A First Course on Kinetics and Reaction Engineering
Activity 22.1

In Example 20.2, the operation of a batch reactor was analyzed. Specifically, a coolant flow rate of 0.2 kg min^{-1} was selected to maximize the net rate of production of B (0.0153 mol min^{-1} including turnaround time) via reaction (1). Suppose that reactor is converted to a CSTR that operates with a space time equal to the total processing time of the two steps in the batch reactor operational protocol (63.8 min). That is, the feed to the CSTR has the same composition and temperature as the initial charge to the batch reactor (a 2 M solution of A at 23 ºC), and the 20 ºC cooling water flows into the jacket at a rate of 0.2 kg min^{-1}. What will the final temperature and outlet molar flow rate of B equal?

The rate expression for reaction (1) is given in equation (2). The heat of reaction (1) may be taken to be constant and equal to -22,200 cal mol^{-1}. The heat capacity of the reacting solution is approximately constant and equal to 440 cal L^{-1} K^{-1}, and its density is constant. The reaction volume is 4 L, and the jacket volume is 0.5 L with a heat transfer area of 0.6 ft^2 and a heat transfer coefficient of 1.13 x 10^4 cal ft^{-2} h^{-1} K^{-1}. The cooling water may be taken to have a constant density of 1 g cm^{-3} and a constant heat capacity of 1 cal g^{-1} K^{-1}.

$$A \rightarrow B \tag{1}$$

$$r_1 = \left(2.59\times10^9\ \text{min}^{-1}\right)\exp\left(\frac{-16500\ \text{cal mol}^{-1}}{RT}\right)C_A \tag{2}$$