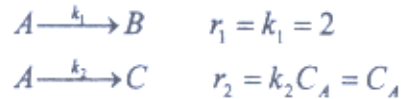


1. For the elementary liquid-phase reaction $A \rightarrow B$, many combinations of CSTR, PFR and recycle reactors may be considered. The total volume of the reactors is 10 liters. The rate constant is $1 \cdot \text{min}^{-1}$ and pure A is fed at $5 \text{ liter} \cdot \text{min}^{-1}$. Please find the maximum conversion. (8%)
2. A long plug flow reactor was used to carry out an exothermic reaction with inlet temperature T_0 . The temperature out side of the reactor, T_a , remains constant. (6%)
 (a) Sketch the temperature profiles inside of the reactor along the reactor length for:
 i. $T_0 > T_a$,
 ii. $T_0 < T_a$.
 (b) What is the major difference between these two profiles?
3. A first order reaction $2A \rightarrow B$ is carried out in an isothermal plug flow reactor. The inlet gas contains 50% A, 5% B and 45% inert. The feed flow rate of A is $1 \text{ mole} \cdot \text{min}^{-1}$. The feed temperature is $100 \text{ }^\circ\text{C}$ and the total pressure is 10 atm. At this temperature, the rate constant is 0.1 min^{-1} . What is the reactor volume to give outlet gas containing 10% A? (20%)
4. (a) The reaction $2NO + O_2 \rightarrow 2NO_2$ is third order. Assuming that a small amount of NO_3 exists in rapid reversible equilibrium with NO and O_2 and that the rate-determining step is the slow bimolecular reaction $NO_3 + NO \rightarrow 2NO_2$, derive the rate equation for this mechanism. (4%)
 (b) Another possible mechanism for the reaction $2NO + O_2 \rightarrow 2NO_2$ is
 (1) $NO + NO \xrightarrow{k_1} N_2O_2$
 (2) $N_2O_2 \xrightarrow{k_2} 2NO$
 (3) $N_2O_2 + O_2 \xrightarrow{k_3} 2NO_2$
 Apply the pseudo-steady-state hypothesis (PSSH) to obtain the rate law.
 If only a very small fraction of the N_2O_2 formed in (1) goes to form products in reaction (3), while most of the N_2O_2 reverts to NO in reaction (2), and if the activation energies are E_1 , E_2 , and E_3 for reactions (1), (2) and (3), respectively, what is the overall activation energy? (8%)
 (c) How would you distinguish experimentally between the mechanisms suggested in parts (a) and (b)? (3%)

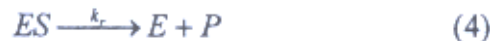
(背面仍有題目,請繼續作答)

5. Calculate the selectivities of forming B in CSTR and PFR reactors at 70% conversion of A starting with $C_{A0} = 5$ moles/liter in the parallel reactions



where rate are in moles/liter-min. (8%)

6. A case of noncompetitive inhibition in enzyme reaction is represented in the following mechanism:



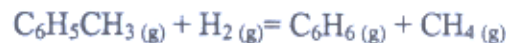
where E is the enzyme, S is a substrate, I is the inhibitor and P is a product.

Show the steady-state rate equation is the form

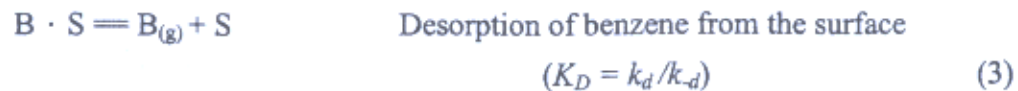
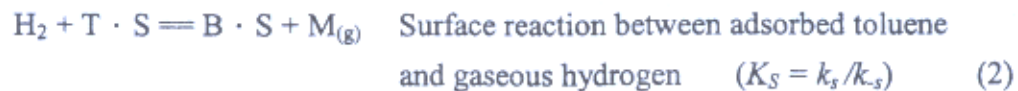
$$r_p = \frac{V_{max} C_S}{C_S(1 + C_I/K_3) + K_m(1 + C_I/K_2)}$$

where V_{max} is the maximum initial rate $r_{p0, max} = k_r C_{E0}$ and K_m is the Michaelis constant ($K_m = (k_{-1} + k_r)/k_1$). (10%)

7. Hydrogen (H) and toluene (T) are reacted over a solid mineral catalyst containing clinoptilolite (a crystalline silica-alumina) to yield methane (M) and benzene (B):



The reaction sequence for this hydrodemethylation is



Assume that the surface reaction is the rate-determining step.

- (a) Derive the rate law in terms of partial pressures of species present and the total concentration of sites (C_t). (10%)
- (b) For an equal molar feed consisting only of toluene and hydrogen, express the initial rate in terms of total pressure (P_0). (5%)

8. The isomerization $A \rightarrow B$ is taking place on the surface of a solid sphere. The surface reaction follows a Langmuir-Hinshelwood single-site mechanism for which the rate law is

$$-r_{As}^* = \frac{k_r C_{As}}{1 + K_A C_{As} + K_B C_{Bs}} \quad (4)$$

and the molar flux to the surface is equal to the rate of reaction on the surface, i.e.,

$$W_A = -r_{As}^* = k_c (C_A - C_{As}) \quad (5)$$

where k_r = rate constant,

k_c = mass-transfer coefficient,

C_A, C_{As} = concentrations of component A in the bulk phase and at surface, respectively.

- (a) Assuming that only very weak adsorption of A and B is needed to consider as the temperature is sufficiently high, show that the rate of reaction on the surface is (6%)

$$W_A = -r_{As}^* = \frac{k_c k_r C_A}{k_r + k_c} \quad (6)$$

- (b) What is the rate of reaction for a rapid reaction? How would be the effects of velocity and particle size of catalyst on the reaction rate? (6%)
- (c) What is the rate of reaction for a slow reaction? How would be the effects of velocity and particle size of catalyst on the reaction rate? (6%)