國立雲林科技大學 113 學年度 碩士班招生考試試題

系所：化材系

科目：化工動力學

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:

$$4PH_{3(g)} \rightarrow P_4 + 6H_2,$$

proceeds at 1200°F with first-order rate,

$$-r_{PH3} = (10/hr)\ C_{PH3}.$$

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%)

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

   $A \rightarrow D,\ r_D = k_D C_A$

   $A \rightarrow U,\ r_U = k_U C_A^2$

   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 (τ) 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

   $A \rightarrow n\,B, \quad r_B = kC_A{}^2$

   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 = 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%)