1. List the various signals generated when high-energy electrons interact with a thin metal foil. Give concisely how the various signals are used in an electron microscope to characterize the microstructure of materials. (6%)

2. About dislocations

1) Figure 1 illustrates a material containing an edge dislocation with the dislocation line along the z axis and the Burgers vector along the x axis. If a stress σ_{xx} is applied, show that the force acting on the edge dislocation will cause the dislocation move perpendicular to the slip plane, i.e., climb process, then as the dislocation moves, determine the vacancy is created or annihilated. (5%)

2) Briefly discuss the various dislocations associated with the FCC metals. (5%)

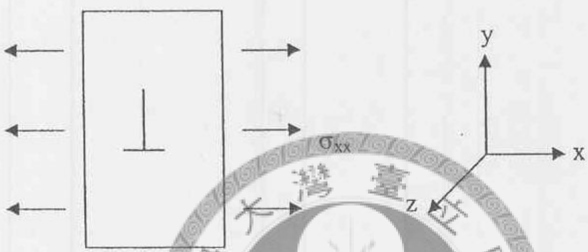

Figure 1

3. Suppose that you want to maximize the strength of an alloy by controlling the grain size,

1) If you intend to control the grain size by means of recrystallization, briefly discuss the factors limiting the grain size of a completely recrystallized alloy. (5%)

2) If you would like to control the grain size by means of solidification, describe how the grain size of the solidified alloy be controlled. (5%)

4. About plastic deformation

1) A bicrystal with a simple cubic structure is oriented as shown in Figure 2. Which crystal will slip first if the slip system is {100}<100>? (5%)

2) Compare and contrast the deformation mechanisms of slip and twining. (5%)

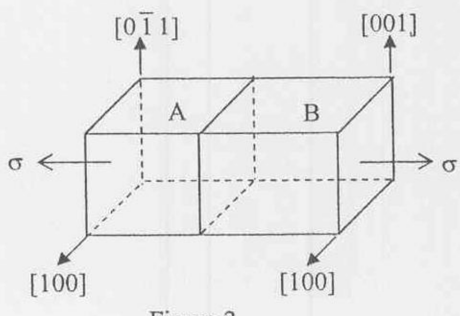

Figure 2

5. For vacancies

1) Suppose you are carrying out a heat-treating process on a piece of steel by annealing at 850℃ and then quenching to room temperature. If the as-quenched steel was further subjected to annealing at temperatures lower than 850℃, would you expect the vacancy concentration of the steel to increase with anneal temperatures? Why? (5%)

2) Briefly discuss how vacancies are related to or affect the following processes: (1) the nonconservative motion of a general dislocation, (2) the solid-state diffusion of atoms, and (3) the formation of GP zone during aging. (5%)

6. About binary phase diagram

1) Explain how the mixing of enthalpy affects the congruent points of a binary phase diagram. (5%)

2) Draw the schematic representations illustrating how the equilibrium microstructure evolves, i.e., the microstructure corresponding to state a, b, c d, and e, for the alloy of composition X1 (as shown in Figure 3) cooled slowly from liquid phase to room temperature. (5%)

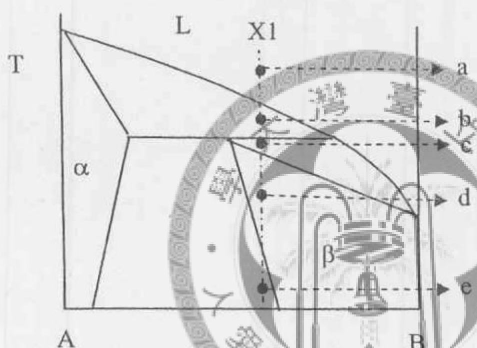

Figure 3

7. About diffusion

1) What are the high-diffusivity paths? Discuss the factors determining the relative contribution of these paths to the overall diffusion. (5%)

2) Discuss in detail the factors controlling the time for the homogenization of metals. (5%)

8. For solidification

1) Explain why the nucleation rate of an undercooled molten metal exhibits a maximum at intermediate temperatures? (5%)

2) Compare and contrast the typical grain structure of the ingots of a pure metal and an alloy. (5%)

9.

1) Explain the sharp yield point associated with mild steel. (4%)

2) Among the various materials properties, which one (or ones) is generally used for the criterion in designing a mechanical component with a preexisting crack? Why? (4%)

3) What is the meaning of the term stress-induced martensite? (4%)

4) When an Al-Cu alloy is subjected to precipitation hardening, why the hardness goes through a maximum during the aging process. (4%)

5) Compare and contrast the diffusion controlled growth and the interface controlled growth for the precipitation of iron-carbide particles from a supersaturated solid solution of carbon in alpha iron. (4%)

6) Explain the anelastic behavior associated with carbon steel. (4%)