1. \[-R_A = 1/(10 \times X) \text{ mol/(liter-s)}\]
   where \[-R_A\] = rate of disappearance of \(A\), \text{ mol/(liter-s)}
   \[X = \text{ conversion} = 0.5\]
   \[F_{A0} = \text{ molar flow rate of } A \text{ fed to a system operated at steady state} = 10 \text{ mol/s}\]
   \[V = \text{ reactor volume, liter}\]
   
   (A) calculate the value of \(V\) for a CSTR \hspace{1cm} (10\%)
   (B) calculate the value of \(V\) for a PFR \hspace{1cm} (10\%)

2. Suppose that the stoichiometry of a reaction is:
   
   \[A \rightarrow B + C\]
   
   The reaction occurs by the following mechanism:
   
   \[(i) \quad A + A \xrightarrow{k_1} A^* + A\]
   \[k_1\]
   
   \[(ii) \quad A^* \xrightarrow{k_2} B + C\]

   If the life-time of \(A^*\) is extremely short and the concentration of \(A^*\) at any time is negligible, please derive an expression for the net rate of disappearance of \(A\) (i.e., \(-R_A = -dC_A/dt = ?\) where \(C_A\) is the concentration of \(A\) and \(t\) is the reaction time). \hspace{1cm} (10\%)

3. An ideal gas undergoes an isothermal, reversible compression in a frictionless piston-cylinder from 1 to 10 atm. Calculate the initial and final molar volumes of the gas and the work necessary to perform the compression if the gas is initially at 100°F. \((R = 0.73 \text{ atm-ft}^3/(\text{lb-mol} \cdot \text{R}) = 1.987 \text{ Btu/(lb-mol} \cdot \text{R})\) \hspace{1cm} (20\%)

- \[\text{命題用紙}\]
- 第1頁共 2 頁
4. a) Define the general characteristics of an equilibrium state. (5%)

b) Define excess mixing fugacity. (5%)

c) Define van der Waals equation of state and the physical meaning of parameters a and b in the equation. (5%)

5. The activity coefficient ($\gamma_i$) of component 1 in a binary mixture can be expressed in terms of the mole fraction ($X_i$):

   $$\ln \gamma_i = aX_i^2 + bX_i^3 + cX_i^4$$

   a, b, and c are constants independent of concentration. Please express d, e, f, and g in terms of constants (a, b, c) if the activity coefficient of component 2 ($\gamma_2$) is:

   $$\ln \gamma_2 = dX_1^2 + eX_1^3 + fX_1^4 + gX_1^5$$  (15%)

6. For the irreversible aqueous-phase reaction

   $$A \rightarrow 2B$$

   The initial concentration of A is 0.2 M, and the volumetric flow rate is 50 dm$^3$s$^{-1}$. The reaction rate follows:

   For $X \leq 0.5$ : $-\gamma_A^{-1} = 4.0$ sM$^{-1}$

   For $X > 0.5$ : $-\gamma_A^{-1} = 4.0 + 10(X - 0.5)$ sM$^{-1}$

   a) What conversion will be achieved in a CSTR that has a volume of 20 dm$^3$? (5%)

   b) What conversion will be achieved in a CSTR that has a volume of 32 dm$^3$? (5%)

   c) What plug-flow reactor volume is required to achieve 70% conversion? (5%)

   d) What CSTR reactor volume is required if the effluent from the PFR in part (c) is fed to a CSTR to raise the conversion to 90%? (5%)