國 立 清 華 大 學 命 題 紙

九十二學年度 工程與系統科學 系（所） 甲 組碩士班研究生招生考試

科目 材料熱力學 科號 3602 共 2 頁第 1 頁 *請在試卷【答案卷】內作答

1. (a) Derive the general conditions for spontaneity and for equilibrium starting from Clausius inequality. (5%)

   (b) What is the definition of an isolated system? State the conditions for spontaneity and for equilibrium in an isolated system. (5%)

   (c) Most of the transformations in solid state are at constant temperature and under constant volume, derive an auxiliary function that can be used as a criterion for equilibrium. (5%)

   (d) The transformations in vapor to liquid are at constant temperature and under constant chemical potential, derive an auxiliary function that can be used as a criterion for equilibrium. (5%)

   (e) If you want to measure the Gibbs free energy, what are the methods or principles you can use? Propose at least two methods. (5%)

2. (a) A 100 ohm resistor carrying a current of 5 A for 1 second is kept at 1 atm and a constant temperature of 27°C by a stream of cooling water, find the entropy change of the resistor and the universe. (10%)

   (b) If the same resistor as in (a) initially at 27°C is thermally insulated and the same current is passed for the same time, find the entropy change of the resistor and the universe. (10%)

   Given the mass of the resistor is 50 g and $C_p = 840\ J.kg^{-1}K^{-1}$.

3. 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? (b) Using quasi-chemical model to explain the physical significance of α in the regular solution model. (c) Derive the critical state of regular solution occurs at $\alpha = 2$. (15%)

4. A graduate student needs to form an Al-2 wt%Cu alloy thin film on a Si wafer, and the only method he can use is evaporation. It is known that atoms in metal alloys are generally less tightly bound than those in compounds, and therefore each constituent evaporates nearly independently. Suppose that the evaporation is carried out at 1350 K using Al-Cu alloy evaporation source, what is the composition of the source? (25%) Assume the activity coefficients $\gamma_{Cu} = \gamma_{Al}$.

The following data are given:

The evaporation flux for each component is

$$\phi = 3.513 \times 10^{22} \frac{P(torr)}{\sqrt{MT}} \text{ molecules/cm}^2 \cdot \text{sec}$$

Vapor pressures

For $Al_{(l)}$, $\log P_{(torr)} = -16{,}380T^{-1} + 12.32 - \log T$

For $Cu_{(l)}$, $\log P_{(torr)} = -17{,}520T^{-1} + 13.21 - 1.21\log T$

Atomic weight $M_{Cu} = 63.7$, $M_{Al} = 27.0$

5. While skating on ice, a high pressure is exerted by a person because of the small area of contact between skates and ice. Thin layer of water acts as lubricant as ice melts making skating possible. If the temperature of the ice is -2°C and the area of contact 25 mm^2, will a person weighing 70 kg be able to skate? Given latent heat of fusion $L = 3.34 \times 10^5$ J/kg, at 0°C and 1 atm pressure and the change in specific volume on melting is -9.05×10^{-5} m^3/kg and $g = 9.81$ m/s^2.(15%)