

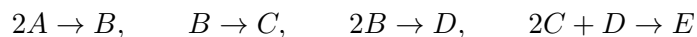
**Written Homework #4**  
**ChE 231**  
**Spring 2019**

Problem 1. Consider a continuous stirred tank reactor in which the following irreversible reaction occurs:  $A \rightarrow B$ ,  $B \rightarrow A$ . The reaction rates per unit volume of the forward and reverse reactions are  $r_f = k_f C_A$  and  $r_r = k_r C_B$ , respectively. The reactor has two inlet streams, with the first stream having volumetric flow rate  $q_1$  and concentrations  $C_{A1}$  and  $C_{B1} = 0$  and the second stream having volumetric flow rate  $q_2$  and concentrations  $C_{A2}$  and  $C_{B2}$ . The reactor has an outlet stream with volumetric flow rate  $q_3$  and concentrations  $C_{A3}$  and  $C_{B3}$ . The reactor operates isothermally with constant volume  $V$  and density  $\rho$ . At steady state the reactor is described by the following linear algebraic equations:

$$\begin{aligned} 0 &= \frac{q_1}{V} C_{A1} + \frac{q_2}{V} C_{A2} - \left( k_f + \frac{q_1}{V} + \frac{q_2}{V} \right) C_{A3} + k_r C_{B3} \\ 0 &= \frac{q_2}{V} C_{B2} + k_f C_{A3} - \left( k_r + \frac{q_1}{V} + \frac{q_2}{V} \right) C_{B3} \end{aligned}$$

Given the parameter values  $k_f = 2$ ,  $k_r = 1$ ,  $\frac{q_1}{V} = 2$ ,  $\frac{q_2}{V} = 1$ ,  $C_{A1} = 1$ ,  $C_{A2} = 1$  and  $C_{B2} = 6$ , formulate and solve a matrix problem  $\mathbf{Ax} = \mathbf{b}$  by Gaussian elimination to find the steady-state values  $C_{A3}$  and  $C_{B3}$ .

Problem 2. Consider a continuous stirred tank reactor with the following reaction sequence:



The rates of the four reactions per unit volume are denoted  $r_1$ ,  $r_2$ ,  $r_3$  and  $r_4$ , respectively. Let  $r_1 = 2$ . Formulate the linear algebraic equation model  $\mathbf{Ar} = \mathbf{b}$  where  $\mathbf{r} = [r_2 \ r_3 \ r_4]^T$ . Find the solution  $\mathbf{r}$  by Gaussian elimination.