國立臺北科技大學九十五學年度碩士班招生考試

系所組別：3302 材料科學與工程研究所不分組

第二節 物理冶金（選考）試題

填准考證號碼 | | | | | | | |

注意事項：

1. 本試題共六題，配分共 100 分。
2. 請標明大題、子題編號作答，不必抄題。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

一、

There are 10 statements below. Please read them carefully. If you think the statement is **correct**, label **T** on your answer sheet. If you think the statement is **wrong**, please label **F** and write down brief correction for this statement. If **F** is marked without correction, you get **NO** point. **No** point either if the correction is wrong or the correction is made without marking **F**. (30%)

1. If atoms are more packed, the material becomes harder. (3%)
2. Edge dislocations move in the same direction as the shear stress since its motion is governed by atomic diffusion. (3%)
3. The volume of a solid stays constant in the elastic region. (3%)
4. In a bi-metal diffusion couple, the two-phase field appears with a finite width. (3%)
5. The recrystallized temperature of a metal decreases with increasing amount of cold work. (3%)
6. During recrystallization, many small grains are formed. Therefore, the hardness of the materials increases. (3%)
7. In a dislocation loop the Burgers vector changes direction depending on the location in the loop. (3%)
8. The area under the stress-strain plot is work per unit volume done by the stress.(3%)
9. A congruent point is a place where a single phase binary liquid solidifies at a single temperature into a binary phase solid. (3%)
10. Spinodal decomposition is a possible way for homogeneous nucleation. (3%)

二、

Atoms diffuse through or around grain boundary by lowering chemical potential in a stressed solid. At constant temperature T, Helmholtz free energy F can be written as $dF = -\sigma dV$, where σ is the applied stress, V is the volume of the solid.

1. Since chemical potential μ can be expressed as the change of energy per atom under stress σ, please derive the relationship between μ and σ. (10%)
2. Based on the equation derived in (1), for aluminum at elastic limit, please estimate the chemical potential. (5%)

三、

A recrystallized, dislocation-free Aluminum grain is growing into a deformed matrix. A 4 cm by 4 cm TEM photograph with a magnification of 20,000 X shows that the total length of the dislocations in the deformed area is 400 cm. The thickness of the foil is 300nm.

1. Please calculate the pulling force per unit area acting on the recrystallized grain boundary. The energy of dislocation equals to $\frac{\zeta b^2}{4}$ J m^{-1}, where ζ and b are shear modulus and burgers vector, respectively. (7%)
2. For a hemisphere nucleus growth, the work of expansion must equal the increase in surface energy. What is the diameter of the smallest nucleus that can be expanded into the surrounding matrix for the growth of recrystallized grains?(8%)

四、

A stress σ is applied along [121] in a single crystal F.C.C. metal, please calculate the shear stress on (111) along $\langle 1\bar{1}0 \rangle$. (10%)

注意:背面尚有試題

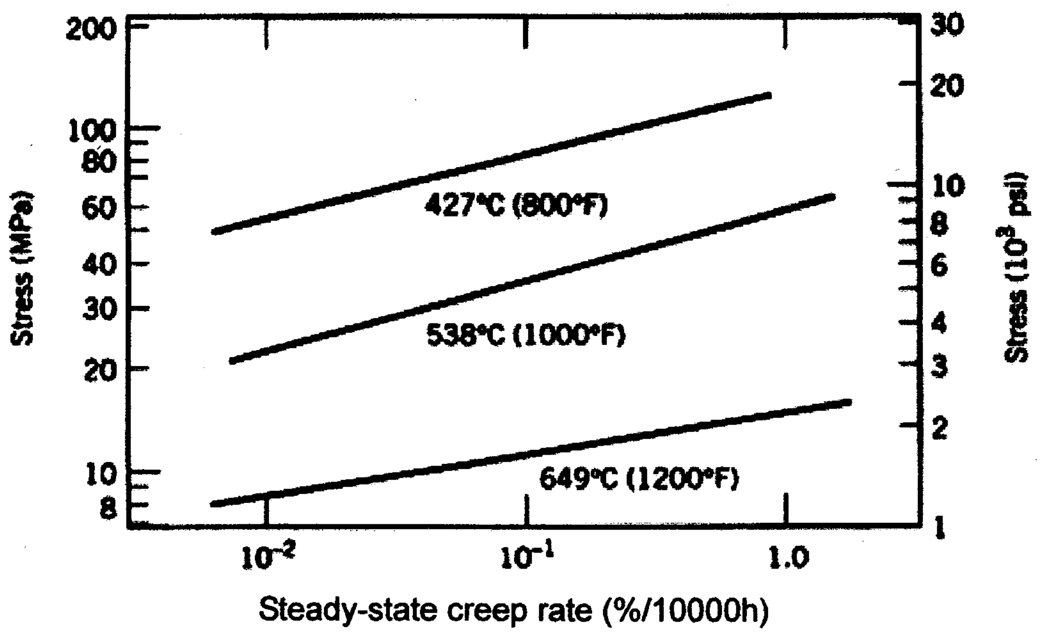
五、

A diffusion couple including inert wires served as a marker was set at the interface of the couple which formed of pure Cu and α-brass with a composition Cu-30 wt% Zn. After 50days at 800^{0}C, the marker velocity was determined as 2.5 x 10^{-8} mm/s. The composition at the marker was X_{Zn}=0.25, X_{Cu}=0.75, and that the concentration gradient of Zn around the interface was 0.090 mm^{-1}.The interdiffusion coefficient was 4.5x$10^{-13}$$m^2$/s.

1. Please calculate the diffusivity of Zn and Cu in α-brass at 25 at% of Zn, respectively. (16%)
2. Please indicate whether the marker will move toward pure Cu or α-brass. (4%)

六、

A 10 mm in diameter and 1000 mm long metal bar is loaded at 538° C. The sum of the instantaneous and primary creep elongation is 0.5 mm. The creep data can be seen below. The maximum loading on this specimen is 2500 N. If the sample is required to survive for 10,000 hours, what will be the maximum allowable change in length? (10%)



注意：參考數值與公式列於右頁

Note:

For Aluminum

Melting point	660°C
Density	2.70 g/cm^3
Atomic weight	27.00 g/mol
Lattice parameter	0.405 nm
Young's modulus	7x10^{10} Pa
Shear modulus	3x10^9 Pa
Bulk modulus	7.6x10^{10} Pa
Poissons ratio	0.35
Burgers vector	0.3nm
Grain boundary energy	0.5 J m^{-2}

$\tau = \zeta\gamma = \frac{\zeta b}{2\pi r}$ $\quad w_s = \frac{\zeta b^2}{4\pi}\ln\frac{r'}{r_o}$ $\quad w_e = \frac{\zeta b^2}{4\pi(1-\nu)}\ln\frac{4r'}{b}$ $\quad \tau = \tau_0 + k\rho^{1/2}$

$\sigma = \sigma_0 + kd^{-1/2}$ $\quad \frac{n_v}{n_0} = \exp\left(\frac{-H_f}{RT}\right)$ $\quad \tau = \sigma\cos\theta\cos\phi$ $\quad \sigma = A\left(\dot{\varepsilon}\right)^n$ $\quad \tau = \eta\frac{d\gamma}{dt}$

$D = \frac{\alpha a^2}{\tau}$ $\quad D = D_0\exp\left(\frac{-Q}{RT}\right)$ $\quad D_A = D_{A0}\exp\left(\frac{-Q_A}{RT}\right)$

$v = \frac{\left(D_A\frac{\partial n_A}{\partial x} + D_B\frac{\partial n_B}{\partial x}\right)}{n_A + n_B}$ $\quad N_A = \frac{n_A}{n_A + n_B} = 1 - N_B$ $\quad \frac{\partial N_A}{\partial t} = \frac{\partial}{\partial x}\tilde{D}\frac{\partial N_A}{\partial x}$

$\tilde{D} = N_B D_A + N_A D_B$ $\quad D^* = D_0^*\exp\left(\frac{-Q}{RT}\right)$ $\quad \tilde{D} = \tilde{D}_0\exp\left(\frac{-Q}{RT}\right)$ $\quad \Delta G_m = \frac{\Delta H \Delta T}{T_m}$

$\Delta G = \frac{4}{3\pi^3}\cdot\frac{\Delta g^{vl}}{v_l} + 4\pi r^2\gamma$ $\quad \Delta G^{het} = \Delta G^{hom}\left(\frac{2 - 3\cos\theta + \cos^3\theta}{4}\right)$ $\quad \gamma = \frac{S}{h}$

$\frac{d\varepsilon}{d\sigma} = \frac{(d\varepsilon_s + d\varepsilon_t)}{d\sigma_s}$ $\quad \Delta\sigma = A(\Delta\varepsilon_p)^n$ $\quad \sigma_f \approx \left(\frac{\gamma E}{a}\right)^{1/2}$ $\quad K_{IC} = \sigma\sqrt{\pi a}$ $\quad \sigma_{x'y'} = T_{x'x}T_{y'x}\sigma$

$\sqrt{2} = 1.414$ $\quad \sqrt{3} = 1.732$ $\quad \sqrt{5} = 2.236$ $\quad \sqrt{7} = 2.646$ $\quad \sqrt{11} = 3.317$

$dU = TdS - PdV$ $\quad dH = TdS + VdP$ $\quad dF = -SdT - PdV$ $\quad dG = -SdT + VdP$