

八十八學年度 化學工程學 系(所) 組碩士班研究生招生考試

科目 化工熱力學及化學反應工程 科號 2402 共 3 頁第 1 頁 *請在試卷【答案卷】內作答

Problem 1 (20%)

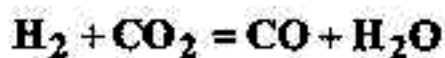
(a) A vessel, divided into two parts by a partition, contains 2 moles of ideal gas A at one side at 300 K and 10^5 Pa and 3 moles of ideal gas B at 400 K and 4×10^5 Pa. What is the volume of the ideal gas A? (b) The gas A is first compressed isothermally to 2×10^5 Pa by following a reversible process. Please calculate Q, W, ΔU , and ΔH for the process. (c) The partition is then removed. The gases A and B mix adiabatically and completely. What is the temperature of the gas mixture? What is the pressure of the gas mixture? What is the change in ΔS ? The heat capacities of the two gases are $C_p = 3.5R$ and $C_v = 2.5R$. R is the universal gas constant and is $8.314 \text{ J mol}^{-1} \text{ K}^{-1}$ ($8.314 \text{ m}^3 \text{ Pa mol}^{-1} \text{ K}^{-1}$). $\ln 2 = 0.6931$, $\ln 3 = 1.0986$, $\ln 5 = 1.6094$, $\ln 7 = 1.9459$.

Problem 2 (20%)

- (i) Draw the $p - x_1 - y_1$ phase diagrams of a binary mixture at constant temperature: (a) $T_a < T_{c1}, T_{c2}$, (b) $T_{c1} < T_b < T_{c2}$, and (c) $T_d > T_{c1}, T_{c2}$.
 T_{c1} and T_{c2} are critical temperatures of components 1 and 2, respectively.
- (ii) Write $\frac{\Delta G}{RT}$, $\frac{P\Delta V}{RT}$, $\frac{\Delta H}{RT}$, and $\frac{\Delta S}{R}$ in terms of activities and find the corresponding expressions for ideal solutions.

Note: ΔM is the property change of mixing.

Problem 3 (20%)



- (4%) Write down the stoichiometric coefficient of $\text{H}_2, \text{CO}_2, \text{CO}, \text{H}_2\text{O}$
- (2%) Define the extent of this reaction
- (4%) If there are 0.5 mole of H_2 and 0.5 mole of CO_2 initially, what are the mole fraction of $\text{H}_2, \text{CO}_2, \text{CO}, \text{H}_2\text{O}$ when the extent of reaction is 0.2.
- (2%) The Gibbs free energy of formation at 1000 K of $\text{CO}_2, \text{CO}, \text{H}_2\text{O}$ are -192,420, -200,240 and -395,790 J mol^{-1} respectively. Find the initial Gibbs free energy of the system
- (6%) Find Gibbs free energy when the extent of reaction are 0.2 and 0.4
- (2%) Which extent of reaction is closer to equilibrium

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The following data are given to facilitate calculations:

$$R = 8.314 \frac{\text{J}}{\text{K} \cdot \text{mol}} \quad RT = 8314 \frac{\text{J}}{\text{mol}}$$

x	ln(x)
0.1	-2.30259
0.2	-1.60944
0.3	-1.20397
0.4	-0.91629
0.5	-0.69315
0.6	-0.51083
0.7	-0.35667
0.8	-0.22314
0.9	-0.10536

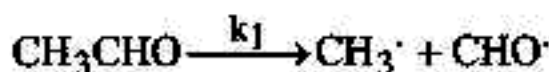
Problem 4 (20%)

The overall reaction for the thermal decomposition of acetaldehyde is

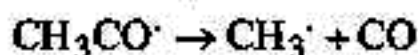
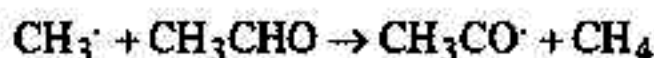


A chain-reaction sequence of elementary steps proposed to explain the decomposition is as follows:

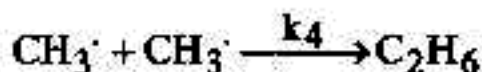
Initiation



Propagation



Termination



Use the stationary-state approximation to derive an expression for the overall rate of decomposition.

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Problem 5 (20%)

Compound A undergoes a reversible reaction $A \rightleftharpoons B$ in a plug flow reactor. The feed to the reactor is pure A and the reaction is elementary. A and B are liquid, miscible, and of nearly identical density. The product from the plug flow reactor are separated and only the unconverted A is fed to a second, identical reactor.

- (5%) (1) Derive the equation for the conversion of A in the first reactor, x_1 .
- (10%) (2) Derive the equation for the conversion of A in the second reactor, x_2 , in terms of x_1 and K_{eq} .
- (5%) (3) Find the overall conversion X .

Notation:

k : forward reaction rate constant

K_{eq} : equilibrium constant for the reaction

F_{AO} : molar flow rate of A to the first reactor

C_{AO} : concentration of A in the feed to the first reactor

V : reactor volume