

國立中央大學103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(一般生) 科目：化工熱力學及化學反應工程 共 2 頁 第 1 頁  
 本科考試可使用計算器，廠牌、功能不拘 \*請在試卷答案卷(卡)內作答

1. (10%)

Trouton's rule (An empirical relation for enthalpy change of phase transition divided by the phase transition temperature) applies well to describe the relation between  $\Delta_{\text{vap}}H$  and boiling point temperature for most of materials. Is the above statement also true to the melting process (from solid phase to liquid phase) and why?

2. (15%)

An exothermic enthalpy change of a process ( $\Delta H_{\text{sys}} < 0$ ) does not guarantee the process happen spontaneously.

a. Please explain why the Second Law of Thermodynamics should be used. (6%)

In a particular biological reaction taking place in the body at 37 °C, the change in enthalpy is -125 J/K mol and the change in entropy is -126 J/K mol.

b. Calculate the change in Gibbs energy. (3%)

c. Is the reaction spontaneous? (3%)

d. Calculate the total change in entropy of the system and surroundings. (3%)

3. (25%)

a. Consider  $p$  phases of a  $c$ -component mixture in equilibrium. What are the equilibrium criteria for such system? Note that no reaction is involved. (5%)

b. Please explain the reason why in the phase-equilibrium calculations (e.g. vapor-liquid equilibrium), fugacity of species  $i$  in a mixture ( $f_i$ ) is used instead of partial molar Gibbs free energy ( $\bar{G}_i$ ). (5%)

c. What is the physical meaning of activity coefficient ( $\gamma_i$ )? How does the activity coefficient relate to fugacity, partial molar excess Gibbs energy of species  $i$  ( $\bar{G}_i^{\text{ex}}$  J/mol), and molar excess Gibbs energy of a mixture ( $G^{\text{ex}}$  J/mol)? (5%)

d. Methanol and methyl ethyl ketone form an azeotrope at 0.841 mole fraction methanol at a temperature of 64.3 °C and a total pressure of 760 mmHg. The vapor pressure of pure methanol and methyl ethyl ketone follow the Antoine equations. The constants in the Antoine equation are listed in the following table [Hint 1]. Using the two-constant Margules model [Hint 2], estimate the mole fractions of methanol in vapor phase and the total pressure at 70 °C and 0.30 mole fraction methanol in liquid phase. (10 %)

	A	B	C
Methanol	7.88	1474.1	230.0
Methyl ethyl ketone	6.97	1209.6	216.0

Hint 1: Antoine equation  $\log_{10} P^{\text{vap}} = A - B/(C + T)$ .  $P^{\text{vap}}$  is the vapor pressure in mmHg.  $T$  in °C.

Hint 2: The two-constant Margules equation is  $G^{\text{ex}}/RT = x_1x_2[x_1D + x_2E]$  ( $D$  and  $E$  are constants)

注意：背面有試題

參考用

國立中央大學103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(一般生) 科目：化工熱力學及化學反應工程 共 2 頁 第 2 頁  
本科考試可使用計算器，廠牌、功能不拘 \*請在試卷答案卷(卡)內作答

4. (10%)

The gas-phase irreversible first order reaction  $A \rightarrow 3B$  is carried out first in a PFR, where the feed is equal molar in A and inerts. The conversion under these circumstances is 60%. The exit from the PFR is fed to a CSTR with double volume of the PFR and carried out under identical condition (ie. temperature, pressure). What is the conversion exiting the CSTR?

5. (15%)

$A+B \rightleftharpoons C+D$  is an elementary reversible liquid-phase reaction. B is to be fed into a semibatch reactor containing pure A. The reaction is carried out isothermally at 300K. The equilibrium constant is 1.08 and the specific reaction rate is  $9 \times 10^{-5} \text{ dm}^3/\text{mol}\cdot\text{s}$ . Initially, there is  $200 \text{ dm}^3$  of A in the vat and B is fed at a volumetric rate of  $3 \text{ dm}^3/\text{min}$ . The feed concentration of B is  $10.93 \text{ mol}/\text{dm}^3$ , and the initial concentration of A is  $7.72 \text{ mol}/\text{dm}^3$ . Please perform differential mole balance on A, B, C and D to arrive a set of coupled differential equations to solve. You also need to list all necessary explication equations and parameters.

6. (15%)

Consider the autocatalytic reaction  $A \rightarrow R$ , with  $-r_A = 0.001 C_A C_R \text{ mol}/\text{liter}\cdot\text{s}$ . We wish to process 1.5 liters/s of a  $C_A = 10 \text{ mol}/\text{liter}$  feed to the highest conversion possible in the reactor system consisting of four 100-liter mixed flow reactors connected as you wish and any feed arrangement.

Sketch your recommended design and feed arrangement and determine  $C_{Af}$  from this system.

7. (10%)

Find the first-order rate constant for the disappearance of A in the gas reaction  $2A \rightarrow R$  if, on holding the pressure constant, the volume of the reaction mixture, starting with 80% A, decreases by 20% in 3 min.

參考用

注意：背面有試題