系所組別： 化學工程學系甲組

考試科目： 化學反應工程

※ 考生請注意：本試題 ☑可 ☐不可 使用計算機

1. Two identical plug flow reactors are used to carry out two gas-phase reactors separately:

   (a) $A \rightarrow 2B$ (b) $A \rightarrow B$

   These two reactions have the same rate constant, and the feed conditions are the same in these two reactors. Without deriving any design equation, how do you judge which reactor will achieve the higher conversion? (6%)

2. (a) What conditions should an ideal plug flow reactor follow? How to make it in the reactor design and operation? (2%)

   (b) What conditions should an ideal continuous-stirred tank reactor follow? How to make it in the reactor design and operation? (2%)

3. In a liquid solution, component A is converted to B on the inner wall of a tubular reactor, $A \rightarrow B$. The product B returns to the bulk solution. The diffusion of A is the rate-limiting step and the concentration of A on the inner wall surface is assumed zero.

   (a) Derive an equation to show the conversion (X) in terms of mass transfer coefficient (k_c), volumetric flow rate (V_o), reactor length (L), and the inner radius of the reactor (R). (15%)

   (b) What is the concentration of A at the outlet with the following condition? (3%)

   mass transfer coefficient = 0.01 cm/sec, volumetric flow rate = 3 cm^3/sec.
   reactor length = 100 cm, inner radius = 1 cm,
   concentration of feed = 0.5 mole/liter.

   (c) Discuss the effect of the flow speed (v) on the conversion with the same reactor. (6%)

4. Three species were found in a CSTR. The following concentration data were obtained as a function of temperature. The initial concentration of the single reactant, A, was the same at all temperatures. Both B and C are products.

   C_{A0} = 2 moles/dm^3

Rur	T (°C)	C_A (mole/dm^3)	C_B (mole/dm^3)	C_C (mole/dm^3)
1		1.70	0.01	0.29
2		1.40	0.03	0.57
3		1.00	0.10	0.90
4		0.50	1.25	1.25
5		0.10	1.80	0.10
6		0.01	1.98	0.01

   (a) Please draw the concentration profile (C_i v.s. T) of each species. (2 %)

   (b) What is the effect of temperature on the reaction rate? (2 %)

   (c) Is the reaction independent, complex, series or parallel? Why? (5 %)

   (d) How does temperature affect the reaction constants in the reactions you suggested in (c)? (6 %)

(背面仍有題目，請繼續作答)

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5. The acid catalyzed irreversible liquid phase reaction, A⟶B, was carried out adiabatically in a CSTR. The reaction is second order in A. The feed, which is equal molar in water (which contains the catalyst) and A, enters the reactor at a temperature of 52°C and a total volumetric flow rate of 100 dm^3/min. The concentration of A entering the reactor is 4 molar.
   (a) From the mole balance, derive the relationship between conversion (X_A) and Da ($Da = \tau k C_{Ao}$, τ is the space time = reactor volume / feed flow rate) (6 %)
   (b) From the energy balance, derive the relationship between X_A and Temperature. (6 %)
   (c) What conversion can be achieved in a 1000 dm^3 CSTR? What is the exit temperature? (6 %)

   Additional information:

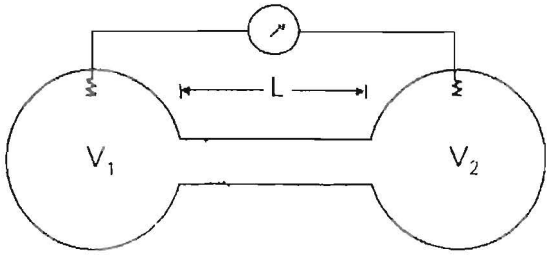
   $\Delta H_{RX} = -3000$ cal/gmol $Cp_W = 18$ cal /gmol · °C
   $k = 5\times10^{-4}$ at 25 °C $Cp_A = 15$ cal /gmol · °C
   $E = 15000$ cal/mol $Cp_B = 15$ cal /gmol · °C

6. Experimental data for the gas-phase catalytic reaction: A + B → C is shown below. The limiting step in the reaction is known to be irreversible, so that the overall reaction is irreversible. The reaction was carried out in a differential reactor to which A, B, and C were all fed.

Run	P_A (atm)	P_B (atm)	P_C (atm)	Reaction Rate (mol)/(g cat·s)
1	1	1	2	0.114
2	1	10	2	1.140
3	10	1	2	0.180
4	1	20	2	2.273
5	1	20	10	0.926
6	20	1	2	0.186
7	0.1	1	2	0.0243

   (a) Suggest a rate law consistent with the experimental data. (8%)
   (b) Evaluate the rate law parameters. (5%)
   (c) Suggest a mechanism and rate-limiting step for this reaction. (8%)

7. A device for measuring the diffusion coefficient of a gas mixture consists of two chambers connected by a small tube, with a cross-sectional area A_c. Initially the chambers contain different proportions of two gases, A and B. The total pressure is the same in each chamber.



Assume that diffusion may be described by the Fick's first law, that the concentration in each flask is uniform, and that the concentration gradient in the tube is linear. Please derive the following equation and state any other assumptions needed. (12%)

$$\ln(C_{A1} - C_{A2}) = -\frac{A_c D_{AB}}{L}\left(\frac{1}{V_1} - \frac{1}{V_2}\right)t + constant$$