

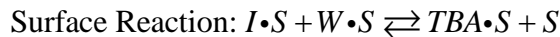
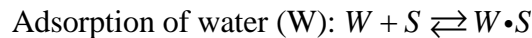
Last Assignment

Practice Problems

Please do not submit – solutions will be provided on 4/24.

1. The reaction $A \rightarrow B$ is taking place in a PBR at a pressure of 2 atmospheres and a temperature of 500 K. Pure A enters the reactor packed with catalyst spheres of 10 mm diameter at a molar rate of 2 mol/s. The diffusion coefficient is $0.25 \text{ cm}^2/\text{s}$. The rate is given by $r_A' = 6 C_A \frac{\text{mol}}{(\text{kg-cat})\text{-s}}$. The bulk density of the catalyst is 2.6667 kg/lit. What is the conversion when the bed is packed with 10 kg of the catalyst? What is the percentage decrease in conversion due to internal diffusion?

2. t-Butyl alcohol is produced by the liquid-phase hydration of isobutene. Water reacts with isobutene over an Amberlyst-15 catalyst. The reactions are:



- a. Write down the rates of all the individual reactions.
 - b. Obtain the concentrations of intermediates assuming that the surface reaction is the rate controlling step.
 - c. Substitute the concentrations from step b into the surface reaction rate and obtain the final form of the rate expression by performing a site balance.
3. A first-order, gas-phase reaction $A \rightarrow 2B$ is performed in a PBR at 400 K and 10 atm. Feed rate is 5 mol/s containing 20% A and the rest inerts. The PBR is packed with 8 mm-diameter spherical porous particles. The intrinsic reaction rate is given as: $r_A' = 3.75 C_A \text{ mol/kg(cat)-s}$. Bulk density of the catalyst is 2.3 kg/liter. The diffusivity is $0.1 \text{ cm}^2/\text{s}$. The pressure drop parameter alpha is found to be $9.8 \times 10^{-4} \text{ kg}^{-1}$.
 - a. What is the value of the internal effectiveness factor? What does it signify?
 - b. How much catalyst (kg) is required to obtain a conversion of 75% in the reactor?
 - c. Find the pressure at the exit of the reactor.
 4. A residence time distribution (in terms of reduced time $= \left(\frac{t}{\tau} \right) = \theta$) is given by:

$$E(\theta) = 15\theta^2 \exp(-2.5\theta)$$

Mean residence time is 3. The reaction is first order with a rate constant of 0.5 in consistent units. Find the conversion with the given RTD and segregated flow and compare it to conversions from a PFR and a CSTR. Comment on your results. Additional information.

$$\int_0^{\infty} ax^2 \exp(-bx) dx = \frac{2a}{b^3}$$

5. CDP 13-M from your text.