A. Chemical Engineering Thermodynamics (50%):

(A1) Write out the first law of thermodynamics for a common unsteady state flow process. (10%)

(A2) Write out the mathematical relations regarding the second law of thermodynamics. (10%)

(A3) (a) Derive a general principle for a closed system to be at equilibrium. (8%)
(b) From the principle derive the criteria of phase equilibrium and chemical reaction equilibrium for a multi-phase reacting system. (7%)

(A4) Freezing point depression of a solvent due to the presence of a solute can be estimated from the thermodynamics of solution. Let T_m be the freezing (or melting) point of the pure solvent, and T_f the freezing point of the solution. You may assume that the solid phase is pure solvent, and the solution follows the ideal solution behavior. The mole fraction of solvent is x_1, and solute x_2; $x_1+x_2=1$.
(a) Please derive the freezing temperature depression (T_m-T_f) as a function of solute mole fraction (x_2). (8%)
(b) Calculate the eutectic point and composition (the same T_f) for an ethyl benzene-toluene solution. (7%)
Physical properties of ethyl benzene and toluene are as follows:
Ethyl benzene: $T_m=178.2K$, ΔH (heat of fusion)=9070.9 $J/mole$, $C_{ps}=105.9$ $J/mol\ K$, $C_{pL}=157.4$ $J/mol\ K$.
Toluene: $T_m=178.16K$, ΔH (heat of fusion)=6610.7 $J/mole$, $C_{ps}=87$ $J/mol\ K$, $C_{pL}=135.6$ $J/mol\ K$.

國立中央大學八十四學年度碩士班研究生入學試題卷

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B. Chemical Reaction Engineering (50%):

(B1) What are the two important factors should be considered for the design and selection for the reactor systems? Which one is the primary consideration for multiple reaction design? (10%)

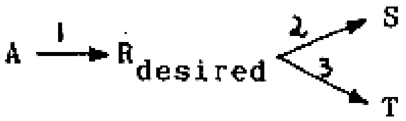
(B2) Given the reactions

$$A \longrightarrow R_{desired}, \qquad r_R = 2C_A$$
$$2A \longrightarrow S \qquad , \qquad r_S = 4C_A^2$$

(a) What is the fractional yield expression φ(R/A) for this system?

(b) In what type of single reactor, plug or mixed, would you expect to find the $C_{R,max}$? (10%)

(B3) Determine the conditions such as T, C_A (high, low, intermediate, rising, falling, etc.) and reactor type (plug, mixed) which will favor the formation of the desired product indicated.



n_1, E_1	n_2, E_2	n_3, E_3
2, 25	0, 35	1, 15

where n_i: reaction order of ith step

E_i: activation energy of ith step (10%)

(B4) An irreversible liquid reaction takes place in a CSTR under isotherm and constant density conditions:

$$A \rightarrow B$$

The reaction of A can be described by a first order reaction as kC_A (kmole/m^{3}s). Before $t=0$, the reactor is empty. From the moment of $t=0$, the feed is pumped into the reactor at a rate of Q (m^3/s) with a concentration of C_{A0} of the reactant. However, at $t=\tau$, the liquid level has reached the overflow and after that the reaction volume V remains constant. You can assume that the mixing is ideal after t=0. Please calculate the concentration C_A as a function of time for

(a) $t < \tau$, (5%)

(b) $t > \tau$, (5%)

(c) $t = \infty$, where $C_A = C_{A\infty}$ (5%)

(d) if the final conversion required is 1%, i.e., $(C_A - C_{A\infty})/(C_{A0} - C_{A\infty}) < 0.01$, how much reaction time is required? (5%)