

1. At 298.15°K the heat of mixing to obtain a 20 mol% ethanol solution is -758 J/mol, i.e.,



The heat capacity of water and ethanol are known as:

$$C_{P(\text{H}_2\text{O})} = 8.314(8.712 + 1.25 \times 10^{-3}T - 0.18 \times 10^{-6}T^2) \text{ and}$$

$$C_{P(\text{ethanol})} = 8.314(33.866 - 172.6 \times 10^{-3}T + 349.17 \times 10^{-6}T^2) \text{ J/mole-}^\circ\text{K}.$$

- (a) If the heat capacity of the 20 mol% solution is a constant 97.8 J/mole-°K, what is the heat of mixing at 323.15°K? (8%)
- (b) If both water and ethanol are originally at 298.15°K and the mixing occurs adiabatically, what is the final temperature of the 20 mol% solution? (7%)

2. A total of 14 m³ of liquid X is stored in a 30 m³ tank in equilibrium with its vapor at 25°C. The vapor pressure of liquid X at the given temperature is 2.43 bar, and T_C, P_C and ω of X are 425.1°K, 37.96 bar and 0.2, respectively. Using a value of 83.14 (bar-cm³)/(mol-°K) for the gas constant R, estimate the mass of X vapor in the tank using the generalized virial coefficient correlation:

$$Z = (1 + B^0 \frac{P_r}{T_r}) + \omega(B^1 \frac{P_r}{T_r})$$

$$\text{where } B^0 = 0.083 - (0.422)/T_r^{1.6} \text{ and } B^1 = 0.139 - (0.172)/T_r^{4.2} \quad (20\%)$$

3. One mole of an ideal gas is compressed isothermally but irreversibly at 130°C from 2.5 bar to 6.5 bar in a piston/cylinder device. The work required is 30% greater than the work of reversible, isothermal compression. The heat transferred from the gas during compression flows to a heat reservoir at 25°C. Calculate the entropy changes of the gas, the heat reservoir, and the ΔS_{total}. (15%)

4. A zero-order homogeneous gas reaction with stoichiometry $2A \rightarrow R$ proceeds in a constant-pressure setup, find the volume of reacting mixture (V) at $t = 5$ min if $V = 1$ m^3 at $t = 0$ min. Please note that the reaction temperature is kept at constant and the rate constant for the zero-order reaction is $2 \text{ mol m}^{-3} \text{ min}^{-1}$. At $t = 0$ min, 30% inerts are present in the batch reactor.

(10%)

5. The desired liquid-phase reaction



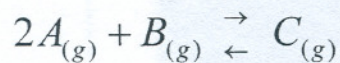
is accompanied by the unwanted side reaction



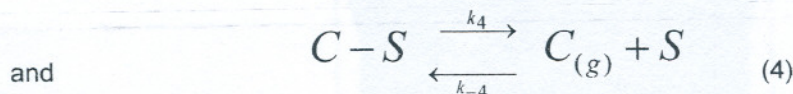
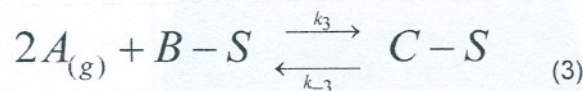
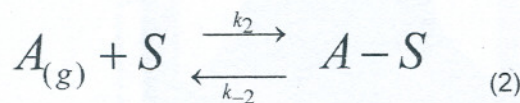
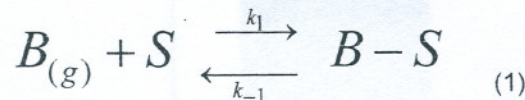
From the standpoint of favorable product distribution, please suggest a connecting scheme of reactors in continuous flow operations. You have to suggest a reactor scheme and its operating strategy and explain why you make the selection.

(10%)

6. Suppose that the reaction



is carried out in the presence of a catalyst. If



where S denotes the active site and subscript (g) means gas phase.

- (1) Develop the rate equation for the case that step (4) is the rate controlling step. (15%)
- (2) Also, suggest an experimental strategy for evaluating all kinetic constants in the rate equation you just developed. (5%)
- (3) Suggest a reactor and operation method for this reaction. (5%)
- (4) What happen on the catalyst if the step (2) becomes an irreversible reaction ($k_{-2} = 0$)? (5%)