1. A first-order reaction $A \rightarrow B$ is taking place in a recycle reactor. The initial concentration is 4 mol/liter, the reactor volume is 200 liters and the volumetric flow rate is 20 liters/s. For a recycle ratio of 5, a conversion of 60% is obtained. This configuration is to be replaced with a CSTR-PFR combination. A 50-liter CSTR is followed by a PFR of unknown volume. What volume of PFR is required is achieve the same conversion as in the recycle reactor?

   17 points

2. Rate versus concentration data for a reaction is given below. Find the order of the reaction and the reaction rate.

Con. (mol/liter)	1.5	1.3	1.1	0.9	0.7	0.5	0.3
Rate (mol/lit-sec)	28	20	12.8	7.7	4.1	1.8	0.5

16 points

3. An elementary irreversible liquid-phase reaction $A + B \rightarrow C$ is carried out in a CSTR. A and B are fed at molar rates of 1.25 mol/s and 1 mol/s respectively, at a temperature of 300 K. The reactor is jacketed and the jacket temperature can be assumed to be 310 K. An agitator contributes a work of 20.9 kW to the reactor. The volumetric flow rate is 5 lit/s. Additionally:

$$H_A^0(298\,K) = -20\,\text{kcal/mol} \quad H_B^0(298\,K) = -25\,\text{kcal/mol} \quad H_C^0(298\,K) = -60\,\text{kcal/mol}$$

$$C_{pA} = C_{pB} = 40\ \frac{\text{cal}}{\text{mol}\cdot\text{K}},\ C_{pC} = 55\frac{\text{cal}}{\text{mol}\cdot\text{K}}$$

$$k = 0.01\frac{\text{lit}}{\text{mol}\cdot\text{s}}\ \text{at 300 K},\quad U\cdot A = 75\frac{\text{cal}}{\text{s}\cdot\text{K}},\ E = 8\ \text{kcal/mol}$$

Determine the volume of the reactor for 60% conversion of A.

17 points

4. Mechanism of a catalytic reaction $A \rightarrow B$ is shown below.

$$A + S \underset{k_{-A}}{\overset{k_A}{\rightleftarrows}} A \cdot S$$

$$A \cdot S \underset{k_{-S}}{\overset{k_S}{\rightleftarrows}} B \cdot S$$

$$B \cdot S \underset{k_{-D}}{\overset{k_D}{\rightleftarrows}} B + S$$

Write down the rates of adsorption, surface reaction and desorption and derive an effective rate when, surface reaction is rate controlling.

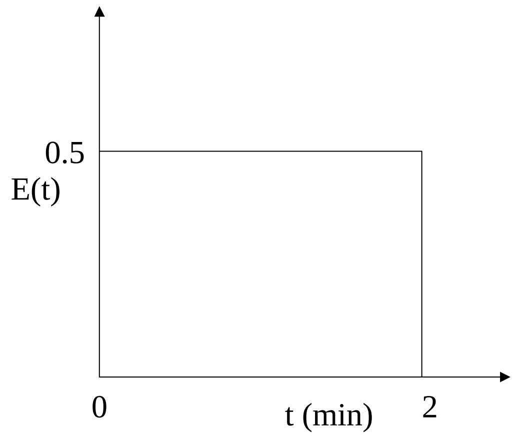
16 points

5. A first-order reaction $A \rightarrow 3B$ is taking place in a PBR. The particles are 10 mm in diameter and the intrinsic rate constant (k')is 0.8 lit/kg-cat-s. A conversion of 75% is desired. Feed at 4 mol/s, containing 40% A and 60% inerts enters the reactor at 127^0C and 5 atmospheres. The engineer designing the reactor neglects to consider that there might be internal diffusion to consider.
    a. What weight of the catalyst does the engineer pack the reactor with?
    b. If the diffusion coefficient is 0.08 cm^2/s ad bulk density of the catalyst is 2.8 kg/liter, what conversion would actually result with the catalyst packed?
    c. What weight of the catalyst did he need to use to meet the design specifications of 75% conversion?

    Assume that the reactor operates at constant pressure.

17 points

6. The residence time distribution function for a reactor is given below. The reaction is ½ order, C_{A0}= 1 mol/lit and the rate constant is $2\,\frac{mol^{1/2}}{lit^{1/2}-min}$. Determine the conversion in the reactor using the segregated-flow model.



17 points