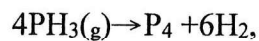




1. Please present the general mole balance equation and utilize it to derive the designed equations for the batch reactor, continuous stirred-tank reactor (CSTR), and plug-flow reactor, respectively, considering a first-order reaction occurring in these reactors. (20%)

2. The homogenous gas decomposition of phosphine:



proceeds at 1200°F with first-order rate,

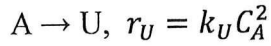
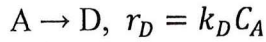
$$-r_{\text{PH}_3} = (10/\text{hr}) C_{\text{PH}_3}.$$

What size of plug-flow reactor (PFR), operating at 1200°F and 4 atm, is necessary to attain a 70% conversion of a feed comprising 5 lb-mol of pure phosphine per hour? Furthermore, if a continuous stirred-tank reactor (CSTR) is employed instead of a PFR, which reactor incurs a higher cost under the assumption of the same material cost per unit volume? (14%)

3. To produce 100 million pounds per year of ethylene glycol by hydrolyzing ethylene oxide (A), two continuous stirred-tank reactors (CSTRs) are employed and operated isothermally. Please demonstrate how to calculate the conversions for the two CSTRs arranged in series and in parallel, respectively, considering a first-order chemical reaction, and include the variables for the reactor volume (V) and the volumetric flow rate entering the reactor ( $v_0$ ). (16%)



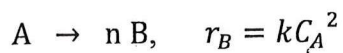
4. Substance A reacts to produce D (desired) and U (undesired), which reaction system is



In the viewpoint of the increase of the  $r_D/r_U$  ratio, which reactor, CSTR or PFR, should be chosen? Explain the reasons and suggest other ways to increase the  $r_D/r_U$  ratio besides the choice of the reactors. (15%)

5. A liquid-phase irreversible reaction ( $-r_A = kC_A^n$ ) was carried out in a CSTR. Pure substance A enters the reactor at a concentration of 1.5 M. The space time ( $\tau$ ) was varied and the effluent concentrations of substance A were recorded as followings: at  $\tau = 10$  min,  $C_A = 1$  M and at space  $\tau = 20$  min,  $C_A = 0.5$  M. Find  $n$  and  $k$ . (15%)

6. The liquid-phase reaction



reacts in two CSTRs in series (space time of the first CSTR  $\tau_1 = 10$  min, space time of the second CSTR  $\tau_2 = 7.5$  min,  $k = \text{constant}$ ). The change in volumetric flow rate is negligible. The pure A ( $C_{A0} = 1$  M and  $C_{B0} = 0$  M) is fed into the first CSTR and the compositions flowing out from the first CSTR and flowing into the second CSTR are  $C_A = 0.5$  M and  $C_B = 0.25$  M. What is the  $n$  value? What are  $C_A$  and  $C_B$  in the effluent flow from the second CSTR? (20%)