1. An aqueous reactant stream (8 mol A/liter) passes through a mixed flow reactor followed by a plug flow reactor. Find the concentration at the exit of the plug flow reactor if n the mixed flow reactor C_A = 2 mol/liter. The reaction is second-order with respect to A. and the volume of the plug flow unit is three times that of the mixed flow unit. (15%)

2. The elementary liquid-phase-series reaction $A \xrightarrow{k_1} R \xrightarrow{k_2} S$ is carried out in a batch reactor with the initial concentration, C_{A0}. The desired product is R and its reaction rate can be expressed as $r_R = k_1 C_A - k_2$. Find the maximum concentration of R. (15%)

3. The elementary irreversible liquid-phase reaction, $A + B \rightarrow C$, is carried out in a mixed flow reactor. An equal molar feed in A and B enters at 27°C, and the volumetric flow rate is 2 dm^3/s and C_{A0} = 0.5 $kmol/m^3$.
   (a) Determine the reactor volume to achieve 85% conversion when operated adiabatically. (10%)
   (b) Calculate the reactor volume to achieve the same conversion with heat exchanger, where U is 100 $cal/s \cdot m^2 \cdot K$ and the heat-transfer area is 0.21m^2. The coolant fluid is kept at 27°C. (10%)

   Additional information:
   H_A(273K)= – 20 kcal/mol, H_B(273K)= – 15 kcal/mol, H_C(273K)= – 41 kcal/mol
   $C_{PA} = C_{PB}$ = 15 cal/mol·K, C_{PC} = 30 cal/mol·K, k = 0.01 dm^3/mol·s at 300K, E =10 kcal/mol.

4. One mole of an ideal gas for which C_v = 25.10 $J.mol^{-1}.K^{-1}$ expands adiabatically from an initial state at 340 K and 5 bar to a final state where its volume has doubled. Please find the final temperature of the gas, the work done and the entropy change of the gas, for (a) a reversible expansion and (b) a free expansion of the gas into an evacuated space (*Joule expansion*). (20 %)

5. A liquid mixture of species **1** and **2** for which x_1 = 0.6 is in equilibrium with its vapor at 144 °C. Please calculate the equilibrium pressure (*P*) and the composition (y_1) of vapor phase from the following information: (15 %)

   * $\ln\gamma_1 = Bx_2^2$, $\ln\gamma_2 = Bx_1^2$
   * $P_1^{sat} = 75.20$, $P_2^{sat} = 31.66$ kPa (at 144°C)
   * The system forms an azeotrope at 144°C for which $x_1^{az} = y_1^{az} = 0.294$

6. A steam of air at atmospheric pressure is cooled continuously from 38°C to 15 °C. The volumetric flow is 0.5 $m^3.s^{-1}$ (as measured at 101.33 kPa and 25 °C). The temperature of the ambient air to which heat is discarded is 38°C. What is the minimum power requirement of a mechanical refrigeration system designed to accomplish the necessary cooling? Assume air as an ideal gas with C_p = (7/2)R. (15%)