1. An ideal gas (C_p = 30 kJ/kmol·K) enters a blower at 20°C with a rate of 1 kmol/sec, where it is compressed adiabatically from 1 to 2.5 bar. And the gas leaves the blower at 135°C. Please calculate
   (a) The power supplied to the blower. (8%)
   (b) The efficiency of the blower based on an adiabatic reversible compression between the same initial and final pressures. (10%)

2. For a binary solution system, A and B, composed of nearly pure component B (liquid molar fraction of x_B is close to 1, but not equal), this solution system is in equilibrium with a vapor phase containing both components. The pressure of this liquid-vapor phase system is 2 bar; the temperature is 298K; Henry's constant of component A is 600 bar; and the saturated vapor pressure of component B is 0.2 bar. Please estimate the liquid molar fraction (x_A) and vapor molar fraction (y_A), respectively. Describe your assumptions, if necessary. (16%)

3. One mole of a gas mixture (25 mol% of methane and 75 mol% of helium) at 400K and 10 bar flows into a two-product stream separation device, which is an adiabatic process. One product stream contains 98 mol% of helium and 2 mol% of methane at 333K and 15 bar. The other contains 85 mol% of methane and 15 mol% of helium at 308K and 1 bar. Assume that helium and methane are ideal gases with $C_{p,helium} = (5/2)R$ and $C_{p,methane} = (9/2)R$, respectively. This process can generate work.
   (a) Please calculate the total change in entropy. (12%)
   (b) Please determine whether the process violates the second law of thermodynamic. (4%)

4. The parallel reactions take place in the liquid phase,

$$A \xrightarrow{k_1} B$$

$$A \xrightarrow{k_2} C$$

   where the first reaction is zero-order with k_1 = 3 M/min and the second reaction is first order with $k_2 = 2\ \text{min}^{-1}$. The concentration of A in the feed is 5 M and the conversion of A is 80%.
   (a) Determine the selectivity of forming B in a CSTR. (7%)
   (b) If the reaction occurs in a PFR, calculate the selectivity of forming B. (8%)

5. One elementary reversible liquid-phase reaction $A \rightleftharpoons B$ is carried out adiabatically. The feed rate of pure A is 150 kmol/h at a concentration of 9.2 kmol/m^3. The feed enters at 330K. Shaft work is neglected. Calculate the CSTR volume to achieve 80% conversion of A.
Additional information: (15%)
   - Specific reaction rate at 330K: 10.5 h^{-1}
   - Activation energy: 70.2 kJ/mol
   - Heat of reaction at 360K: – 6000 J/mol A
   - Equilibrium constant (K_C) at 360K: 5.8
   - Heat capacity of A: 100 J/mol·K
   - Heat capacity of B: 100 J/mol·K

6. One first-order exothermic reaction is taking place in the steady-state operation of a CSTR with a heat exchanger. There will be multiple steady states at which the reactor may operate.
(a) Draw the conversion-temperature plot to interpret multiple steady-states? (3%)
(b) What is thermal runaway? (3%)
(c) Based on the plot of (a), plot the ignition-extinction curve. (4%)

7. For a heterogeneous catalytic reaction, the reactant concentration profile in a catalyst pellet is closely related to the Thiele modulus, ϕ.
(a) Interpret the physical meaning of Thiele modulus. (3%)
(b) What is the internal effective factor? (3%)
(c) For a first order reaction in a catalyst sphere, the internal effective factor can be expressed as $\frac{3}{\phi_1^2}(\phi_1 coth\ \phi_1 - 1)$, discuss the relationship between the internal effective factor and the size of the catalyst for the large and small values of Thiele modulus. (4%)