

**Problem 1 (20%)**

A gas mixture of one mole  $C_2H_2$  and three moles  $N_2O$  was ignited at 300 K. A gas mixture which contains two moles CO, one mole  $H_2O$ , and three moles  $N_2$  is then formed corresponding to the following reaction:  $C_2H_2 + 3N_2O = 2CO + H_2O + 3N_2$ . Assume that the gas mixture is contained at 1 atm in an insulated container, the combustion process is isobaric, the gases behave ideally, and their heat capacities are all 10 cal/degree/mole. (a) What is the enthalpy change of the gas mixture before and after combustion? (b) What is temperature of the gas mixture after combustion? (c) What is the entropy change of the gas mixture before and after combustion?

Given:

$$\Delta H_{300K, (C_2H_2)}^{\circ} = 54.23 \text{ kcal/mole}, \quad \Delta H_{300K, (N_2O)}^{\circ} = 19.70 \text{ kcal/mole}$$

$$\Delta H_{300K, (CO)}^{\circ} = -26.42 \text{ kcal/mole}, \quad \Delta H_{300K, (H_2O)}^{\circ} = -57.80 \text{ kcal/mole}$$

$$C_{p, (C_2H_2)} = C_{p, (N_2O)} = C_{p, (CO)} = C_{p, (H_2O)} = C_{p, (N_2)} = 10 \text{ cal/degree/mole}$$

Logarithms to Base e (Natural logarithms)

N	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1	0.000	0.095	0.182	0.262	0.336	0.405	0.470	0.531	0.588	0.642
2	0.693	0.742	0.788	0.833	0.875	0.916	0.956	0.993	1.030	1.065
3	1.099	1.131	1.163	1.194	1.224	1.253	1.281	1.308	1.335	1.361
4	1.386	1.411	1.435	1.459	1.482	1.504	1.526	1.548	1.569	1.589
5	1.609	1.629	1.649	1.668	1.686	1.705	1.723	1.740	1.758	1.775
6	1.792	1.808	1.825	1.841	1.856	1.872	1.887	1.902	1.917	1.932
7	1.946	1.960	1.974	1.988	2.001	2.015	2.028	2.041	2.054	2.067
8	2.079	2.092	2.104	2.116	2.128	2.140	2.152	2.163	2.175	2.186
9	2.197	2.208	2.219	2.230	2.241	2.251	2.262	2.272	2.282	2.293
10	2.303	2.313	2.322	2.332	2.342	2.351	2.361	2.370	2.380	2.389

**Problem 2 (20%)**

- (i) For a separations process it is necessary to determine the VLE compositions of a mixture of ethyl bromide and n-heptane at 30°C. At this temperature the vapor pressure of pure ethyl bromide is 0.7569 bar, and the vapor pressure of pure n-heptane is 0.0773 bar. Calculate the bubble pressure and the composition of the vapor in equilibrium with a liquid containing 47.23 mol % ethyl bromide assuming ideal solution behavior.
- (ii) The values of H and S for steam at 400°C are listed below. Use them to calculate the fugacity of 10% steam at 400°C and 15 Mpa.

State 1 (low pressure)

$T_1 = 400^\circ\text{C}$

$P_1 = 0.01 \text{ MPa}$

$H_1 = 3279.9 \text{ KJ/kg}$

$S_1 = 9.6094 \text{ KJ/kg}\cdot\text{K}$

State 2

$T_2 = 400^\circ\text{C}$

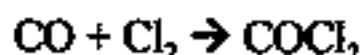
$P_2 = 15 \text{ MPa}$

$H_2 = 2975.7 \text{ KJ/kg}$

$S_2 = 5.8819 \text{ KJ/kg}\cdot\text{K}$

**Problem 3 (20%)**

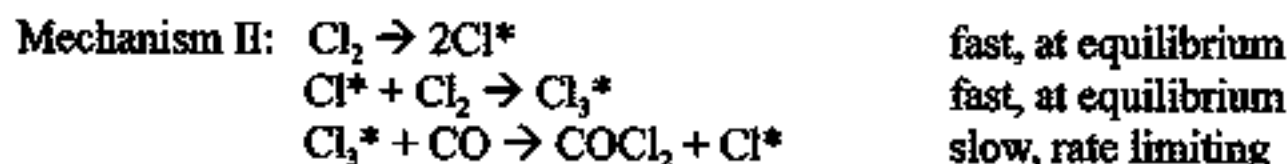
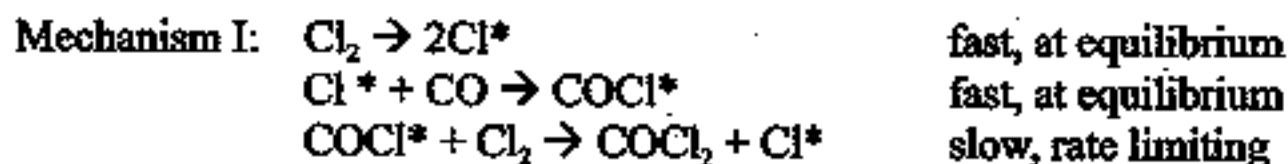
The formation and decomposition of phosgene can be described by the following rate expressions:



Forward reaction:  $r = k_1[\text{Cl}_2]^{1.5}[\text{CO}]$

Reverse reaction:  $r = k_2[\text{Cl}_2]^{0.5}[\text{COCl}_2]$

Determine which of the following mechanisms is consistent with these rates. Also, state how you are going to further test this mechanism.



**Problem 4 (20%)**

A first-order irreversible gas-phase reaction  $\text{A} \rightarrow \text{B} + 2\text{C}$  takes place in a CSTR with a constant volume. The operation is isothermal and isobaric. The reaction rate constant is  $0.2 \text{ min}^{-1}$ , and the reactor volume is 500 L. The feed contains a 60 mol% of A and a 40 mole % of an inert compound. The molar flow rate of the reactant A is 400 mol/min and the concentration of A in the feed is 4 mol/L. What is the conversion at the exit of this CSTR?

**Problem 5 (20%)**

Methane can be produced from hydrogen and carbon monoxide according to the reaction



Laboratory investigations using a nickle catalyst resulted in the following expression for the forward reaction rate at a particular temperature

$$r = \frac{1.1 P_{\text{CO}} P_{\text{H}_2}^{0.5}}{1 + 1.5 P_{\text{H}_2}}, \text{ lb moles CH}_4 / \text{hr} \cdot \text{lbm catalyst}, T = 400^\circ \text{K}$$

With partial pressures in atmospheres.

At the temperature of the study

$$\Delta G^\circ = -34,000 \text{ cal/gm} \cdot \text{mole}$$

$$\Delta H^\circ = -49,300 \text{ cal/gm} \cdot \text{mole}$$

八十九學年度 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 3 頁 \*請在試卷【答案卷】內作答

- (a) Calculate the chemical reaction equilibrium constant. (8%)
- (b) Write the expression for the backward rate. (8%)
- (c) What principle of catalysis did you use to determine your answer to part b? (4%)