※ 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。

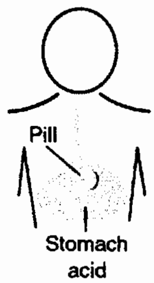
1. The elementary reversible liquid-phase reaction A + B ↔ C + D is carried out in an ideal and isothermal CSTR with volume of 300 liters at 350 K. Reactant A and B are fed at equal molar flow rate of 20 mol/min, and the volumetric flow rate of entrance stream is 10 l/min. Please calculate the conversion of reactant A and concentration of each species at the exit of reactor. (20%)

Additional information: k_A = 10 (l/mol-min) at 300 K, E = 20 kJ/mol, K_c = 3.0 at 300 K, ΔH_{RX} = –40 kJ/mol. Assume that $\Delta C_p \sim 0$.

2. For a reactor system composed of n ideal and isothermal CSTRs with the same space time of τ_i connected in series (n is positive integer),
(a) Please derive the expression for the conversion (x_A) of a first-order and liquid phase reaction, A → B, carried out in this reactor system. Pure A is fed, and the rate constant is k. (8%)
(b) Use the Lavenspiel plot to illustrate that an ideal PFR could be described using this reactor system with n approaches to infinity. (6%)

3. An antibiotic drug is contained in a solid inner core and is surrounded by an outer coating that makes it palatable. The outer coating and the drug are dissolved at different rates in the stomach, owing to their differences in equilibrium solubilities. If D_2 = 4 mm and D_1 = 3 mm, please calculate the time necessary for the pill to dissolve completely. (12%)

Additional information:
Assume density of outer layer = inner layer
Amount of drug in inner core = 500 mg
Solubility of outer layer at stomach conditions = 1.0 kg/cm^3
Solubility of inner layer at stomach conditions = 0.4 kg/cm^3
Volume of fluid in stomach = 1.2 L
Sh = 2, D_{AB} = 6 × 10^{-4} cm^2/min



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4. The elementary irreversible gas phase catalytic reaction

$$A + B \xrightarrow{k} C + D$$

is to be carried out in a *moving-bed reactor* at constant temperature. The reactor contains 5 kg of catalyst. The feed is stoichiometric in A and B. The entering concentration of A is 0.2 mol/dm^3. The catalyst decay law is zero-order with $k_D = 0.2\ s^{-1}$.

(a) Sketch the catalyst activity as a function of catalyst weight (i.e., distance) down the length of the reactor (from 0 to 5 kg) for a catalyst feed rate of 0.5 kg/s. What does an activity of zero mean? Can catalyst activity be less than zero? (5%)

(b) What conversion will be achieved for a catalyst feed rate of 0.5 kg/s? (8%)

Additional information: $k = 1.0$ dm^6/(mol·kg·cat·s); $V_0 = 1.0$ dm^3/s

5. Cyclohexanol was passed over a catalyst to form water and cyclohexene:

Cyclohexanol → Water + Cyclohexene

The following data were obtained:

Run	*Reaction Rate* (mol/dm^3·s) × 10^5	*Partial Pressure of Cyclohexanol*	*Partial Pressure of Cyclohexene*	*Partial Pressure of Steam (H_2O)*
1	3.3	1	1	1
2	1.05	5	1	1
3	0.565	10	1	1
4	1.826	2	5	1
5	1.49	2	10	1
6	1.36	3	0	5
7	1.08	3	0	10
8	0.862	1	10	10
9	0	0	5	8
10	1.37	3	3	3

It is suspected that the reaction may involve a dual-site mechanism, but it is not known for certain. Please suggest a rate law and mechanism consistent with the data above. (8%)

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6. A mixture of γ-amylase and α-amylase is obtained from bacteria broth to carry out the hydrolysis of amylose. To simplify the analysis, the reactions of γ-amylase and α-amylase are written as:

$$\text{amylose} \xrightarrow{\gamma\text{-amylase}} \text{glucose} \quad \text{or} \quad S \xrightarrow{E_1} P_1$$

$$\text{amylose} \xrightarrow{\alpha\text{-amylase}} \text{maltose} \quad \text{or} \quad S \xrightarrow{E_2} P_2$$

(a) If the total amount of each enzyme is known (E_{t1} and E_{t2}, respectively), derive the rate equations for glucose and maltose using PSSH. (9 %)

(b) Since maltose sells for a higher price, how do you design your reaction system to achieve the highest production rate of maltose? Please discuss the possibilities in terms of reactor type and temperature. (7 %) Like all enzymes, the amount of active enzyme (E_{act}) changes with temperature:

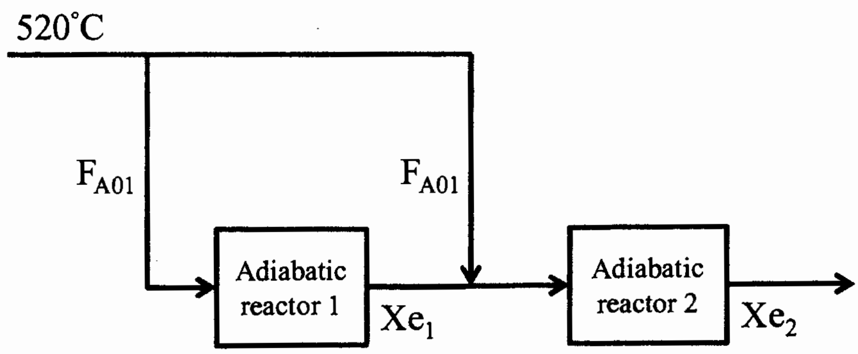
$$E_{act,i}=\frac{E_{ti}}{1+K_{eq}}, \text{ i: 1(γ-amylase) or 2(α-amylase)}$$

$$\text{For γ-amylase: } K_{eq}=\frac{1000}{8.314}\left|\frac{1}{T_{eq}}-\frac{1}{T}\right|, T_{eq}=320\text{K}$$

$$\text{For α-amylase: } K_{eq}=\frac{1500}{8.314}\left|\frac{1}{T_{eq}}-\frac{1}{T}\right|, T_{eq}=330\text{K}$$

7. Two adiabatic reactors with identical volume are applied to carry out a reversible endothermic reaction:

$$A \rightleftarrows B$$



(a) Please derive the relationship between equilibrium conversion (Xe) and equilibrium constant (Ke) for reactor 1 and 2. (11%)

(b) Please sketch the temperature-conversion trajectory for these two reactors assuming that equilibrium conversion is achieved in each reactor. Calculation is not necessary, but rationales are required for each trajectory. (6 %)