1. Sketch a typical P_{xy} diagram for a binary solution. In doing this, you may take acetonitrile (A) and nitromethane (B) at 75℃ as an example. The vapor pressures of A and B are: P_A = 83.21 kPa and P_B = 41.98 kPa. Imagine a subcooled liquid mixture of 60% A and 40% B existing in a piston/cylinder arrangement at 75℃. The pressure of the system is reduced slowly (so that the system is always in equilibrium at 75℃) until the liquid mixture becomes a superheated vapor. Indicate the path of this process on your P_{xy} diagram. According to your diagram, what are the compositions of the first bubble and the last liquid drop in this process? (13%)

2. At 35℃ a liquid solution containing 40.5 mol% ethanol and 59.5 mol% methylcyclohexane exerts a pressure of 152.4 mmHg. The vapor phase composition is 54.7 mol% ethanol and 45.3 mol% methylcyclohexane. The vapor pressures of the pure compounds at 35℃ are as follows：

   Ethanol：103.1 mmHg

   Methylcylohexane：73.6 mmHg

   Estimate the mol fraction of ethanol in the vapor phase in equilibrium with a liquid phase containing 60 mol% ethanol at 35℃ (20%)

   The van Laar equations, i.e.,

   $\ln \gamma_1 = A'_{12}\left(1 + A'_{12}X_1/A'_{21}X_2\right)^{-2}$

   $\ln \gamma_2 = A'_{21}\left(1 + A'_{21}X_2/A'_{12}X_1\right)^{-2}$

   are applicable for obtaining the activity coefficients.

3. An ideal gas with C_p = 29.3 kJ/kmol·K undergoes the following three-step process:

   Step 1: The gas is heated at constant volume from 300 K and 0.1 MPa until the pressure reaches 0.2 MPa.

   Step 2: The gas is expanded adiabatically and reversibly to a pressure of 0.1 MPa

   Step 3: At a constant pressure of 0.1 MPa, the gas is cooled to 300 K.

   Determine the heat and work effects for each step (18%, 6% each) and an efficiency defined as the ratio of work done to heat supplied (3%).

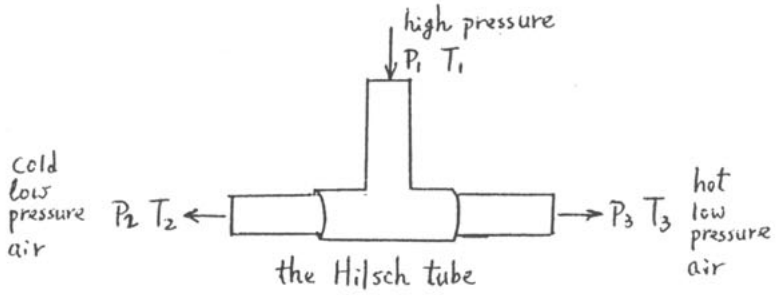
4. For a reversible adiabatic process involving an ideal gas with constant c_p we can derive the expression

$$\frac{T_2}{T_1} = \left[\frac{P_2}{P_1}\right]^{\frac{\gamma-1}{\gamma}}$$

   Using the same derivation procedure, please give an equivalent expression for an ideal gas with a varying heat capacity, $C_p = a + bT + T^2$. (12%)

(背面仍有題目,請繼續作答)

5. A salesman offered a Hilsch tube, a device that splits a stream of high-pressure air (P_1 = 1.5 bar, T_1 = 27 °C) into two equimolar streams, one hot and the other cold, both at lower pressure ($p_2 = p_3$ = 1 bar). The device is well insulated. The salesman claims that the cold air is at –123 °C. Would you please determine whether his claim violate the laws of thermodynamics. (heat capacity of air c_p = 29.1 J/mol-K; R = 8.314 J/mol-K; the air is assumed to be an ideal gas) (17%)



6. The properties of saturated steams at 360 °F and 212 °F are listed as follows:

T (°F)	P (psia)	V (ft^3/lbm)		H (Btu/lbm)		S (Btu/lbm·°R)	
		V^l	V^g	H^l	H^g	S^l	S^g
360	153.01	0.01811	2.939	332.31	1194.4	0.5161	1.5678
212	14.696	0.01672	26.80	180.17	1150.5	0.3121	1.7568

(a) A two-phase system of liquid water and vapor in equilibrium at 153.01 psia consists of equal volumes of liquid and vapor. If the total volume is 12 ft^3, what is the total enthalpy and what is the total entropy? (6%)

(b) A rigid vessel contains 1 lbm of saturated vapor at 360 °F. Heat is removed from the vessel and the system reaches equilibrium at 212 °F. What is the entropy change of the water? (6%)

(c) Show from the data above that, at any temperature, the value of the Gibbs energy is the same for both saturated liquid and vapor. (5%)

(0 °F = 459.6 °R)