國立中央大學98學年度碩士班考試入學試題卷

所別：化學工程與材料工程學系碩士班 甲組　科目：化工熱力學及化學反應工程　共 3 頁 第 1 頁

*請在試卷答案卷（卡）內作答

熱力學部份

A1. What is the entropy change of a system undergoing an adiabatic **reversible/ irreversible** process? a) > 0/> 0, b) = 0/< 0, c) = 0/= 0, d) = 0/> 0, e) none of above answers. (3 points)

A2. A system consisted of C_3H_8 (20%), C_5H_{10} (30%), C_6H_{14} (40%), C_8H_{18} (10%) and with total 50 moles. How many degrees of freedom does this system have? a) 2, b) 3, c) 4, d) cannot be determined. (3 points)

A3. A well insulated chamber is divided into two partitions with a membrane. A gas at T_1, P_1 was contained in partition A, and partition B is in vacuum. When the membrane is broken and gas is homogeneous in the chamber. Assume the gas is ideal. What is the final temperature of gas in chamber? (You can use 1st law or the energy balance equation given in Problem 5. Don't waste your time if you cannot answer in 1 minute) (4 points)

A4. A three-component two-phase (vapor and liquid) mixture has three degrees of freedom. Please count the number of variables and equations to explain how to obtain this value. **Note:** the answer is $f = c + 2 - P$. So directly quoting this equation is not allowed. (4 points)

A5. The general energy balance equation is given as below equation (5 points)

$$\left[(H+\frac{u^2}{2g_c}+\frac{gZ}{g_c})\delta M\right]_{in}-\left[(H+\frac{u^2}{2g_c}+\frac{gZ}{g_c})\right]_{out}+\delta Q-\delta W=d\left[(U+\frac{u^2}{2g_c}+\frac{gZ}{g_c})M\right]_{sys}$$

where all the thermodynamic properties are in quantity per mole.
Please reduce the above equation to its simplest possible form for the process and the systems given below:
Steam flowing steadily through a horizontal, insulated nozzle. **system: the nozzle and its contents.**

A6. Same as Problem 5, except the **process is**: A rubber balloon being inflated. **system: the rubber.** (5 points)

A7. Can you explain the following simple questions? (10 points)

(1) What are the differences between internal energy (U), and enthalpy (H)? Why do we need to define enthalpy in addition to internal energy?

(2) What are the differences between Helmholtz free energy (U), and Gibbs free energy (G)? Why do we need to define free energy in addition to internal energy and enthalpy?

A8. Can you explain the following simple question? (10 points)

(1) What are the differences between ideal gases and real gases? What kinds of molecular level information you can extract from the equation of state of one real gas?

(2) What are the differences between ideal solutions and non-ideal solutions? What kinds of molecular level information you can extract from the expression of chemical potential of one of the component in a non-ideal solution?

參考用

A9. How does an azeotrope form? Why do some of the azeotropes have the lower and some of them have the higher boiling points than their mother pure compounds? (6 points)

化學反應工程

(B1) 13%

At 650°C phosphine vapor decomposes as follows:

$$4PH_3 \rightarrow P_4(g) + 6H_2,\ -r_{phos} = (10\ hr^{-1})C_{phos}$$

What size of plug flow reactor operating at 649°C and 11.4 atm is needed for 75% conversion of 10 mol/hr of phosphine in a 2/3 phosphine, 1/3 inert feed? gas constant R = 0.08206 (L·atm/g mol·K)

(B2) 12%

In a reactive environment, chemical A decomposes as follows:

$A \rightarrow R$, $r_R = C_A$ mol/liter·s,　$A \rightarrow S$, $r_S = 1$ mol/liter·s

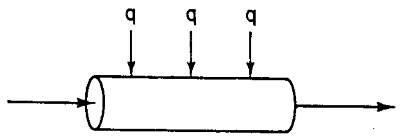
For a feed stream $C_A = 4$ mol/liter what size ratio of two mixed flow reactors will maximize the production rate of R? Also give the composition of A and R leaving these two reactors.

參考用

(B3) 25%

The reactor consisting of a bank of one thousand tubes with 1 in. ID was used to conduct an elementary reaction of the vapor phase cracking of acetone to ketene and methane ($CH_3COCH_3 \rightarrow CH_2CO + CH_4$; ln k ($sec^{-1}$) = 34.34 − 34,222/T(K)). The reactor is to be jacked so that a high-temperature gas stream can supply the energy to maintain isothermal operation. You are asked to determine the temperature profile $T_a(L)$ of external heating gas down the length of the reactor that would necessary to maintain isothermal operation. For the steady isothermal operation, $Ua(T_a - T) = (-r_A)[-\Delta H_R(T)]$ (U: total heat transfer coefficient, a: heat transfer area per unit volume of reactor tube, T_a: the temperature in the jacked heat exchanger around the tubes). The feed of pure acetone is 8,000kg/hr, the inlet temperature is 1035K and the pressure is 1.6 atm.

F_{A0}= 8 kg/hr
(per tube)
T = 1035 K



T = 1035 K
X = 0.2

The standard heats of formation are:

$$H^\circ(T_R)_{\text{acetone}} = -216.67 \text{ kJ/mol}$$
$$H^\circ(T_R)_{\text{ketene}} = -61.09 \text{ kJ/mol}$$
$$H^\circ(T_R)_{\text{methane}} = -74.81 \text{ kJ/mol}$$

The heat capacities are:

CH_3COCH_3: $C_{pA} = 26.63 + 0.183T - 45.86 \times 10^{-6}T^2$ J/mol·K

CH_2CO: $C_{pB} = 20.04 + 0.0945T - 30.95 \times 10^{-6}T^2$ J/mol·K

CH_4: $C_{pC} = 13.39 + 0.077T - 18.71 \times 10^{-6}T^2$ J/mol·K

The total heat transfer coefficient is:

$$U = 110 \text{ J/m}^2\cdot\text{s}\cdot\text{K}$$

The heat transfer area per unit volume of tube is:

$$a = \frac{\pi D L}{(\pi D^2/4)L} = \frac{4}{D}$$

參考用