A. Briefly cite the difference between "space time" and "holding time"?

B. Consider the ideal MFR (mixed flow reactor) (volume = 10 liter). The gas-phase reaction $2A \rightarrow 4B$ is carried out isothermally as follows. Find the space time and holding time of MFR for 50% conversion of a feed stream of 1 liter/min contains 2 mol A/liter, the other inert 2 mol/liter. (20 points)

The kinetics of the aqueous-phase decomposition of A is investigated in two mixed flow reactors in series, the second having twice the volume of the first reactor. At steady state with a feed concentration of 1 mol A/liter and mean residence time of 96 sec in the first reactor, the concentration in the first reactor is 0.5 mol A/liter and in the second is 0.25 mol A/liter. Find the kinetic equation for the decomposition. (15 points)

A. The rate of reaction is given in following figure, what size of mixed flow reactor is needed for 80% conversion of a feed stream of 1000 mol A/hr at $C_{A0} = 1.0$ mol/liter?

B. Repeat part A) with the modification that the feed rate is doubled, thus 2000 mol A/hr at $C_{A0} = 1.0$ mol/liter are to be treated.

C. What is the minimum size setup without recycle? (Hint: two flow reactor in series) (15 points)

\begin{center}
\includegraphics[width=0.5\textwidth]{figure.png}
\end{center}
四、At moderate pressures the volumetric equation of state for nitrogen may be written as \( PV = RT + BP \), where \( P \) is pressure, \( V \) is molar volume, \( T \) is temperature, \( R \) is gas constant, and coefficient \( B \) is a function of temperature only.

(a) Nitrogen at 30 bar and 300 K passes through a heater-expander and emerges at 20 bar and 400 K, and there is no flow of work into or out of the heater-expander. Compute the flow of heat into the heater-expander per mole of nitrogen (10 %) and what will be the entropy change for the nitrogen (5 %)?

(b) Nitrogen at 30 bar and 300 K passes through a heater-expander and emerges at 20 bar and 300 K, and there is no flow of work into or out of the heater-expander. What will be the fugacity of the inlet and outlet nitrogen (5 %) and what will be the Gibbs free energy change for the nitrogen (5 %)?

The data for nitrogen are given below:

(1) \( B(\text{cm}^3/\text{mol}) \) at 300 K = 4.2, \( B(\text{cm}^3/\text{mol}) \) at 400 K = 9.0

(2) \( d\ln B/dT = 0.132 \text{ cm}^3/\text{mol-K} \)

(3) Constant-pressure heat capacity for nitrogen when it is assumed as ideal gas

\[ C_p = 30 \text{ J/mol K} \]

五、Joule-Thomson coefficient is defined as \( \mu = \left( \frac{\partial T}{\partial P} \right)_H \)

(a) Derive that \( \mu = -\frac{1}{C_p} \left[ \left( \frac{\partial H}{\partial P} \right)_T \right] \) (5 %)

(b) For nitrogen at 300 K, \( \mu = 0.146 \text{ K/bar} \) and \( C_p = 30 \text{ J/mol K} \), what will be the enthalpy change for nitrogen compressed from 1 bar, 300K to 30 bar, 300K? (3 %) Is the nitrogen here an ideal gas, why? (2 %)

六、In a chemical process, the equilibrium constant at 1 bar and temperature \( T \) can be expressed as \( K = 1.25 \exp(0.35T) \). What is the expression of Gibbs free energy change, enthalpy change and entropy change at 1 bar and temperature \( T \) in this process? (15%)

\[ \Delta G = -RT \ln K \]

\[ \Delta H = \int_C \left( \frac{\partial Q}{\partial T} \right)_P \]

\[ \Delta S = \int_C \left( \frac{\partial Q}{\partial T} \right)_P \]

\[ K = \frac{\exp(-\Delta G/RT)}{\exp(-\Delta H/RT)} \]