國　立　清　華　大　學　命　題　紙

96 學年度 工程與系統科學系　（所）甲　組碩士班入學考試

科目 物理冶金　科目代碼 2801　共 2 頁第 1 頁　*請在【答案卷卡】內作答

1. (a) At 900℃, growth rate, G is a dominant term in the crystallization of a copper alloy. By dropping the system temperature to 400℃, the growth rate drops six orders of magnitude and effectively reduces the crystallization rate to zero. Calculate the activation energy for self-diffusion in this alloy system.
(b)A coating of impurity B can penetrate more deeply into grain boundaries and even further along a free surface of polycrystalline A. Taking $D_{\text{grain boundary}} = 1.0 \times 10^{-10} m^2/s$, calculate the penetration of B into A along the grain boundary after 1 hour, defined as the distance, x, at which $C_x = 0.01\ C_s$ (with $C_0 = 0$ for initial pure A). For comparison, calculate the penetration defined in the same way within the bulk grain for which $D_{\text{volume}} = 1.0 \times 10^{-14}\ m^2/s$. (20%)

Note: $$\frac{Cx - C_0}{Cs - C_0} = 1 - erf\left(\frac{x}{2\sqrt{Dt}}\right)$$

2. (a) Calculate the atomic volume of a vacancy, ω, in a copper crystal. Lattice parameter of copper, a, is 3.165×10^{-10} m.
(b) If the work needed to form a mole of vacancies in copper is 83,000 J/mole, what is the equilibrium number of vacancies in this metal at 700 K? R= 8.314 J/mole K
(c) The equilibrium concentration of vacancies at a transverse grain boundary, C_{gb}, depending on the applied stress and is accordingly larger than the thermal equilibrium concentration C_0 of an unstressed metal and is given by $C_{gb} = C_0 \exp(\sigma\ \omega/kT)$ where C_0 is the thermal equilibrium vacancy concentration, σ is the applied stress, and ω is the atomic volume of a vacancy. If a tensile stress of 100 MPa is applied to a copper specimen at 700 K, by what factors should the vacancy concentration be increased at the transverse grain boundaries?
(d) What kind motion of edge dislocation close to the grain boundary could be involved in the absorption of the excessive vacancy concentration due to the localization of strain near grain boundaries? R= 8.314 J/ (mol K) (20%)

3. Explain the mechanisms of precipitation hardening with the interactions of precipitate with dislocation. (10%)

4. The basic effect of high temperature recovery is the movement of the dislocations resulting from plastic deformation into subgrain or cell boundaries. This process can actually start during plastic deformation. When this happens, the metal is said to undergo dynamic recovery. (a) When dynamic recovery occurs, how will the effective work hardening rate change? (4%) (b)What is the primary mechanism involved in dynamic recovery? (4%) (c)Discuss how the temperature would affect the occurrence of dynamic recovery? (6%) (d)Discuss how the magnitude of stacking fault energy of FCC metals would affect the occurrence of dynamic recovery? (6%)

國　立　清　華　大　學　命　題　紙

96 學年度 工程與系統科學系　（所）甲　組碩士班入學考試

科目 物理冶金　科目代碼 2801　共 2 頁第 2 頁　*請在【答案卷卡】內作答

5. (a) Both cleavage and twinning in iron are favored by increasing the strain rate. Rationalize this statement. (b) Describe the development of a cup-and-cone fracture in a tensile specimen. (20%)

6. Make a guess at how you think the following variables would affect the dendrite zone length, and then explain the reasoning for your guess.
   (a)An increase of alloy composition.
   (b)A decrease of thermal conductivity of the mold material.
   (c)An increase of the latent heat of the alloy.
   (d)An increase of convective mixing within the liquid ahead of the interface. (10%)

(a)