

CHEMICAL AND BIOLOGICAL REACTION ENGINEERING

ASSIGNMENT

INSTRUCTIONS: Answer ALL the questions

Problem 1.

The irreversible liquid phase reaction $A \rightarrow R + S$ is carried out in a CSTR. The reaction is first order in A. The feed stream is available at a temperature of 298 K.

$$k = 1.7 \times 10^{-4} \text{ s}^{-1} \text{ at } 298 \text{ K.}$$

$$E_a = 41.87 \times 10^3 \text{ kJ/kmol}$$

$$\Delta H_R(298) = -167.5 \times 10^3 \text{ kJ/kmol}$$

$$C_{A0} = 2.0 \text{ kmol/m}^3 \text{ (Feed is pure A)}$$

$$V = 0.5 \text{ m}^3$$

$$\rho = 1050 \text{ kg/m}^3$$

$$C_p = 4.19 \text{ kJ/kg/K}$$

These values can be considered to be constant over the used interval of concentration and temperature. The CSTR is made of carbon steel and weighs 800 kg.

$$C_{p,\text{steel}} = 502.4 \text{ J/kg/K}$$

Calculate:

- Conversion and heat duty for an isothermal reactor operating at 298 K.
- Conversion and reactor temperature for an adiabatic reactor with inlet temperature of 298 K.
- Conversion and preheating temperature for an adiabatic reactor with a reactor temperature of 363 K.
- Conversion and heat duty if the reactor is operated non-adiabatically without preheating and at a temperature of 363 K.

Problem 2.

Consider an organism which follows Monod equation of growth with $\mu_{\max} = 0.5 \text{ h}^{-1}$ and $K_s = 2 \text{ g/L}$.

- In a continuous perfectly mixed vessel at steady state with no cell death, if the substrate concentration in the feed is $S_{\text{feed}} = 50 \text{ g/L}$, the yield $Y = 1 \text{ (g cells / g substrate)}$, what dilution rate D gives the maximum *volumetric productivity*?
- For the same dilution rate as part (a) using tanks of the same size in series, how many vessels will be required to reduce the substrate concentration to less than 1 g/L?