國立成功大學 104 學年度碩士班招生考試試題

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：0211，節次：3

※ 考生請注意：本試題可使用計算機。 請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. The gas reaction for "$CH_3CHO \rightarrow CH_4 + CO$" is reacted at the conditions as 550℃ and 1 atm in a plug flow reactor with the diameter of 4.5 cm and length of 90 cm. The results of flow-rate and fraction of acetaldehyde (Mw 44 g/mole) decomposed are as follows: (20%)

Flow-rate of CH_3CHO (g/hr)	120	60	25	12
Fraction of CH_3CHO decomposed	0.06	0.10	0.22	0.32

(a) Please derivate the expression of reaction rate as second order reaction (5%)

(b) Calculate reaction constant *k* (10%) and final reaction rate (5%)

Hints: Pure acetaldehyde is fed and assumes ideal gas law is applicable. The flow-rate and conversion can be considered as a "linear curve" when calculate reaction constant *k*.

2. For the elementary and gas-phase reaction, $A + B \rightarrow C + D$, being carried out isothermally in a packed bed reactor (PBR), reactants A and B are fed in equal molar with total molar rate of 10 mole/min. The initial pressure is 10 atm, the temperature is 400 K, and the pressure drop parameter is 0.01 [(g catalyst)$^{-1}$]. Please determine the catalyst weight to achieve 90% conversion. (10 %)

Additional information:

(a) The pressure inside PBR should be kept above 1 atm.

(b) Specific reaction rate at 400 K, k = 50 [liter^2•(mole•g catalyst•min)$^{-1}$].

(c) $\int_0^x \frac{(1+\varepsilon x)^2}{(1-x)^2}dx = 2\varepsilon(1+\varepsilon)\ln(1-x)+\varepsilon^2 x+\frac{(1+\varepsilon)^2 x}{1-x}$.

3. For the following liquid-phase multiple reaction system being carried out isothermally in the temperature between 300~350 K,

$A \rightarrow B$	$r_{1B} = k_{1B}C_A$	$k_{1B} = 2.5$ (min)$^{-1}$ at 300 K, $E_1 = 10$ Joule/mole
$A \rightarrow 2C$	$r_{2C} = k_{2C}$	$k_{2C} = 4.0$ (mole/liter)/min at 300 K, $E_2 = 15$ Joule/mole
$2A \rightarrow D$	$r_{3D} = k_{3D}C_A^2$	$k_{3D} = 1.0$ (mole/liter)$^{-1}$/min at 300 K, $E_3 = 25$ Joule/mole

pure A is fed with the concentration of 5 M and volumetric flow rate of 2.0 liter/min. The desired product is B. (20%)

(a) Please specify the optimum conditions to achieve maximum selectivity ($S_{B/CD}$). (10 %)

(b) Design a reactor to maintain maximum selectivity throughout the reactor. Please specify the type, size and operating conditions of your reactor and also calculate the mole flow rates of all species in the exit stream. (10%)

4. The pyrolysis of n-pentane, which can be represented by the following two reactions: (20%)

$$C_5H_{12} \longleftrightarrow CH_4 + i-C_4H_8$$
$$2C_5H_{12} \longleftrightarrow 2i-C_4H_8 + H_2 + C_2H_6$$

has been shown to give a simple reaction order of the production of methane:

$$r_{CH_4} = kC_{C_5H_{12}}^{3/2}$$

(a) Assuming the following chain reaction mechanism, justify the above rate law. Note that the name of each reaction rate constant is listed to the right of each reaction. (10%)

$$C_5H_{12} \rightarrow (CH_3)_3C^* + CH_3^* \qquad (k_1)$$
$$(CH_3)_3C^* \rightarrow i-C_4H_8 + H^* \qquad (k_x)$$
$$H^* + C_5H_{12} \rightarrow H_2 + C_5H_{11}^* \qquad (k_y)$$
$$C_5H_{11}^* \rightarrow i-C_4H_8 + CH_3^* \qquad (k_2)$$
$$CH_3^* + C_5H_{12} \rightarrow CH_4 + C_5H_{11}^* \qquad (k_3)$$
$$2CH_3^* \rightarrow C_2H_6 \qquad (k_t)$$

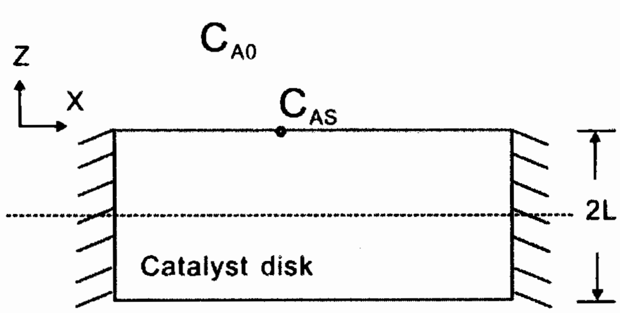
(b) Please build the reaction pathway (network) based on the aforementioned mechanism. (5%)

(c) If methane is the desired product, the rate constant(s) of which step(s) should be promoted? Why? (5%)

5. An irreversible, zero order reaction A → B is conducted in the porous catalyst disk (shown below). Please prove that the concentration profile using the symmetry boundary conditions is

$$\frac{C_A}{C_{AS}} = 1 + \phi_0^2\left[\left(\frac{z}{L}\right)^2 - 1\right] \qquad where\ \phi_0^2 = \frac{kL^2}{2D_eC_{AS}}$$

, k is the rate constant, 2L is the thickness of the catalyst disk, D_e is the diffusivity, and C_{AS} is the concentration of C_A at the z = L. (10%)



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6. The elementary irreversible gas-phase catalytic reaction

$$A \xrightarrow{k_1} B$$

is carried out isothermically in a batch reactor. The catalyst deactivation follows a first-order decay law and is independent of the concentrations of both A and B. (15%)

(a) Make a qualitative sketch of catalyst activity as a function of time. Does a(t) ever equal zero for a first-order decay law? (5%)

(b) Calculate the conversion in the reactor after 10 min-uses. (10%)

Additional information:

$C_{A0} = 1\ mol/dm^3$; $V_0 = 1\ dm^3$; $W = 1\ kg$; $k_d = 0.1/min$; $k_1 = 0.2\ dm^3/(kg\ cat \bullet min)$

Single choice (5%)

7. for the reaction: $A + B \rightarrow C$

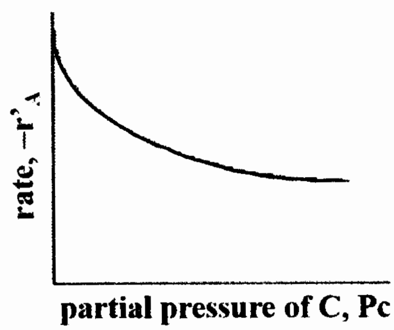

Figure. Data from a differential reactor.

Which one of the following best describes the data in the above figure?

(A) Specie C could be adsorbed on the surface.
(B) The reaction could be reversible.
(C) Both the above statements could be true.
(D) Neither A or B are on the surface.
(E) None of the above could be true.