1. The mechanism of the reaction

\[ H_2 + Br_2 \rightleftharpoons 2HBr \]

was proposed as the following steps

- **Initiation**: \[ Br_2 \xrightarrow{k_1} 2Br \quad \Delta H_f = 46.1 \text{ kcal/mole} \] (1)
- **Propagation**: \[ Br + H_2 \xrightarrow{k_2} H + HBr \quad \Delta H_f = -6.1 \text{ kcal/mole} \] (2)
\[ H + Br_2 \xrightarrow{k_2} Br + HBr \] (3)
\[ H + HBr \xrightarrow{k_2} Br + H_2 \] (4)
- **Termination**: \[ 2Br \xrightarrow{k_2} Br_2 \] (5)

Prove that the reaction rate can be fitted as

\[
\frac{d[HBr]}{dt} = \frac{k[H_2][Br_2]}{1 + k'[HBr][Br_2]} \quad (15\%)
\]

2. For the decomposition \( A \rightarrow R \), \( C_{A0} = 1 \text{ mol/liter} \), in a batch reactor conversion is 75% after 1 hour, and is just complete after 2 hours. The rate equation can be expressed as \( -r_A = kC_A^n \), find \( k \) and \( n \). (15%)

3. Consider an isothermal single-phase flow reactor operating at steady-state and constant pressure. Given a gaseous feed, \( C_{A0} = 200, C_{B0} = 100, A + B \rightarrow R, C_B = 50 \). Find the conversion \( X_A, X_B \) and the concentration \( C_A \). (15%)

4. Reaction \( A \rightarrow R \), second-order kinetics and \( C_{A0} = 1 \text{ mol/liter} \), we get 50% conversion after 1 hour in a plug flow reactor. What will be the conversion and concentration of \( A \) after 1 hour if \( C_{A0} = 10 \text{ mol/liter} \)? (15%)

5. In an aqueous feed stream (25 liter/min) with reactant \( A \) (\( C_{A0} = 2 \text{ mol/liter} \)) the kinetics of the fermentation at a given enzyme concentration is given by

\[
A \xrightarrow{\text{mech}} R, \quad -r_A = \frac{0.1C_A}{1 + 0.5C_A} \quad \text{mol/liter-min}
\]

Find the conversion of \( A \) in the exit stream of a 500 liter mixed flow reactor. (15%)

6. Reactant \( A \) (\( A \rightarrow R, C_{A0} = 10 \text{ mol/liter} \), \( -r_A = 0.5 C_A \text{ mol/liter-min} \)) passes through 2 equal-sized mixed flow reactors in series. When steady state is achieved \( C_A \) is found to be 1 mol/l, what must be the space time \( \tau \) for each mixed flow reactor? (15%)

7. For a reaction \( A \rightarrow R \) with \( -r_A = kC_A \) is proceeded in \( N \) equal-sized mixed flow reactors, when \( N \rightarrow \infty \) prove that \( \text{Nr} = \frac{1}{k \ln \frac{C_0}{C}} \), where \( \tau_i \) is the space time for each single mixed flow reactor, \( C_0 \) is the initial concentration of \( A \) and \( C \) is the final concentration of \( A \). (10%)