# 國立清華大學 100 學年度碩士班入學考試試題

系所班組別：核子工程與科學研究所甲組(工程組)

考試科目（代碼）：物理冶金(3005)



1. (10%) Assume that the electrons in a transmission electron microscope are accelerated through a potential of 80,000 volts. Determine
   (a) The electron velocity given by this potential by assuming that the energy the electrons gain falling through the potential equals the gain in their kinetic energy.
   (b) The effective wavelength of the electrons.
   (c) The Bragg angle, if the electrons undergo a first order reflection from a {100} plane of a vanadium crystal. Take the lattice parameter of vanadium as 0.3039 nm.

   1 electron volt = 1 eV =$1.6\times10^{-19}$ J

   The mass of the electron = m = $0.911\times10^{-30}$ kg

   Planck's constant = $6.63\times10^{-34}$ J/Hz

2. (20%) Assume a pure component is solidified from liquid and the volume free-energy change associated with the formation of the solid nuclei is $\Delta G_v$. The energyof the interface between the liquid and solid phase is $\sigma$. The radius of spherical nucles is r and the number of atoms is n, in the particle.
   (a) Please determine the critical radius $r_0$ and the free energy change at that radius
   (b) Please draw the free energy of a particle as a function of its radius.
   (c) Prove that for a spherical nucleus

$$\left(\frac{\partial^2 \Delta G_n}{\partial n^2}\right)_{n^*} = \frac{-2\Delta G_n^*}{3(n^*)^2}$$

3. (10%) What are the three stages of annealing? Discuss the driving force for each stage. And describe the changes in microstructure and mechanical properties in each stage.

4. (20%) An Aluminum (fcc structure) single crystal with critical resolved shear stress $\tau_{crss}$ =20 MPa is loaded in a simple tension along [311] direction.

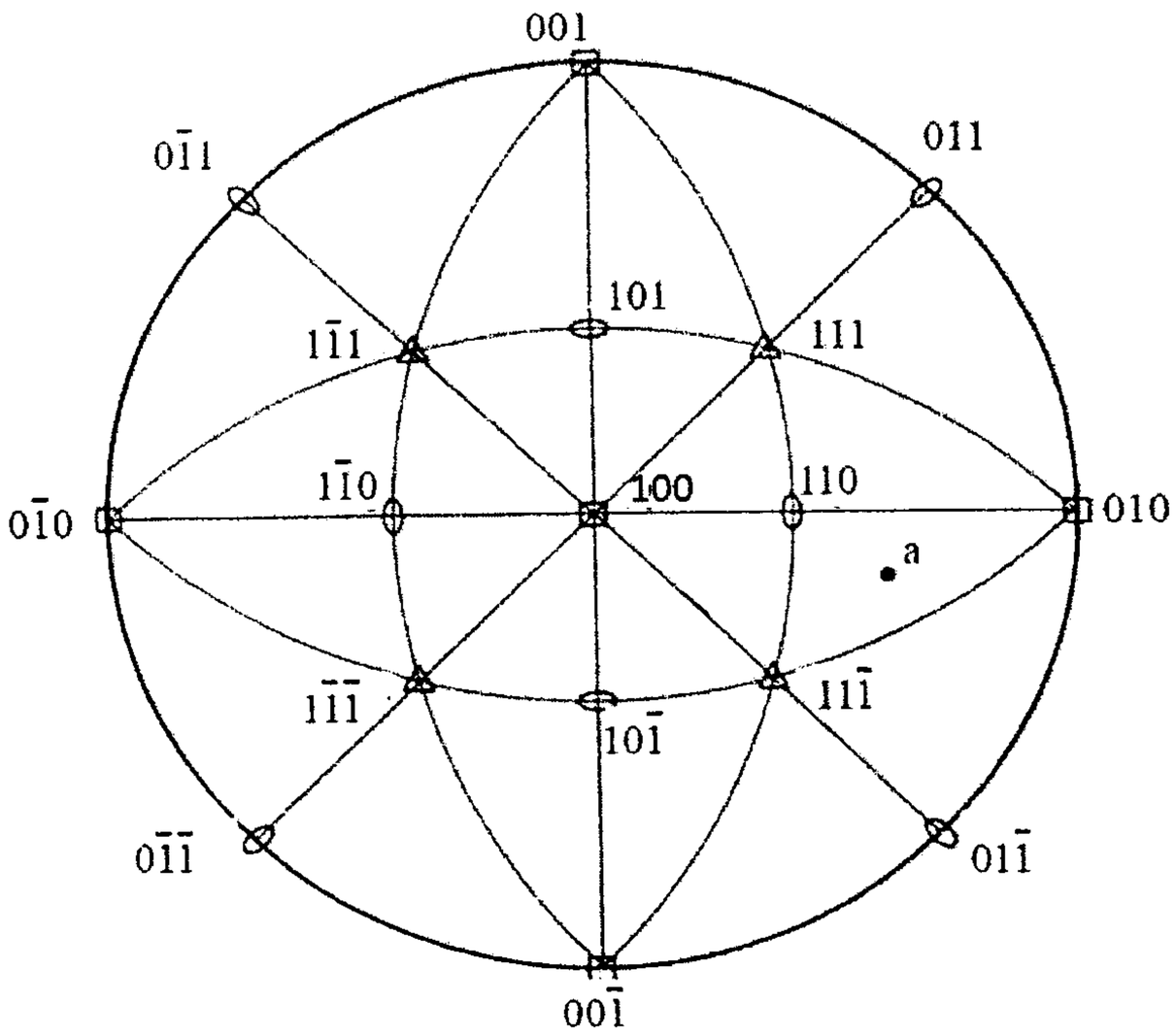
(a) Considering the following five slip systems, determine which one of the listed slip systems are valid one for aluminum when the sample is loaded along [311] direction.

1: $(1\bar{1}1)[\bar{1}0\bar{1}]$ 2: $(0\bar{1}1)[100]$ 3: $(1\bar{1}1)[110]$ 4: $(110)[\bar{1}11]$ 5: $(11\bar{1})[011]$

(b) From valid system found in (a), using calculated Schmid factors to determine which one will be active one.

(c) Calculated the yield strength of the crystal for simple tension in [311] direction

(d) A stereographical projection on 001 is shown below. Another Aluminum (fcc structure) single crystal is loaded in a simple tension along **a** direction in the following figure. Please describe slip plan and slip direction for primary slip and cross slip system.



5. (10%) (a) Please write down the Hall-Petch equation, and identify physical meaning of each term. (b) Why a much higher applied stress is required to cause dislocation slip to pass through the grain boundary in fined grain materials than in the case of coarser grain materials?

6. (20%) Regarding the spinodal decomposition, please answer the following questions: (a) describe the necessary conditions for it to happen, (b) draw the phase diagram and the free energy versus composition diagram, (c) draw the schematic composition profiles at increasing times in an alloy quenched into the spinodal region, (d) distinguish the coherent and incoherent spinodals.

7. (10%) It is determined by experiment that the Kirkendall markers placed at the interface of a diffusion couple, formed by welding a thin plate of metal A to a similar plate of metal B, move with a velocity of $4.5\times10^{-12}$ m/s toward the A component when the concentration $N_A=0.38$ and the concentration gradient, $dN_A/dx$, is $2.5\times10^{2}$ per m. The chemical diffusion coefficient D under these conditions is $3.25\times10^{-14}$ $m^2/s$. Determine the values of the intrinsic diffusivities of the two components.