

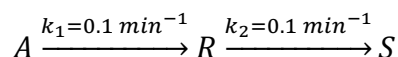
**Assignment 4**

(Submission deadline-11 Sept 2020, 5 PM)

1. For each of the following sets of reactions, describe reactor system and conditions to maximize the selectivity to D. The rates are in  $\text{mol}/(\text{dm}^3\cdot\text{s})$  and concentrations are in  $\text{mol}/\text{dm}^3$ .

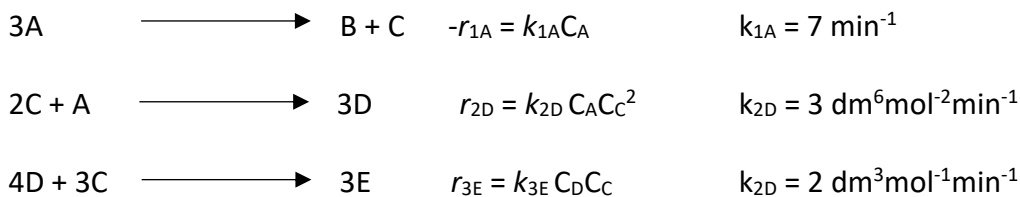
- (a) (1)  $A + B \rightarrow D$   $-r_{1A} = 10 \exp(-8000^\circ\text{K}/T) C_A C_B$   
 (2)  $A + B \rightarrow U$   $-r_{2A} = 100 \exp(-1000^\circ\text{K}/T) [C_A]^{1/2} [C_B]^{3/2}$
- (b) (1)  $A + B \rightarrow D$   $-r_{1A} = 100 \exp(-1000^\circ\text{K}/T) C_A C_B$   
 (2)  $A + B \rightarrow U$   $-r_{2A} = 10^6 \exp(-8000^\circ\text{K}/T) C_A C_B$
- (c) (1)  $A + B \rightarrow D$   $-r_{1A} = 10 \exp(-1000^\circ\text{K}/T) C_A C_B$   
 (2)  $B + D \rightarrow U$   $-r_{2A} = 10^9 \exp(-10000^\circ\text{K}/T) C_B C_D$

2. Under certain conditions, A decomposes as follows



R is to be produced from 1000 liter/hr of feed in which  $C_{A0} = 1 \text{ mol/liter}$ ,  $C_{R0} = C_{S0} = 0$ .

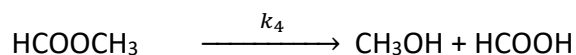
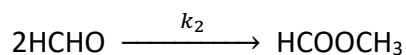
- (a) What size of plug flow reactor will maximize the concentration of R, and what is that concentration in the effluent stream from this reactor?
- (b) What size of mixed flow reactor will maximize the concentration of R, and what is  $C_{R,\text{max}}$  in the effluent stream from this reactor?
3. The following liquid-phase reactions were carried out in a CSTR at 325 K:



The concentrations measured inside the reactor were  $C_A = 0.1$ ,  $C_B = 0.93$ ,  $C_C = 0.51$ , and  $C_D = 0.049$  all in  $\text{mol}/\text{dm}^3$ .

- (a) What are the values of  $r_{1A}$ ,  $r_{2A}$ , and  $r_{3A}$ ?
- (b) What are the values of  $r_{1B}$ ,  $r_{2B}$ , and  $r_{3B}$ ?
- (c) What are the values of  $r_{1C}$ ,  $r_{2C}$ , and  $r_{3C}$ ?
- (d) What are the values of  $r_{1D}$ ,  $r_{2D}$ , and  $r_{3D}$ ?
- (e) What are the values of  $r_{1E}$ ,  $r_{2E}$ , and  $r_{3E}$ ?
- (f) What are the net rates of formation of species A, B, C, D and E?
- (g) The entering volumetric flow rate is  $100 \text{ dm}^3/\text{min}$  and the entering concentration of A is  $3 \text{ mol/liter}$ . What is the CSTR reactor volume?
- (h) What are the exit molar flow rates from the CSTR of volume obtained in (g)?

4. The complex reactions involved in the oxidation of formaldehyde to formic acid over a Vanadium titanium oxide catalyst are shown below. Each reaction follows an elementary rate law:



Let A = HCHO, B = O<sub>2</sub>, C = HCOOH, D = HCOOCH<sub>3</sub>, E = CO, W = H<sub>2</sub>O and G = CH<sub>3</sub>OH.

The entering flow rates are  $F_{A0} = 10$  mol/s and  $F_{B0} = 5$  mol/s, and  $v_0 = 100$  dm<sup>3</sup>/s. At a total entering concentration  $C_{T0} = 0.147$  mol/dm<sup>3</sup>, the suggested reactor volume is 1000 dm<sup>3</sup>.

Data available:

At 300 K,

$$k_1 = 0.014 \text{ (dm}^3\text{/mol)}^{1/2} \text{ s}^{-1}.$$

$$k_2 = 0.007 \text{ dm}^3\text{/(mol.s)}$$

$$k_3 = 0.014 \text{ s}^{-1}$$

$$k_4 = 0.45 \text{ dm}^3\text{/(mol.s)}$$

- Plot the molar flow rates of each species along the volume (length) of the reactor on the same figure.
- Plot and analyze  $\tilde{Y}_C$ ,  $\tilde{S}_{A/E}$ ,  $\tilde{S}_{C/D}$  and  $\tilde{S}_{D/G}$  along the length of the reactor. Find volume at which maximum occur, if any.