國立臺灣科技大學
八十九學年度碩士班招生考試試題

系所組別：化學工程系、化學工程系在職教師
科　目：化工熱力學與動力學　　本科總分爲 100 分

Part I. 化工熱力學

(1) What is the change of Gibbs free energy (G) and entropy (S) when 3 mol of CO_2 and 2 mol of N_2, each at 1 atm and 298 K, blend to form a homogeneous gas mixture at the same conditions? Assume ideal gas mixture and R = 8.314 J/(mol · K). (15%)

(2) In a chemical vapor deposition (CVD) reaction system to synthesize silicon carbide (SiC) thin films, silane (SiH_4) and carbon tetrachloride (CCl_4) are used as the source gases for Si and C, respectively. SiH_4 is a gas in normal state while CCl_4 is a liquid. To supply CCl_4 vapor into the reactor, it is necessary to use an evaporator to carry the CCl_4 vapor by carrying gas. Then, the vapor pressure data of CCl_4 at various temperatures are also necessary in estimating the concentration of CCl_4 into the reactor. From the following vapor pressure data for CCl_4, evaluate the mean heat of vaporization in this range: R = 1.987 cal/(mol · K). (15%)

T (°C)	25	35	45	55
P^0 (mmHg)	113.8	174.4	258.9	373.6

(3) For gas-liquid two phases system of a pure species coexisting at equilibrium, the equilibrium criteria is $G_l = G_g$, where G is the Gibbs free energy. Considering the effect of pressure on the vapor pressure of a pure species at constant temperature, the changes of molar Gibbs free energy when the pressure of the system is changed from P to P + dP are: $dG_l = V_l dP$ for liquid phase and $dG_g = V_g dP$ for gas phase, where V_l and V_g are the molar volumes for the liquid and the gas, respectively.

Question 1: Based on the above equations, find the ratio of water vapor pressure at 373 K and 100 atm to that at 373 K and 1 atm? Assume ideal gas behavior and the molar volume of liquid water (V_l) is 0.018 liter/mol (V_l is independent of pressure). R = 0.082 atm · liter/(mol · K) (10%)

Question 2: Please explain what will happen when 5 mol of steam at 373 K and 2 atm mixes with 3 mol of hot water at 373 K and 2 atm (see Fig. 1)? That is, will it evaporate (path 1) or condense (path 2)? Why? Assume a constant temperature and constant pressure process. (10%)

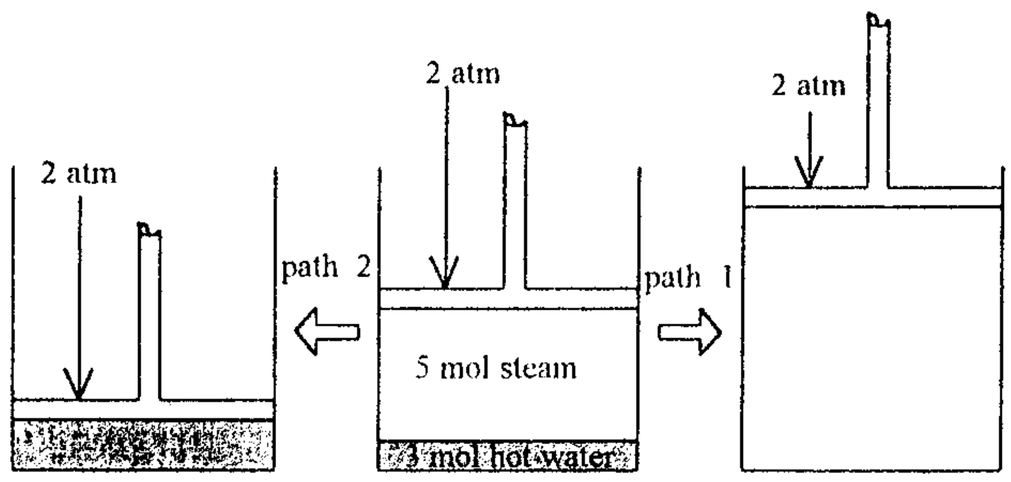

Fig. 1. Changes of mixing hot water and steam

國立臺灣科技大學
八十九學年度碩士班招生考試試題

系所組別： 化學工程系、化學工程系在職教師
科　目： 化工熱力學與動力學

Part II 化工動力學

(4) A gas mixture, which consists of 50% A and 50% inerts at 10 atm, enters the first reactor with a flow rate of 6m^3/s at 126.85 °C. All of the reactions are carried out at the same temperature of 126.85 °C. The mixture can be considered as an ideal gas and the ideal gas constant, R=0.082dm^3 · atm/(mol · K). The reciprocal of this reaction rate (at 126.85 °C) was plotted as a function of conversion shown in Figure 1.

(a) Please calculate the entering concentration, C_{A0}, and the entering molar flow rate, F_{A0}. (10%)

(b) Calculate the reactor volumes V_1 and V_2 for the two CSTRs in series shown in Figure 2 when the intermediate conversion is 40% and the final conversion is 80%. (10%)

(c) Calculate the reactor volumes V_1 and V_2 for the plug-flow sequence shown in Figure 3 when the intermediate conversion is 40% and the final conversion is 80%. (10%)

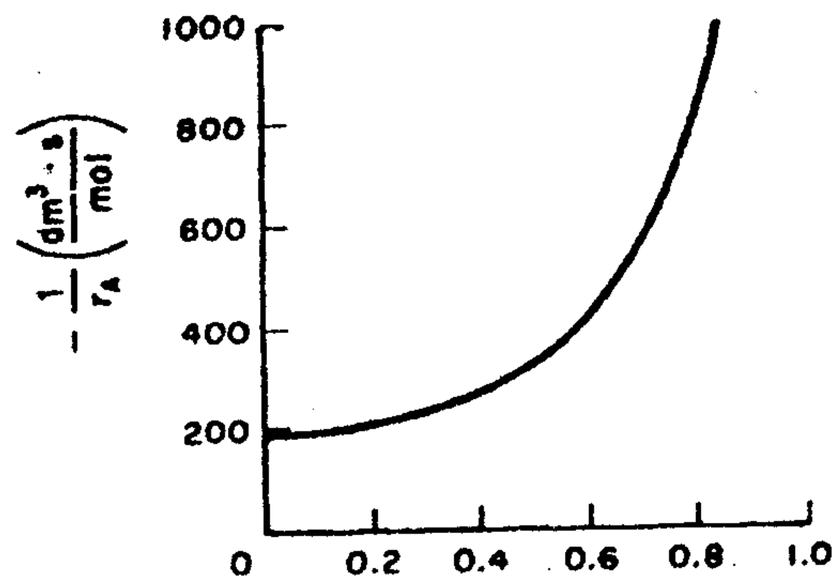

Figure 1

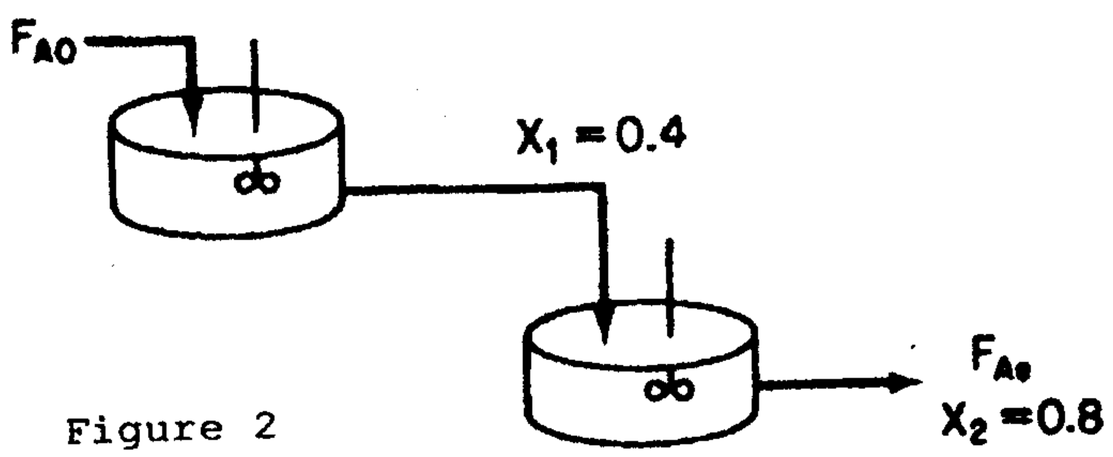

Figure 2

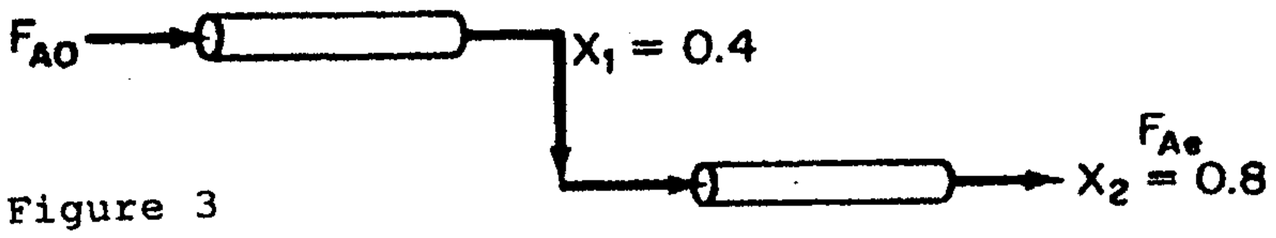

Figure 3

國立臺灣科技大學
八十九學年度碩士班招生考試試題
系所組別：化學工程系、化學工程系在職教師
科　目：化工熱力學與動力學

(5) The following heterogeneous reaction is taking place in a system in which there is an inert adsorbing gas (inhibitor) present:

Adsorption

$$A(g) + S = A \cdot S$$

Surface reaction

$$A \cdot S + B(g) = C \cdot S$$

Desorption

$$C \cdot S = C(g) + S$$

Inhibition

$$I + S = I \cdot S$$

Where S and I represent an active site and the inhibitor, respectively. Please sketch the initial rate as a function of the total pressure assuming that

(a) Adsorption of A is limiting. (10%)
(b) Surface reaction is limiting. (10%)