中原大學 102 學年度 **碩士班** 入學考試

102/3/2 15:30 ~ 17:00 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，惟僅限不具可程式及多重記憶者 □不可使用計算機

(15%) Problem 1: True/False and short answer.

(1)What is isenthalpic expansion? (5%)

(2) Is the activity coefficient of species *i* in an ideal solution greater, less, or equal to one? Why? (5%)

(3)**True/False**: Please justify the following statement: For the liquid-vapor coexistence region of a benzene-toluene solution, $x_{benzene}$ and $y_{benzene}$ can be varied independently because this system has two degrees of freedom (F).
Please explain your answer. (Hint: F= Components – Phases + 2) (5%)

(15%) Problem 2.
For a binary system, the following equations provide a reasonable correlation for the activity coefficients (γ):
$\ln\gamma_1 = Ax_2^2$;$\ln\gamma_2 = Ax_1^2$ where $A = 2.771 - 0.00523T$
In addition, the following Antoine equations provide vapor pressures:

$$lnP_1^{sat} = 16.5 - \frac{3643}{T-33} \quad ; \quad lnP_2^{sat} = 14.2 - \frac{2665}{T-53}$$

Where T is in kelvins and the vapor pressures are in *kPa*.
Assuming the validity of $y_iP = x_i\gamma_iP_i^{sat}$, calculate P and y_2, for T=320 K and x_1=0.35.

(20%) Problem 3
An inventor has devised a complicated non-flow process in which 1 mole of air is the working fluid. The net effects of the process are claimed to be:

- A change in state of the air from 523.15K and 3 bar to 353.15K and 1bar.
- The production of 1800 J of work.
- The transfer of an undisclosed amount of heat to a heat reservoir at 303.15K

Determine whether the claimed performance of the process is consistent with the second law. Assume that air is an ideal gas for which C_p=3.5R (Hint:$\Delta S = C_p\ln(T_2/T_1)-R\ln(P_2/P_1)$)

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(15%) Problem 4

The thermal decomposition of ethane to ethylene, methane butane, and hydrogen is believed to follow the sequence below:

$$C_2H_6 \xrightarrow{k_1} 2CH_3\cdot \qquad E_1$$

$$CH_3\cdot + C_2H_6 \xrightarrow{k_2} CH_4 + C_2H_5\cdot \qquad E_2$$

$$C_2H_5\cdot \xrightarrow{k_3} C_2H_4 + H\cdot \qquad E_3$$

$$H\cdot + C_2H_6 \xrightarrow{k_4} H_2 + C_2H_5\cdot \qquad E_4$$

$$C_2H_5\cdot \xrightarrow{k_5} C_4H_{10} \qquad E_5$$

(a) Derive a rate law for the rate of formation of ethylene (10%)

(b) What is the overall activation energy for the formation of ethylene ? (5%)

(15%) Problem 5

What is the definition of selectivity for multiple reactions? (5%) What feed concentration (high or low C_{A0} and C_{B0}), temperature (high or low) and reactor type (PFR or CSTR) will promote the formation of desired product R over S and B for the following set of elementary reaction: (10%)

$$2A + B \xrightarrow{k_1} R \qquad E_1 = 20 \text{ kcal/mol}$$

$$R + 3B \xrightarrow{k_2} S \qquad E_2 = 40 \text{ kcal/mol}$$

(20%) Problem 6

The reaction described by the data in the following table. A → B

X	0.0	0.1	0.2	0.4	0.6	0.7	0.8
$-r_A(mol/m^3\ s)$	0.928	0.825	0.455	0.305	0.289	0.15	0.01

The flow rate of A is 0.5 mol/s. If we use one CSTR (X is from 0.0 to 0.4) and one PFR (X is from 0.4 to 0.8) in series. Please use the data to calculate the volume necessary for CSTR and PFR, respectively, to achieve 80% conversion.