# 國立成功大學
# 115學年度碩士班招生考試試題

編　號：53

系　所：化學工程學系

科　目：化學反應工程

日　期：0203

節　次：第 3 節

注　意：1.可使用計算機
　　　　2.請於答案卷(卡)作答，於試題上作答，不予計分。

1. **[18% in total]** The coordination of a bulky organic ligand (L) to a copper ion ($Cu^{2+}$) follows the rate equation of $2L + Cu^{2+} \leftrightarrow [CuL_2]^{2+}$ with the formation rate of $[CuL_2]^{2+}$: $r = k''C_L^2 C_{Cu^{2+}}/(1 + k'C_L)$, where $C_L$ and $C_{Cu^{2+}}$ are the concentration of the ligand and copper ion and $k'$ and $k''$ are the combinatory rate constant inside the composite reaction. (a) Derive a plausible mechanism for the rate law of $[CuL_2]^{2+}$ **[9%]**. (b) Given that the reaction is performed in a mixed flow reactor with a molar flow rate of the ligand of 1 mol $s^{-1}$. Assume that the ligand concentration (1 mol $L^{-1}$) is greatly in excess of the copper ion (0.1 mol $L^{-1}$). The observed rate constant of the copper ion coordination is 100 $min^{-1}$. Calculate the tank volume and the flow retention time to achieve a 90% coordination conversion of the copper ion **[9%]**.

2. **[15% in total]** A parallel irreversible reaction set of "A" compound becomes a target product "T" and a side product "S" with the corresponding rate laws of:

The production rate of T: $r_T = k_T C_A^2$

The production rate of S: $r_S = k_S C_A$

where $k_T$ and $k_S$ are the rate constants of each reaction, and $C_A$ is the concentration of the starting material A. All the compounds are in the same liquid phase. Please respond to the following questions with derivations or explanations to support the answers.

(a) Derive the fractional yield and selectivity of the target product of this reaction set **[2%]**.

(b) If this reaction is conducted in a continuous mixed flow or a plug flow reactor, which can you use to maximize the selectivity of the target product **[2%]**?

(c) If the activation energies of each reaction are $E_{a,T}$ for the production of T and $E_{a,S}$ for the production of S, given that $E_{a,T} > E_{a,S}$. How can you maximize the selectivity of the target product by changing the reaction temperature **[2%]**?

(d) If this set of reactions is conducted with a solid porous catalyst, and the reaction is performed at a diffusion-controlled regime. Derive the fractional yield and selectivity of the target product of this reaction set **[3%]**.

(e) Based on question (d), which can you use to maximize the selectivity of the target product by using a mixed flow or a plug flow reactor for this heterogeneous reaction **[3%]**?

(f) Based on questions (c) and (d), how can you maximize the selectivity of the target product for this heterogeneous reaction by changing the reaction temperature **[3%]**?

3. **[12% in total]** Answer the following:

(a) What is the physical interpretation of Michaelis-Menten constant in enzyme kinetics? **[3%]**

(b) Explain why multiple steady states is observed in a non-isothermal CSTR and is not in a non-isothermal PFR? **[3%]**

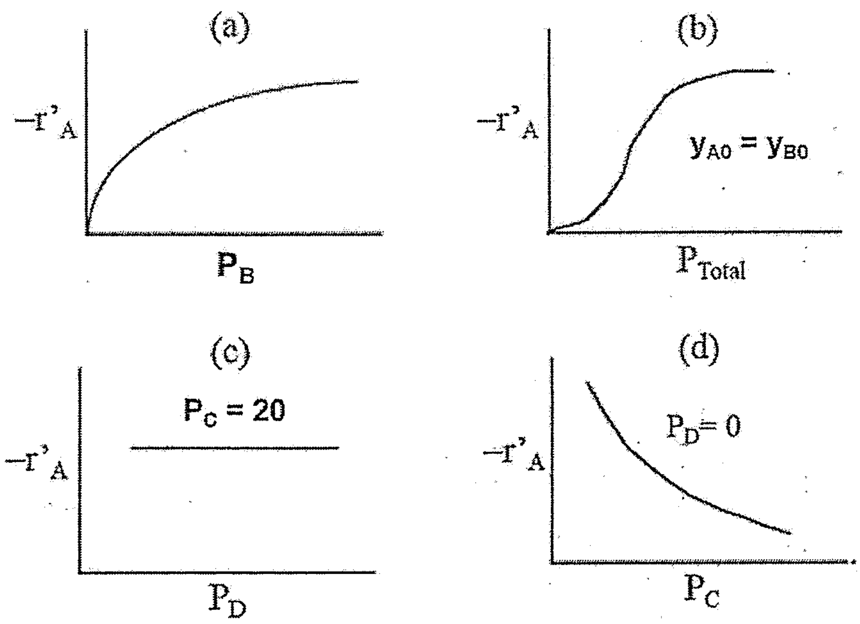
(c) What are the three scenarios occurring in unsteady state operations? **[3%]**

(d) In a multiple steady-state flow reactor with an exothermic reaction, explain what is ignition temperature. **[3%]**

4. **[22% in total]** The elementary reaction, irreversible reaction (A → B) is running in an adiabatic CSTR reactor (V = 50 L) without shaft work at steady state. The total flow rate is 100 mL/h and the feed is 10 mol% A balanced with inert (I). The volumetric feed rate is 25 L/h. The feed enters the reactor at 350 K and its heat

capacity is 16 kcal/mol/K. The reaction heat is -6000 cal/mol and reaction rate is $r_A = C_A^2 \exp(14-5000/T)$ mol/L/h. Determine the outlet temperature and outlet flow rate of A.

5. **[16% in total]** The following figures were reported for the reaction $A + B \rightarrow C + D$.




Please find the rate law **[8%]** and mechanism consistent with these figures **[8%]**.

6. **[17% in total]** For a first order, gas-solid (catalyst) reaction, A (g)→ Product (s).
   (a) Show that the isothermal overall effectiveness factor (Ω) is related to the catalyst effectiveness factor (η) by

$$\frac{1}{\Omega} = \frac{k_A}{k_{Ag}} + \frac{1}{\eta}$$

   where $k_A$ is the reaction rate constant, and $k_{Ag}$ is the gas-film mass transfer coefficient. **[8%]**
   **(b)** If the surface reaction is rate-controlling, what is the rate law in terms of the concentration of A in bulk gas ($C_{Ab}$) and η, and what does this mean for $k_{Ag}$, $C_{As}$, η, and Ω? **[9%]**