

系所組別：化學工程學系甲組

考試科目：化學反應工程

考試日期：0223，節次：3

※ 考生請注意：本試題可使用計算機

1. A reactor system is to be designed for 85% conversion of A in a second-order liquid-phase reaction, $A \rightarrow$ products; $k_A = 0.075 \text{ L mol}^{-1}$, $v_0 = 25 \text{ L min}^{-1}$ (volumetric flow rate), and $C_{A0} = 0.04 \text{ mol L}^{-1}$. The cost of a vessel is \$ 0.29 L^{-1} , but a 10% discount applies if both vessels are of the same size and geometry. The design options are:

(A) two equal-sized stirred tanks in series; what is the capital cost of this design? (11%)

(B) two stirred tanks in series to provide a minimum total volume: what is the capital cost of this design? (11%)

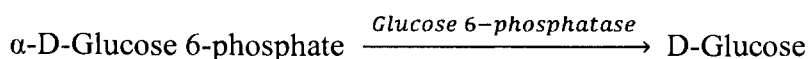
(Hint: the solutions may be obtained by trial & error.)

2. Calculate the ratio of the volumes of a CSTR and a PFR (V_{ST}/V_{PF}) required to achieve a fractional conversion of 0.99 for the reactant A with an identical feed rate for each reactor, if the liquid-phase reaction $A \rightarrow$ products is

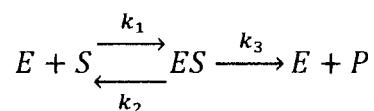
(A) first-order with respect to A (please find the value of V_{ST}/V_{PF}) (5%)

(B) second-order with respect to A (please find the value of V_{ST}/V_{PF}) (7%)

3. An enzyme Glucose 6-phosphatase has a K_M value of 10^{-4} M and a k_3 value of 10^4 min^{-1} at 37°C . The reaction catalyzed is the following:



Which can be represented as



Where S is α -D-Glucose 6-phosphate and P is D-glucose, E is the enzyme Glucose 6-phosphatase. The enzyme is not stable at 37°C and the amount of active enzyme will decrease along time:

$$E = E_0 e^{-k_d t}$$

Where E_0 is the initial enzyme concentration and $k_d = 0.1 \text{ min}^{-1}$. In an experiment, a certain amount of enzyme and 0.02M of α -D-Glucose 6-phosphate is added into a batch reactor and incubated at 37°C . After 12 hours, the concentration of D-glucose is found to be 0.002M. What is the initial concentration of enzyme (E_0)? (8%)

(背面仍有題目，請繼續作答)

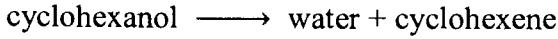
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4、Cyclohexanol was passed over a catalyst to form water and cyclohexene:



The following data were obtained:

Run	Reaction rate ($\text{mol}/\text{dm}^3 \cdot \text{s}$) $\times 10^5$	Partial pressure of cyclohexanol	Partial pressure of cyclohexene	Partial pressure of steam (H_2O)
1	3.30	1	1	1
2	1.05	5	1	1
3	0.57	10	1	1
4	1.83	2	5	1
5	1.49	2	10	1
6	1.36	3	0	5
7	1.08	3	0	10
8	0.86	1	10	10
9	0.00	0	5	8
10	1.37	3	3	3

It is suspected that the reaction may involve a dual-site mechanism. Please suggest a reaction mechanism and corresponding rate law for the above data. Detailed rationales and supporting calculations are required. (12%)

5、Reactant A at $P_{A0} = 500\text{kPa}$ is to be passed through a packed bed catalytic reactor where it will decompose into either R or S. To maximize the formation of R, determine:

(A) Should the reactor operated in the strong pore diffusion regime or reaction rate limited regime? Please state your reason in detail and provide equations to validate your statement. (5%)

(B) Following (A), what is the length of the reactor if the conversion of A is 90%? (8%)

Additional information:

without the diffusion limitation, the reaction rates of R and S are: $A \begin{cases} \nearrow R, \tau_R = 0.02C_A \\ \searrow S, \tau_S = 0.03C_A \end{cases}$

Effective diffusivity of A: $2.66 \times 10^{-8} \text{ m}^2/\text{s}$

Catalyst pellet diameter: 0.4 cm

(背面仍有題目，請繼續作答)

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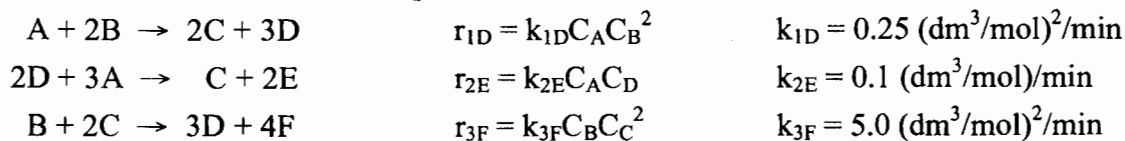
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Catalyst pellet density: $2 \times 10^6 \text{ g/m}^3$ Internal surface area of the catalyst pellet: $400 \text{ m}^2/\text{g}$ Linear velocity of A: 3 m/s Inlet temperature: $250 \text{ }^\circ\text{C}$

6、The following liquid-phase reactions were carried out in a 100-dm^3 PFR at 300K . The entering volumetric flow rate was $10 \text{ dm}^3/\text{min}$, with equal molar feed of A and B of $C_{A0} = C_{B0} = 2 \text{ mol/dm}^3$.



- (A) Please list out all the equations you need to input into a computer software in order to obtain the species concentrations and the instantaneous selectivity $S_{\text{C/DEF}}$ (i.e. C is the desired product and D~F are undesired products) as a function of reactor volume. (10%)
- (B) Please qualitatively describe how to enhance the selectivity and which type of reactor would be suitable. (3%)

7、Please explain the phenomenon of “multiple steady state” in a nonisothermal CSTR running an exothermic and first-order reaction and define the condition of runaway point mathematically. (20%)

Hint: By neglecting the shaft work and assuming $\Delta C_p = 0$,

$$-X\Delta H_{\text{Rx}}^{\circ} = C_{\text{P}0}(1 + \kappa)(T - T_c)$$

where $C_{\text{P}0} = \sum \Theta_i C_{\text{P}i}$; $\kappa = (UA/C_{\text{P}0}F_{\text{A}0})$; $T_c = (\kappa T_a + T_0)/(1 + \kappa)$

(X: conversion; $\Delta H_{\text{Rx}}^{\circ}$: heat of reaction; U: overall heat transfer coefficient; A: heat transfer area; T_a : coolant temperature)