1. One mole of superheated water at 110°C and at 1 atm is evaporated to steam at the same temperature and pressure. Assume that:

   (i) In the pressure range 1 atm to 1.4 atm the entropy of liquid water at 110°C can be considered constant.

   (ii) At 110°C liquid water and steam are in equilibrium at a pressure of 1.4 atm, and the latent heat of evaporation under these conditions is 4×10^4 J/mol.

   (iii) In the pressure range 1 atm to 1.4 atm water vapor at 110°C behaves as an ideal gas.

   (a) Calculate the change in entropy. (10%)

   (b) Calculate the error introduced by the last assumption if in the range 1 atm to 1.4 atm and at 110°C on has, for one mole of steam,

$$\left(\frac{\partial V}{\partial T}\right)_P = \frac{R}{P} + 0.46 \text{ cm}^3/\text{K} \quad (10\%)$$

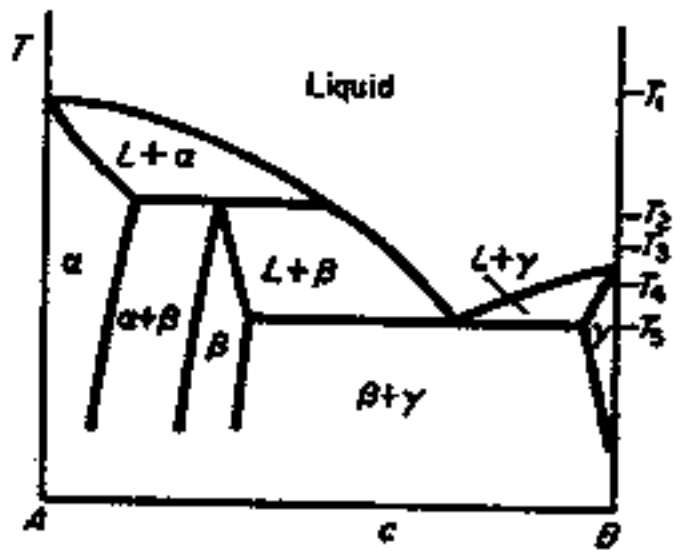
2. Derive the following equations related to the internal energy U.

   (a) $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$ (5%)

   (b) $\left(\frac{\partial U}{\partial T}\right)_P = c_P - PV\alpha$ where α is the thermal expansion coefficient (5%)

   (c) Prove $\left(\frac{\partial U}{\partial P}\right)_T = 0$ for one mole of an ideal gas. (10%)

3. Consider a binary alloy system. Sketch the molar free energy vs. composition curve for a system which shows insolubility at the temperatures specified (from T_1 to T_5 in the phase diagram shown below).(20%)



4. For a van der Waals gas $P=\frac{RT}{V-b}-\frac{a}{V^2}$, calculate the change in the Gibbs free energy and the change in entropy, when the volume of one mole of the gas is increased from V_1 to V_2 at a temperature T. (20%)

5. The molar excess Gibbs free energy of formation of solid solution in the system Au-Ni can be represented by

$$G^{XS}=X_{Ni}X_{Au}(24{,}140X_{Au}+38{,}280X_{Ni}-14{,}230X_{Au}X_{Ni})(1-\frac{T}{2660})J$$

Calculate the activities of Au and Ni in the alloy of $X_{Au}=0.5$ at 1100 K. (20%)