國立清華大學 101 學年度碩士班考試入學試題

系所班組別：工程與系統科學系碩士班 甲組

考試科目（代碼）：物理冶金（2501）

1. (a)Draw a (001) standard stereographic projection for a cubic material including the <001>, <110>, and <111> poles. Please specify the important zone circles (e,g, {111}, {110}, {100}) between them. (4%)(b) If a single crystal with fcc structure is in tension at [213] direction (located at (001),(101),(111) stereographic triangle), calculate the Schmid factor of the primary slip system. (4%) (c) On the stereograph you drew in (a) please specify the primary, conjugate, cross slip and critical planes, and the direction where the rotation of slip direction ends. (4%) (d) Draw a three-stage stress-strain curve for the single crystal in (b) and explain the deformation mechanisms in each stage. (4%) (e) Based on the rotation of slip direction during tension you have answered in (c), explain the deformation mechanism occurs in the stage two. (4%)

2. It is known that yield point in mild steel is caused by dislocation atmosphere formed by interstitial atoms such as nitrogen and carbon. Suppose the atmosphere is a condensed atmosphere where the atom positions on the dislocation line are all occupied by the interstitial atoms. Estimate the concentration of interstitial atoms needed to form condensed atmospheres around the dislocation for annealed steel and heavily cold worked steel. Given the radius of Fe is 1.25 Å and lattice parameter of Fe is 2.86Å. The dislocation density for annealed steel is 10^6 cm/cm^3 and for heavily cold worked steel is 10^{12} cm/cm^3. (20%)

3. The work for nucleation of two hemispherical caps each has the same shape is $w_R = 2\times\frac{4}{3}\pi\times\frac{v_\alpha^2\gamma_{\alpha\beta}^3(1-\cos\theta)^2(2+\cos\theta)}{\Delta\mu^2}$. In a case shown in Fig. 1, there are two half-sphere nuclei formed by heterogeneously nucleation on the grain boundary of β. Since the two half nuclei are formed in different grains, the two new α nuclei also have different orientation; therefore there is a grain boundary between the two α nuclei. If you substitute θ = 90° into the equation to calculate w_R, the equation goes back to the work for homogeneous nucleation. However, you know this is not correct because heterogeneous nucleation will reduce the surface energy barrier. Calculate the correct ratio of $\Delta G^*_{\text{hetero}} / \Delta G^*_{\text{hom}}$ to demonstrate that heterogeneous nucleation of a sphere nucleus is easier than homogeneous nucleation. (20%)

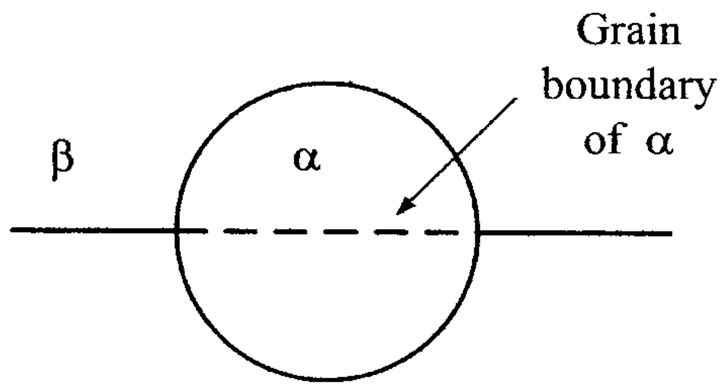

Fig. 1

4. The original diffusion couple designed by Kirkendall was Cu and Zn. The phase diagram of Cu and Zn is shown in Fig. 2. The Kirkendall experiment was carried out at 390°C and maintained at the temperature for a long time to facilitate the interdiffusion. (a) Referring to the phase diagram, draw a schematic diagram to show the layer structure of the diffusion couple after cooling. (4%) (b)Explain the thermodynamic and kinetic reasons for the formation of layer structure. (6%) (c) For metallic alloys, as strength increases the elongation normally decreases and thereby losing fracture toughness, which is problematic in alloy design; therefore, it is one of the most important goals to design an alloy with high strength and high ductility. One of the model examples is Cu-Zn alloy, in which strength and elongation increase simultaneously compared with pure Cu. Based on Considère's criterion, explain the strengthening mechanism of brass. (10%)

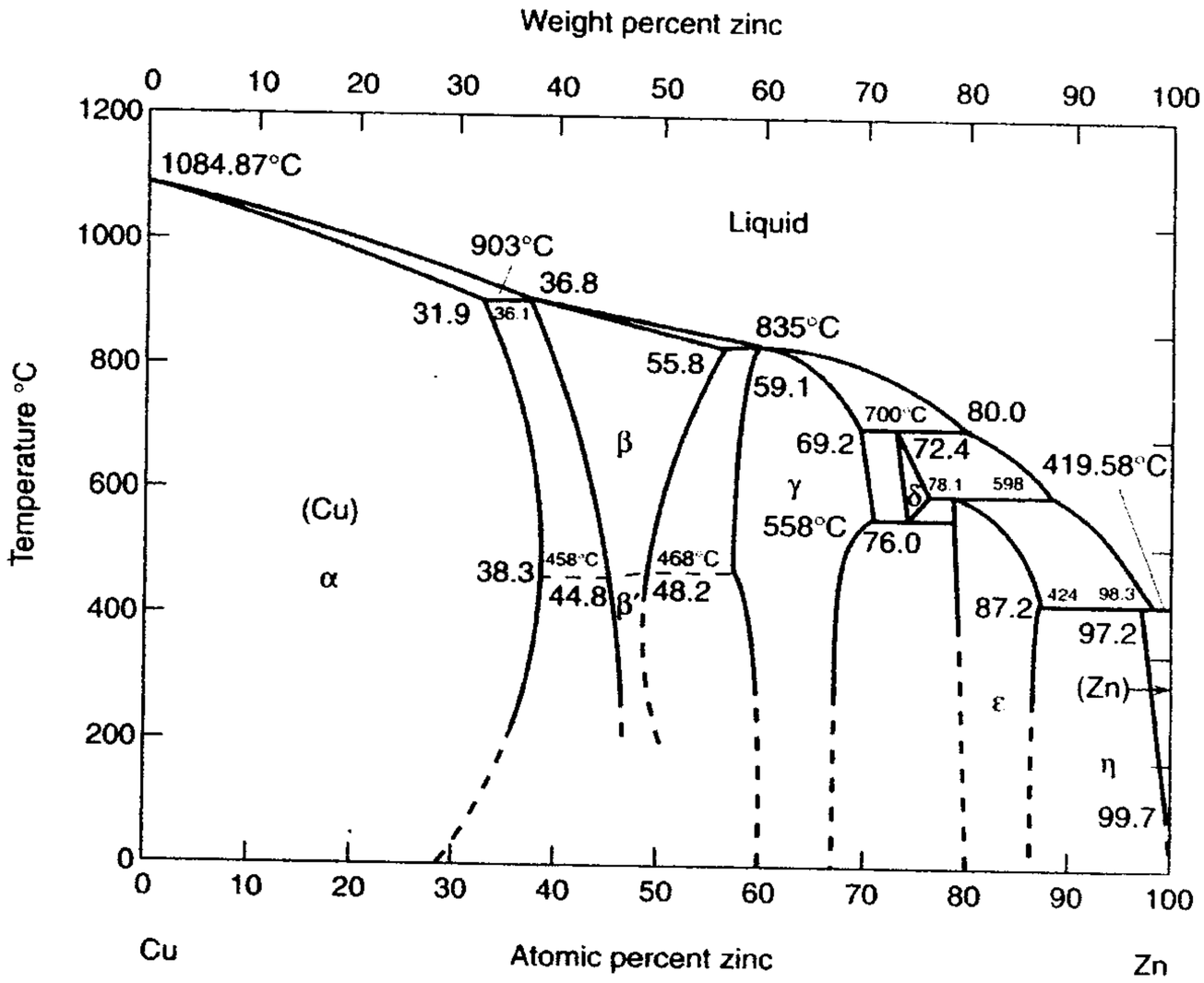

Fig. 2

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5. (a) What is creep of metal? Draw a typical three-stage creep curve and explain the mechanical behavior in each stage.(10%)
   (b) For fcc and bcc metals, there are different temperature dependence on the flow stress components, as shown in the Figs.3 and 4. Explain the reasons that cause this difference. (10%)

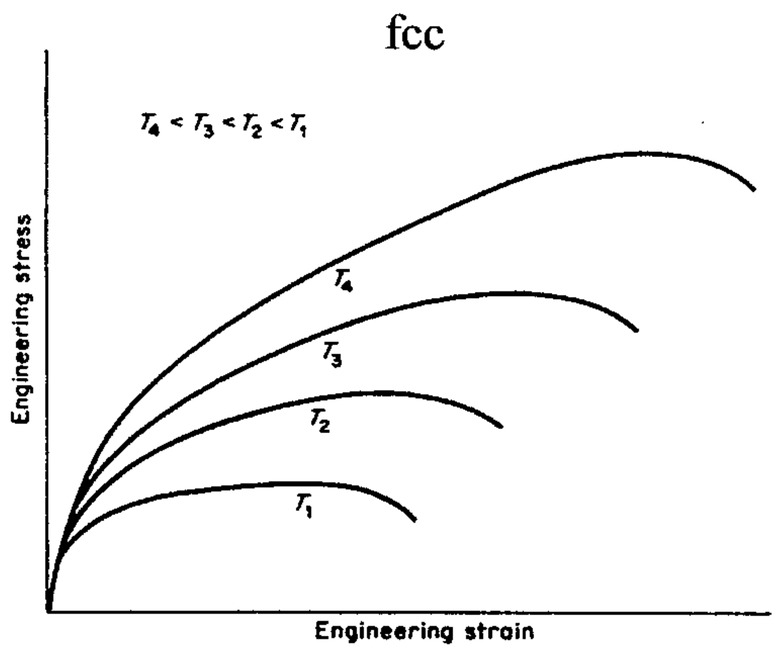

Fig. 3

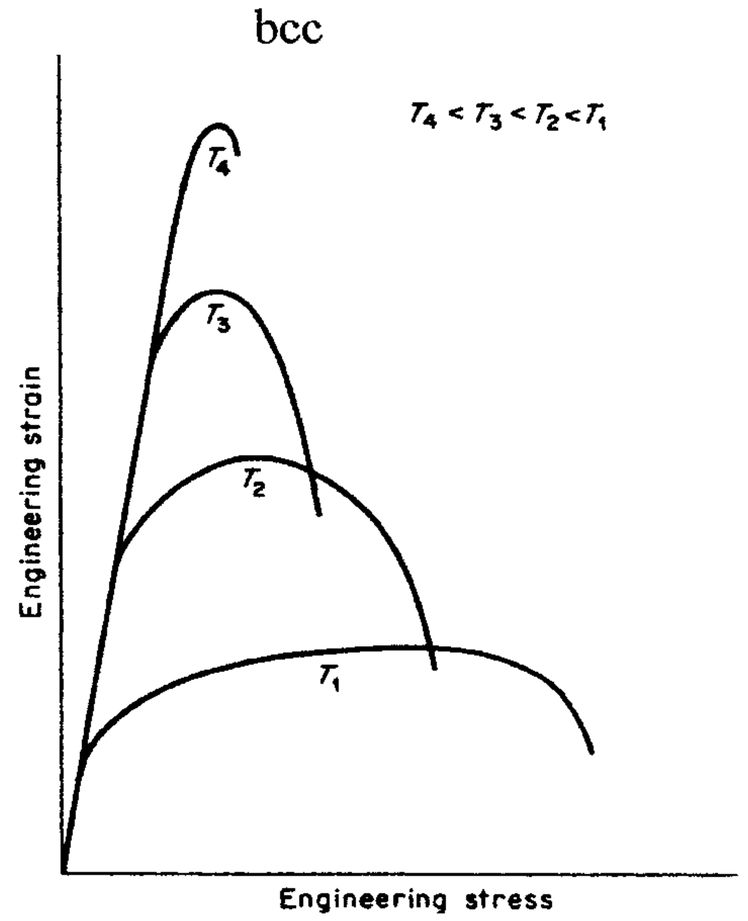

Fig. 4