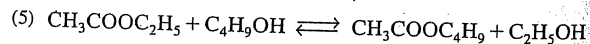
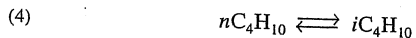
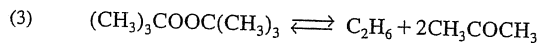
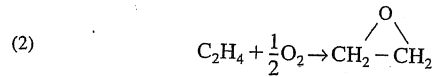
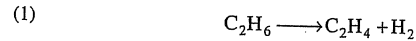


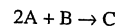
Chemical Reaction Engineering

Chapter 3

P3-10_A (a) Write the rate law for the following reactions assuming each reaction follows an elementary rate law.

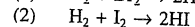
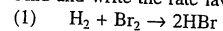


(b) Write the rate law for the reaction



if the reaction (1) is second order in B and overall third order, (2) is zero order in A and first order in B, (3) is zero order in both A and B, and (4) is first order in A and overall zero order.

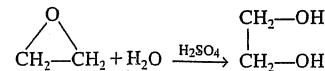
(c) Find and write the rate laws for the following reactions



P3-11_A Set up a stoichiometric table for each of the following reactions and express the concentration of each species in the reaction as a function of conversion

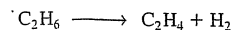
evaluating all constants (e.g., ϵ , Θ). Then, assume the reaction follows an elementary rate law, and write the reaction rate solely as a function of conversion, i.e., $-r_A = f(X)$.

(a) For the liquid-phase reaction



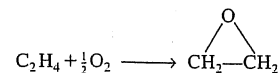
the initial concentrations of ethylene oxide and water are 1 lb-mol/ft³ and 3.47 lb-mol/ft³ (62.41 lb/ft³ ÷ 18), respectively. If $k = 0.1 \text{ dm}^3/\text{mol} \cdot \text{s}$ at 300 K with $E = 12,500 \text{ cal/mol}$, calculate the space-time volume for 90% conversion at 300 K and at 350 K.

(b) For the isothermal, isobaric gas-phase pyrolysis



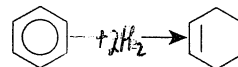
pure ethane enters the flow reactor at 6 atm and 1100 K. How would your equation for the concentration and reaction rate change if the reaction were to be carried out in a constant-volume batch reactor?

(c) For the isothermal, isobaric, catalytic gas-phase oxidation



the feed enters a PBR at 6 atm and 260°C and is a stoichiometric mixture of only oxygen and ethylene.

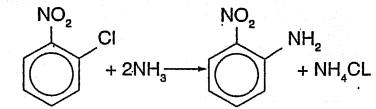
(d) For the isothermal, isobaric, catalytic gas-phase reaction is carried out in a PBR



the feed enters a PBR at 6 atm and 170°C and is a stoichiometric mixture. What catalyst weight is required to reach 80% conversion in a fluidized CSTR at 170°C and 270°C? The rate constant is defined wrt benzene and $v_0 = 50 \text{ dm}^3/\text{min}$.

$$k_B = \frac{53 \text{ mol}}{\text{kgcat} \cdot \text{min} \cdot \text{atm}^3} \text{ at } 300 \text{ K with } E = 80 \text{ kJ/mol}$$

P3-13_B The formation of nitroaniline (an important intermediate in dyes—called fast orange) is formed from the reaction of orthonitrochlorobenzene (ONCB) and aqueous ammonia. (See Table 3-1 and Example 9-2.)



The liquid-phase reaction is first order in both ONCB and ammonia with $k = 0.0017 \text{ m}^3/\text{kmol} \cdot \text{min}$ at 188°C with $E = 11,273 \text{ cal/mol}$. The initial entering concentrations of ONCB and ammonia are 1.8 kmol/m³ and 6.6 kmol/m³, respectively (more on this reaction in Chapter 9).

(a) Write the rate law for the rate of disappearance of ONCB in terms of concentration.

(b) Set up a stoichiometric table for this reaction for a flow system.

(c) Explain how part (a) would be different for a batch system.

(d) Write $-r_A$ solely as a function of conversion. $-r_A = \underline{\hspace{2cm}}$

(e) What is the initial rate of reaction ($X = 0$) at 188°C? $-r_A = \underline{\hspace{2cm}}$

at 25°C? $-r_A = \underline{\hspace{2cm}}$

at 288°C? $-r_A = \underline{\hspace{2cm}}$

(f) What is the rate of reaction when $X = 0.90$ at 188°C? $-r_A = \underline{\hspace{2cm}}$

at 25°C? $-r_A = \underline{\hspace{2cm}}$

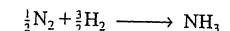
at 288°C? $-r_A = \underline{\hspace{2cm}}$

(g) What would be the corresponding CSTR reactor volume at 25°C to achieve 90% conversion at 25°C and at 288°C for a molar feed rate of 2 mol/min

at 25°C? $V = \underline{\hspace{2cm}}$

at 288°C? $V = \underline{\hspace{2cm}}$

P3-15_B The gas-phase reaction



is to be carried out isothermally. The molar feed is 50% H₂ and 50% N₂, at a pressure of 16.4 atm and 227°C.

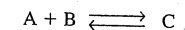
(a) Construct a complete stoichiometric table.

(b) What are C_{A0} , δ , and ϵ ? Calculate the concentrations of ammonia and hydrogen when the conversion of H₂ is 60%. (Ans: $C_{H_2} = 0.1 \text{ mol/dm}^3$)

(c) Suppose by chance the reaction is elementary with $k_{N_2} = 40 \text{ dm}^3/\text{mol} \cdot \text{s}$. Write the rate of reaction *solely* as a function of conversion for (1) a flow system and (2) a constant volume batch system.

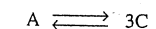
P3-16_B Calculate the equilibrium conversion and concentrations for each of the following reactions.

(a) The liquid-phase reaction



with $C_{A0} = C_{B0} = 2 \text{ mol/dm}^3$ and $K_C = 10 \text{ dm}^3/\text{mol}$.

(b) The gas-phase reaction



carried out in a flow reactor with no pressure drop. Pure A enters at a temperature of 400 K and 10 atm. At this temperature, $K_C = 0.25(\text{dm}^3/\text{mol})^2$.

(c) The gas-phase reaction in part (b) carried out in a constant-volume batch reactor.

(d) The gas-phase reaction in part (b) carried out in a constant-pressure batch reaction.