國立清華大學 104 學年度碩士班考試入學試題

系所班組別：工科與系統科學系　甲組

考試科目（代碼）：材料熱力學 (2502)

1. One mole of iron, initially at a uniform temperature of 0 ˚C, is brought in thermal contact with another mole of iron, initially at a uniform temperature of 100 ˚C. The total system, consisting of two moles of iron, is contained adiabatically and kept at constant pressure while it comes to equilibrium. **(Total 21%)**

   (a) Compute the final temperature of the system. The isobaric heat capacity of iron is given by **(6%)**

   $$C_p(T) = 37.12 + 6.17 \times 10^{-3} T \text{ J/(molK)}$$

   (b) Is the final temperature equal to the average of the initial temperatures? Explain your answer. **(4%)**
   (c) Calculate the amount of heat transferred from the hot piece to the cold piece. **(5%)**
   (d) Compute the amount of entropy that is produced in this process. **(6%)**

2. Please answer the following questions. **(Total: 18%)**

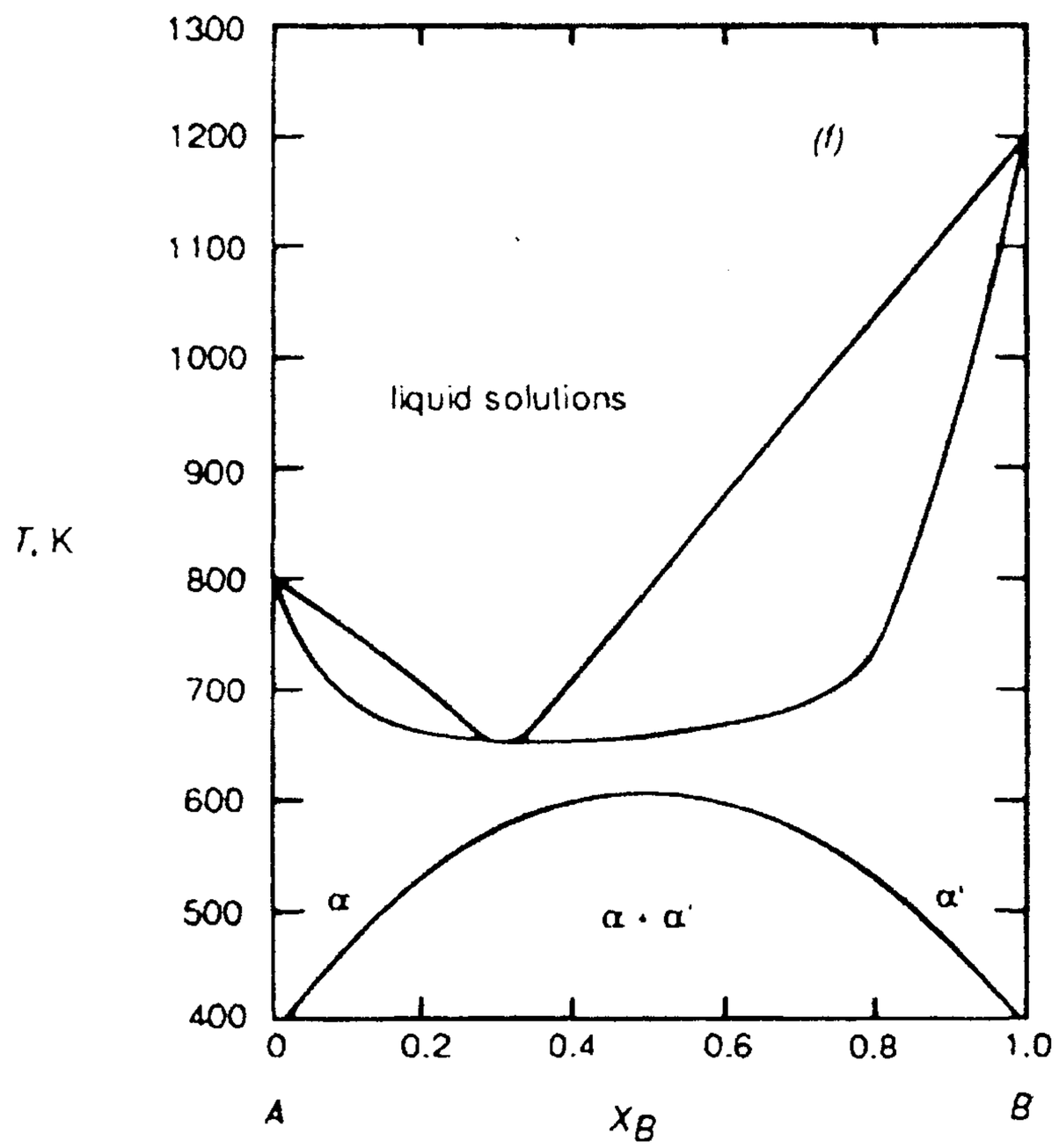
   (a) At 700K, the activity of Ga in a liquid Ga-Cd solution of composition X_{Ga}=0.5 has the value 0.79. On the assumption that liquid solutions of Ga and Cd exhibit regular solution behavior, estimate the energy of the Ga-Cd bond in the solution, The molar enthalpies of evaporation of liquid Ga and liquid Cd at their melting temperatures are, respectively 270000 and 100000 J. The coordination numbers of liquid Cd and liquid Ga are, respectively, 8 and 11 at their melting temperature. **(7%)**

   (b) Based on the information above, when the temperature of solution **increases,**

   (i) What would you expect the solution tend to become? Ordering, clustering or random mixing? Please use ΔH^M v.s. probability of Ga-Cd bond to explain your answer. **(5%)**

   (ii) How does the activity coefficient of Ga (γ_{Ga}) change? Will the partial enthalpy of mixing of Ga $\overline{(\Delta H_{Ga}^M)}$ be endothermic or exothermic? **(6%)**

3. For a hypothetical A-B binary phase diagram shown as below , which forms regular solid solution in which Ωs=10000 J and regular liquid solution in which Ωs=-2000 J. **(Total: 20%)**

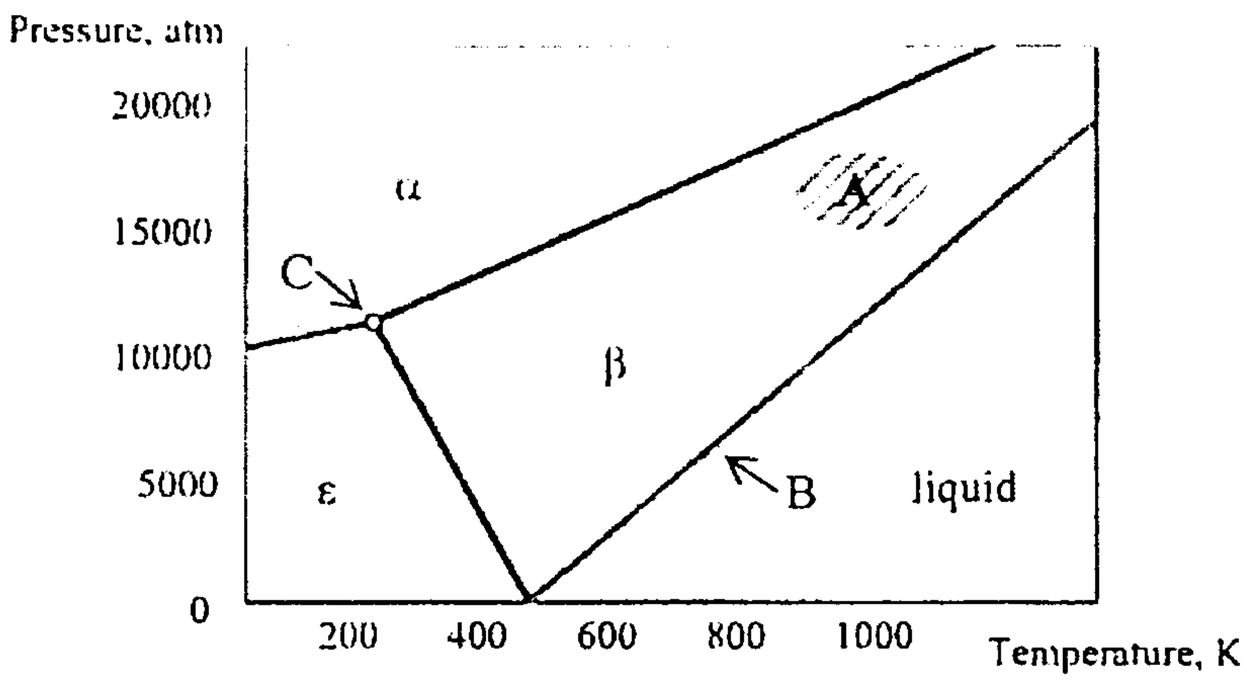


(a) List the composition and temperature of ALL of the invariant points, congruent points, monotectics, and miscibility gaps shown in the phase diagram abovle and what kind of reaction it is. (4%)

(b) Plot the Gibbs free energy of mixing v.s. composition for temperature 700K and 500K, respectively. (8%)

(c) Plot the activity v.s. composition for temperature 700K and 500K, respectively. (8%)

4. Based on the schematic phase diagram for thallium given below, please answer the following questions. **(Total: 21%)**



(a) List the phases α, β,ε and liquid in the order of increasing density. (8%)
(b) Sketch the Gibbs free energies of all phases as function of temperature at a pressure of 5000 atm and as function of pressure at temperature of 300 K. (8%)
(c) An experimental work has been reported that a new phase (γ) was found to coexist in equilibrium with α, β and ε phases at a particular set of conditions. What is your opinion about this report? (5%)

5. Derive the equation **(6%)**

$$dS = \frac{c_p}{T} dT - V\alpha dP$$

6. A gas mixture initially containing 90% CO, 0.4% COS, and 9.6% inert constituents (by volume) is passed over sponge iron at 1000K to remove sulfur by the following reaction: **(Total 14%)**

$$COS_{(g)} + Fe_{(s)} = CO_{(g)} + FeS_{(s)}$$

Given:

$C_{(s)} + ½\ O_{2(g)} + ½\ S_{2(g)} = COS_{(g)}$ $\quad \Delta G^\circ = -202800 - 9.96T$

$Fe_{(s)} + ½\ S_{2(g)} = FeS_{(s)}$ $\quad \Delta G^\circ = -150200 + 52.55T$

$C_{(s)} + ½\ O_{2(g)} = CO_{(g)}$ $\quad \Delta G^\circ = -111700 - 87.65T$

(a) Assuming that the effluent gas is in equilibrium with Fe and FeS, calculate the percentage of sulfur removed from the gas by reaction with sponge iron. **(7%)**

(b) Calculate the partial pressure of S_2 in the effluent gas. **(7%)**