國　立　清　華　大　學　命　題　紙

九十三學年度＿工程與系統科學＿系（所）＿甲＿組碩士班入學考試

科目　材料熱力學　科號 3802　共 二 頁第 一 頁 *請在試卷【答案卷】內作答

1. In a monatomic crystalline solid each atom can occupy either a regular lattice site or an interstitial site. The energy of an atom at an interstitial site exceeds the energy of an atom at a lattice site by an amount ε. Assume that the number of interstitial sites equals the number of lattice sites, and also equals the number of atoms N. (a) Calculate the entropy of the crystal in the state where exactly n of the N atoms are at interstitial sites.(10%) (b) What is the temperature of the crystal in this state, if the crystal is in thermal equilibrium?(10%) (c) If ε = 1 eV and the temperature of the crystal is 300 K, what is the fraction of atoms at interstitial sites? (10%)

   (Boltzmann constant k = 8.62×10^{-5} eV/K)

   Stirling's approximation $\ln n! = n \ln n - n$ for n>>1

   Boltzmann equation $S = k \ln \Omega$, S: entropy, k: Boltzmann constant, and Ω: number of arrangements.

2. There are a few phase transition in iron:

   (a) Below 900°C and above 1400°C, α- and δ-iron with BCC crystal structure are the stable phases, respectively.

   (b) Between these temperatures, γ-iron with FCC crystal structure is stable.

   (c) The specific heat of each phase may be taken as constant:

   $C_\alpha = C_\delta = 0.775$ J/g·K; $C_\gamma = 0.690$ J/g·K.

   What is the latent heat at each transition? (20%)

3. The phase diagram for the system Cd-Bi is shown in Fig. 1; Cd is virtually insoluble in solid Bi, and the maximum solubility of Bi in solid Cd is 2.75 mole percent at the eutectic temperature of 419 K.

   (a) If the liquid solutions are ideal and the small solid solubility of Bi in Cd is ignored, calculate the Bi liquidus and Cd liquidus.(10%)

   Heat of fusion for pure Bi = 10,900 joules

   Heat of fusion for pure Cd = 6400 joules

   Melting point for Bi = 544 K

   Melting point for Cd = 594 K

   $c_{p,Bi(s)} = 18.8 + 22.6 \times 10^{-3} T$ J/mole·K

   $c_{p,Bi(l)} = 20 + 6.15 \times 10^{-3} T + 21.1 \times 10^{5} T^{-2}$ J/mole·K

   $c_{p,Cd(s)} = 22.2 + 12.3 \times 10^{-3} T$ J/mole·K

   $c_{p,Cd(l)} = 29.7$ J/mole·K

   Gas constant R = 8.314 J/mole·K

   (b) The actual eutectic composition is X_{Cd}=0.55, X_{Bi}=0.45. Calculate the activity coefficients for both components in the eutectic melt.(10%)

(c) In Figure 1, the actual liquidus lines (line (ii)) lie above those calculated (line (i)), why?(positive or negative deviation?)(10%)

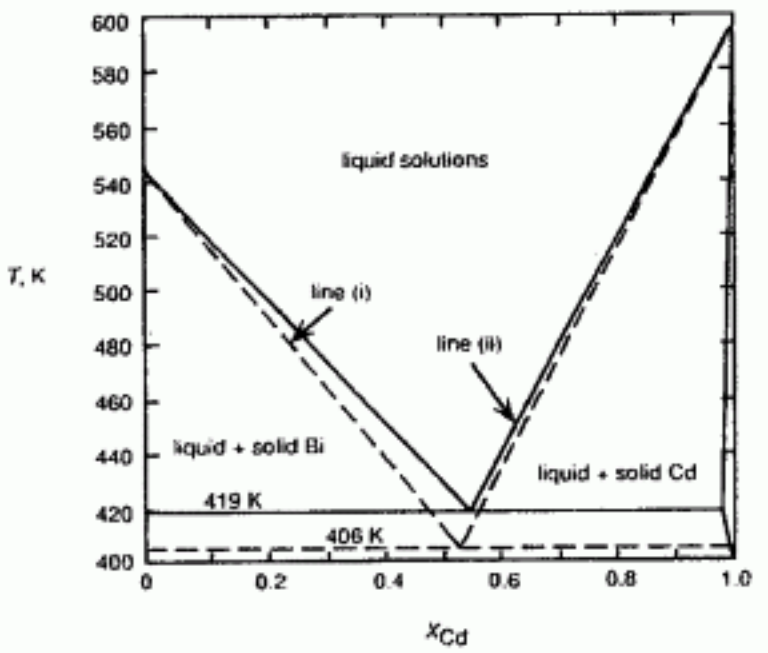

Fig. 1

4. Regular solution model is the most popular one among the solution models. The central idea of the regular solution model is to introduce the interaction between solution components into the solution model and thereby relating the activity coefficient with the formation enthalpy of solution. By this way, the model can predict the critical state that a binary solution has an immiscicible region (two-phase coexistence). However, in the regular solution model, the parameter α (α function) does not have a clear physical significance, which was later given by the quasi-chemical solution model. Answer the following questions about regular solution model. (a) What is the definition of regular solution? (5%)(b) Using quasi-chemical model to explain the physical significance of α in the regular solution model. (5%)(c) Derive the critical state of regular solution occurs at $\alpha = 2$.(10%)