1. The van der Walls equation of state is

   $(P+\frac{a}{V^2})(V-b)=RT$, where *a, b, R* are constant.

   When you solve the van der Waals equation at a given temperature T_A, you obtain a P-V curve shown in Figure 1.

   (a) How can you modify this curve to remove the portion of CDE that shows no physical significance? (5%)

   (b) Let P_A be the pressure under which liquid and vapor are in equilibrium at T_A, show that $P_A = \frac{1}{V_F - V_B}\left[RT_A \ln\frac{V_F - b}{V_B - b} + a\left(\frac{1}{V_F} - \frac{1}{V_B}\right)\right]$ (15%)

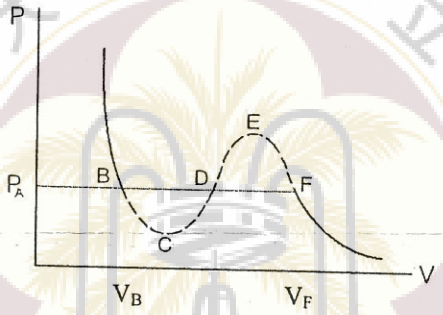

Figure 1

2. One mole of a monatomic ideal gas undergoes a reversible expansion at constant pressure during which the entropy of the gas increases by 14.41 J/K and the gas absorbs 6236 joules of heat. Note the constant-volume heat capacity of the gas is 1.5R, where R is the gas constant = 8.314 J/(mole K)

   (a) Calculate the initial and final temperatures of the gas. (10%)

   (b) Calculate the work done by the gas during this expansion. (10%)

3. Assume Cu and Ni form an ideal solid solution at 727℃, calculate the equilibrium composition of a Cu-Ni alloy (in wt%) capable of existing in equilibrium with Cu_2O and NiO at 727℃ from the following data:

   At 727℃ $\Delta G^0_{Cu_2O} = -18230 cal/mol$, $\Delta G^0_{NiO} = -30150 cal/mol$, and atomic weights of Cu and Ni are 63.54 and 58.7, respectively.
   The gas constant R = 1.987 cal/(mole K) (20%)

4. Figure 2 shows an A-B binary phase diagram. The solubility of B in α and β phase at T_1 is $N_B^*(\alpha)$ and $N_B^*(\beta)$, respectively. Assume both α and β phases are dilute solutions; thereby, the solute obeys the Henry's law and the solvent obeys the Raoult's law. Find the Henrian activity coefficient of B. (20%)

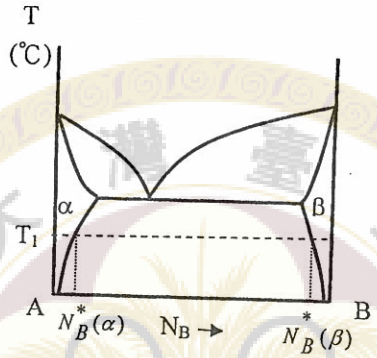

Figure 2

5. True or false. Reason or prove your answer. (20%)
   (a) The sign of $(\Delta S_{system} + \Delta S_{surrounding})$ for the mixing of two different ideal gases in an adiabatic enclosure is positive.
   (b) Trouton's rule (the molar entropy of boiling of a liquid metal is 88 J/K) generally applies with better accuracy than Richards' rule (the entropy of fusion of a metal is 8.4 J/K).
   (c) For a binary alloy, the solubility of a stable phase is generally higher than the solubility of a metastable phase.
   (d) The compressibility factor, $Z = \frac{PV}{RT}$, of a real gas generally increases with increasing pressure.

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