pure oxygen at 1 bar, 25°C to form water in a Fuel Cell Super Electro Converter (FCSEC) that generates electrical power directly. CTI claims that their concept can produce more power than even the most efficient IC engine using the same  $H_2$  and  $O_2$  feeds because the FCSEC converter is not subject to Carnot limitations. According to CTI, water exits the FCSEC at 1 bar, 25°C, what do you think of CTI's claim? Back up your answer with appropriate thermodynamic analysis and discussion.