中原大學 104 學年度碩士班考試入學

104/3/4 10:10AM ~ 11:40AM

化學工程學系

誠實是我們珍視的美德，
我們喜愛「拒絕作弊，堅守正直」的你！

科目：熱力學及動力學 （共 2 頁第 1 頁）

☑可使用計算機(僅限於四則運算、三角函數及對數等基本功能，可程式之功能不可使用)
☐不可使用計算機

----------(不可直接作答於試題，請作答於答案卷)----------

(10%) Problem 1: True/False (please provide an explanation)

(1) **True/false**: A and B liquids are miscible (spontaneously). Therefore, the mixing process is impossible to be endothermic when mixing these two liquids. $\Delta G = \Delta H - T\Delta S$

(2)**True/false**: An ideal gas with C_v independent of temperature expands adiabatically into a vacuum, thereby doubling its volume. In this process, the initial and final temperatures should stay the same.

(20 %) Problem 2

A power plant, rated at 400 kW, generates steam at 600K and discards heat to a river at 300 K. If the thermal efficiency of the plant is 80% of the maximum possible value, how much heat is discarded to the river and how much heat is taken from the steam, respectively, at rated power?

(20 %) Problem 3

A and B form an ideal solution at 30 °C, with $x_A = 0.5$, P_A^*=100 Torr and P_B^*=60 Torr

(1) Calculate the partial pressures of A and B in the gas phase.

(2) A portion of the gas phase is removed and condensed in a separate container. Calculate the partial pressures of A and B in equilibrium with this liquid sample at 30 °C.

(Note: P_i^* is the vapor pressure of the corresponding pure substance. x_A is the mole fraction of that component in the liquid)

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(15%) Problem 4

The reaction mechanism of hydrodemethylation of toluene (T) is as follows:

Absorption $T_{(g)} + S \underset{k_{-1}}{\overset{k_1}{\rightleftarrows}} T \cdot S$

Surface reaction $H_{2(g)} + T \cdot S \underset{k_{-2}}{\overset{k_2}{\rightleftarrows}} B \cdot S + M_{(g)}$

Desorption $B \cdot S \underset{k_{-3}}{\overset{k_3}{\rightleftarrows}} B_{(g)} + S$

(a) Derive a rate law for the decomposition of toluene if surface reaction is rate limiting step. (10%)

(b) If the surface reaction is an exothermic reaction, how to increase the conversion and why? (5%)

(20%) Problem 5

The following data were obtained from a reaction $A_{(g)} \rightarrow B_{(g)}$ in a PFR. The reaction rate can be expressed as $-r_A = k\,C_A^{\alpha}$. The design equation for the PFR is $-r_A = dF_A/dV = dC_A/d\tau$. Initial concentration of A was constant in each experiment.

Volumetric flow rate, v (liter/min)	8	12	24	48
Conversion, X	0.6	0.5	0.33	0.2

(a) Proof that the reaction order is two (α=2) using the "Integral Method."(10%)

(b) What is the conversion of A if the reaction is occurred in a CSTR of the same size of PFR with a volumetric flow rate of 8 liter/min? (10%)

(15%) Problem 6

Consider the following reactions and try to optimize the condition to maximum the selectivity ($S_{D/U}$) in terms of reaction temperature, concentration and contact pattern. D is the desired product.

$A + B \rightarrow D \quad -r_A = 10^9 \exp(-10000\,K/T)\,C_A C_B$

$D \rightarrow A + B \quad -r_D = 20 \exp(-2000\,K/T)\,C_D$

$A + B \rightarrow U \quad -r_A = 10^3 \exp(-3000\,K/T)\,C_A C_B$