1. (1) State van der Waals equation of state for a real gas. (5%)

   (2) Give a physical interpretation of the equation.(5%)

   (3) Express the constants in terms of the critical data T_c, V_c, and P_c. (10%)

2. Consider the dilute solid solution of A in B.   (1) Prove that if the solute obeys Henry's law then the solvent obeys Raoult's law. (10%) (2) Prove that complete insolubility is not possible.   State any assumptions you make in the proof. (10%)

3. (1)Show that $\left(\dfrac{\partial T}{\partial P}\right)_S = \dfrac{T}{c_P}\left(\dfrac{\partial V}{\partial T}\right)_P$ (10%)   (2) Derive the following equation and fill the blank in the equation $\left(\dfrac{\partial H}{\partial V}\right)_T = -V^2\left(\dfrac{\partial P}{\partial T}\right)_V\left(\dfrac{\partial (\ )}{\partial V}\right)_P$ (10%)

4. The activity coefficient of component A in a binary solution is known to be of the form

   $\exp\dfrac{C(1-2x+x^2)}{T}$, where C is a constant and x is the mole fraction of A.

   (1) Write out the partial molar free energy for component A.(5%)

   (2) Starting from (1), derive the partial molar free energy of component B.(5%)

   (3) Derive the molar Gibbs free energy of mixing, as well as the molar entropy and enthalpy change of mixing.(5%)

   (4) If mixing is exothermic, draw the vapor pressure ratio for A as a function of the composition.(5%)

5. The vapor pressure (in mm Hg) of solid ammonia is given by

   $$\ln p = 23.03 - \frac{3754}{T},$$

   that of liquid ammonia by

   $$\ln p = 19.49 - \frac{3063}{T}.$$

   (1)What is the normal boiling temperature of ammonia? (5%)

   (2)What is the temperature and pressure at the triple point? (5%)

   (3) Find the heat of sublimation and vaporization at the triple point. (10%)

   (1 atm = 760 mm Hg)