

3 HOUR

Marks 80

NOTE: 1) Question no.1 is compulsory.

2) Attempt any THREE of the remaining questions.

3) Figure to the right indicates full marks.

4) Assume suitable data wherever necessary.

- Q.1] a) Define is chemical potential. What is its physical significance.
- b) A vessel is divided in two compartments one contains 100 moles  $N_2$  at 298 K and 1 bar and the other contains 100 mol of  $O_2$  at the same conditions. The barrier separating them is removed and the gases are allowed to reach equilibrium under adiabatic conditions. What is the change in entropy of contents of the vessel ?
- c) Discuss in brief the criteria of chemical reaction equilibria.
- d) What are the desirable properties of the refrigerant?
- e) Discuss heat of reaction in brief.
- Q.2] a) With proper phase diagrams, distinguish between minimum and maximum boiling azeotropes.
- b) The standard heat of formation and standard free energy of formation of Ammonia at 298K are  $-46000\text{J/mol}$  and  $-16500\text{J/mol}$  respectively. Calculate the equilibrium constant for the reaction:
- $$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$$
- at 500K. Assuming that the standard heat of reaction is constant in the temperature range 298K to 500K.
- Q.3] a) Explain in brief estimation method for Mixture Enthalpy and Entropy
- b) A azeotrope of benzene and ethanol system has a composition of 44.8 mole% ethanol with a Boiling point of 341.4K at 101.3kPa. At this temperature the vapor pressure of benzene is 68.9 kPa and vapor pressure of ethanol is 67.4 kPa. What is the activity coefficients in a solution containing 10% alcohol?
- Q.4] a) A gas mixture containing 25%  $CO$ , 55%  $H_2$ , and 20% Inert gas is to be used for methanol synthesis. The gases issue from the catalyst chamber in chemical equilibrium with respect to the reaction
- $$CO(g) + 2H_2(g) \longrightarrow CH_3OH(g)$$
- at a pressure of 300 bar and temperature of 625K. Assume that the equilibrium mixture form an ideal ~~solution~~ <sup>mixture</sup> and  $K_f$  and  $K_\phi$  are  $4.9 \times 10^{-5}$  and 0.35 respectively. What is the percent conversion of  $CO$ ?
- b) The enthalpy of reaction for the formation of ammonia according to the reaction,



At 27°C was found to be -91.94 KJ. What will be the enthalpy of reaction at 50°C? The molar heat capacities at constant pressure and at 27°C for N<sub>2</sub>, H<sub>2</sub> & NH<sub>3</sub> are 28.45, 28.32 & 37.07 Joules/mole-K respectively.

- Q.5] a) What are the different methods for estimation of critical properties? Discuss any one method in detail. 10
- b) Determine the number of degrees of freedom F for a system consisting of the gases CO, CO<sub>2</sub>, H<sub>2</sub>, H<sub>2</sub>O, and CH<sub>4</sub> in chemical equilibrium. 10
- Q.6] a) Define refrigeration. Discuss Vapour absorption refrigeration cycle. 10
- b) The vapour pressures of acetone(1) and acetonitrile(2) can be evaluated by the Antoine equations, 10

$$\ln P_1^s = 14.5363 - \frac{2940.46}{T - 35.93}$$

$$\ln P_2^s = 14.2724 - \frac{2945.47}{T - 49.15}$$

where, T is in K and P is in kPa. Assuming that the solution formed by these are ideal, Calculate-

$x_1$  and  $y_1$  at 327 K and 65 kPa.

T and  $y_1$  at 65 kPa and  $x_1 = 0.4$