國立成功大學 105 學年度碩士班招生考試試題

系　所：化學工程學系

考試科目：化學反應工程

考試日期：0227，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. Assume a reaction as following:

   $A + B \rightarrow 14C$

   With the rate expression $-r_A = k_1 C_A^2 C_B$ is taking in a cylindrical batch reactor without friction.

   a) Write the rate law solely as a function of conversion in numerically evaluating all possible symbols. **(10 %)**

   b) What is the conversion and rate of reaction when the volume (V) = 0.2 ft^3? **(10 %)**

   Additional information:

   Equal moles of A and B are present at $t = 0$.

   Initial volume is 0.15 ft^3.

   Value of k_1 is 1.0 $(ft^3/lb\ mol)^2/s$

   Temperature of system: 140°F (where °R = °F + 460)

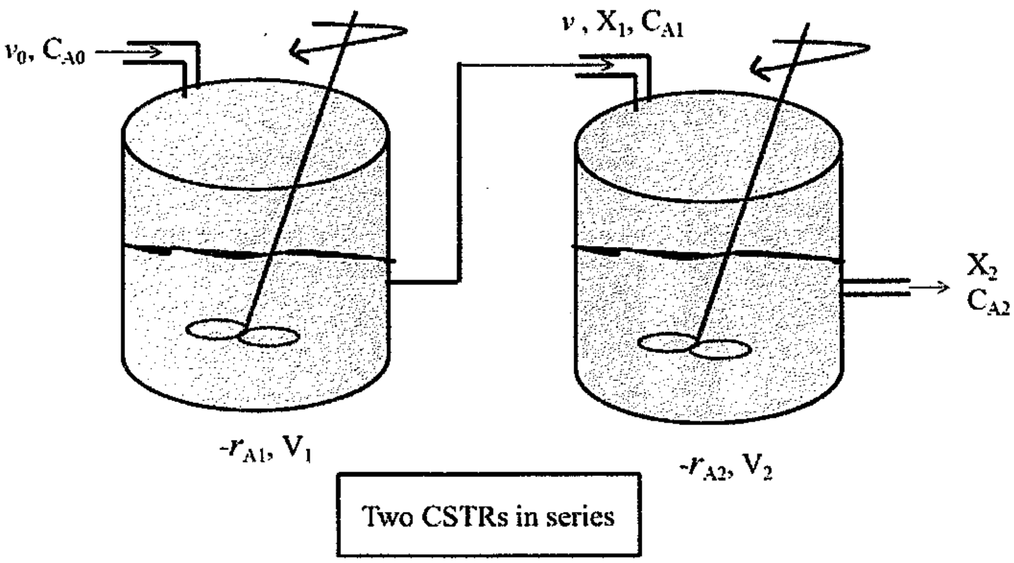
   Gas constant: 0.73 ft^3 *atm/lb-mol °R

   The relationship between the volume of the reactor and pressure within the reactor is V = 0.1 P (V in ft^3, P in atm)

2. a) What is the definition of space time (τ) based on conversion (X), and Damkohler Number (Da) in a CSTR. **(4%)**

   b) What is the conversion for a second order reaction in a CSTR by function of Da? **(4%)**

   c) As shown below is two CSTRs in series, to derivate the equation of C_{A1} and C_{A2} in terms of space time (τ), kinetic constant (k) and input concentration C_{A0} for each tank. **(5%)**



3. The liquid phase reactions are conducted in an insulated CSTR:

(1) $A+B \xrightarrow{k_1} D$ (desired)

(2) $A+B \xrightarrow{k_2} U$ (undesired)

The desired reaction is first order in A and zero order in B, while the undesired reaction is zero order in A and first order in B. The feed rate is equimolar in A and B. The inlet temperature of A is at 100 °C, and the entering temperature for B is 50 °C. The CSTR is operated at 400 K. **(20%)**

Additional information:

F_{A0} = 60 mol/min

C_{A0} = 0.01 mol/dm^3

C_{PA} = 20 cal/mol/K

C_{PB} = 30 cal/mol/K

C_{PD} = 50 cal/mol/K

C_{PU} = 40 cal/mol/K

For reaction 1: ΔH_{RX} = -3000 cal/mol of A at 300 K

For reaction 2: ΔH_{RX} = -5000 cal/mol of A at 300 K

k_1 = 1000exp(-2000/T) min^{-1} (T is in Kevin)

k_2 = 2000exp(-3000/T) min^{-1} (T is in Kevin)

a) Please express the CSTR volume as a function of merely C_A and C_B. You should consider mass and energy balances coupled with rate expressions. **(10 %)**

b) What is the CSTR volume and conversion of A at the outlet? **(10 %)**

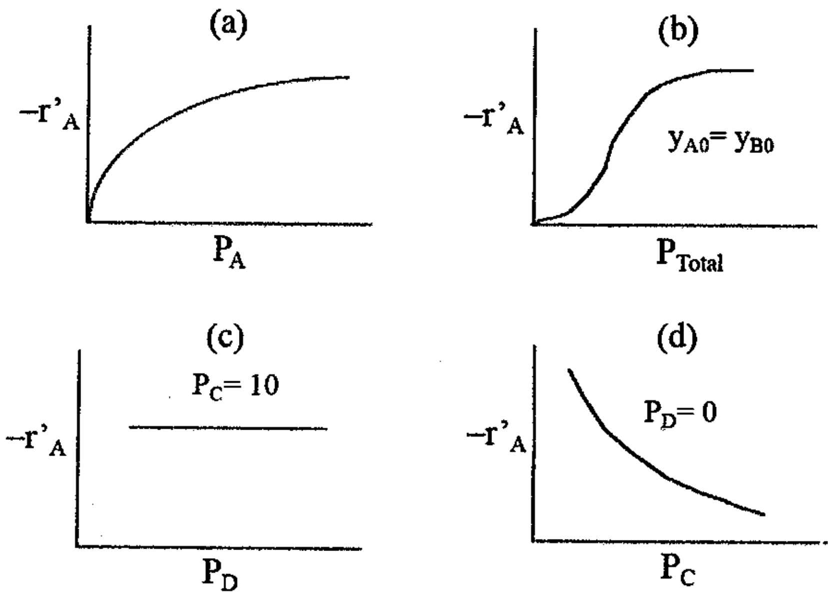
4. The overall reaction of ethanol dehydrogenation to acetaldehyde is $C_2H_5OH \Rightarrow C_2H_4O + H_2$, and can be conducted on copper catalysts (e.g., Cu/SiO_2). **(13%)**

a) Please derive the rate expression based on the Langmuir-Hinshelwood model, assuming that the surface reaction step is the rate limiting step. **(7 %)**

b) The data below was obtained by differential analysis conditions. According to the above derived rate expression, please obtain the kinetic parameters. **(6 %)**

***T* (°C)**	***P$_t$* (bar.)**	***r$_{A0}$* (kmol/kg cat. h)**
302	1.0	0.0227
302	3.0	0.0277
302	5.0	0.0255
302	7.0	0.0217
302	9.6	0.0183

5. The following figures were reported for the reaction A + B goes to C + D



Please find the rate law **(8%)** and mechanism **(6%)** for A + B ↔ C + D.

6. A mass transfer–limited reaction is being carried out in two packed-bed reactors of equal volume and packing, connected in series as shown in **Figure a**. Currently, 86.5% conversion (X_1) is being achieved with this arrangement. It is suggested that the reactors be separated and the flow rate be divided equally among each of the two reactors (**Figure b**) to decrease the pressure drop and hence the pumping requirements. In terms of achieving a higher conversion, Robert is wondering if this is a good idea? What is the conversion (X_2) of the parallel arrangement? **(20%)**

(*Hint*: Please determine the conversion X as a function of reaction length L for a mass transfer-limited packed-bed reactor first)

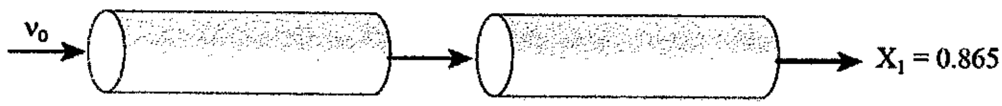


Figure a. Series arrangement

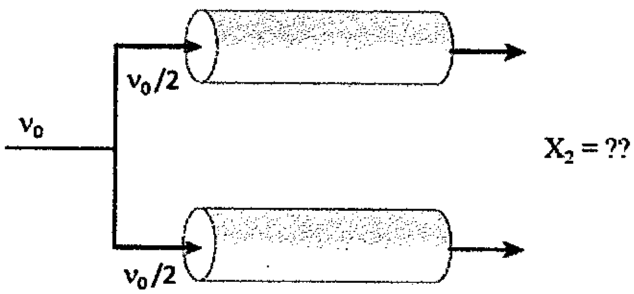


Figure b. Parallel arrangement