國立清華大學 106 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(0526)

考試科目（代碼）：物理冶金 (2601)

 *請在【答案卷】作答

1. Please estimate the equilibrium concentration of vacancy defect in crystal structure at a temperature T. Assuming that formation energy of one vacancy is ΔH' and the total number of atoms is N in this crystal. (**15%**) <15/100>

2. (a) Mark Luo is a director of R&D department at Aerospace Industrial Development Corporation. His team is now bidding a reliability test of Co / Ni doped super alloy framework for A-350 type jet plane offered by Airbus Co. The length of the framework stand is designed as 80 meters with the cross section of 0.3 in diameter. A qualification product in EVT-1 for the framework stand was made 6 months ago and shipped to Airbus today. The shipping duration takes 3 months from Taiwan to France. The arrival frame-stand is banded by 0.1% due to an improper shipping via AIDC Co.. You are in charge of the import qualification control in Airbus and found that the frame-stand was packed in overloaded stress at 20 GPa across the diameter section and stored at 50°C (note that the yield stress of this alloy is higher than 100 GPa at 25°C). Please draw a strain-time correlation curve with description on reason of different strain rates at the three stages at a constant stress for the elongation of C/Ni doped super alloy frame-stand during the shipping (**9%**); (b) Draw the strain-time correlation curves at temperatures higher and lower than the case mentioned in question (a) in the same figure and explain the reason for changes of strain rate in the three stages. (**6%**); (c) Please discuss the microstructure mechanisms on the constant "low stress" induced strain in the frame-stand (**12%**); (d) to prevent such a low-stress induced strain, please provide the possible method in synthesis process of the Co/Ni frame-stand (**4%**). <46/100>

3. Also in Aerospace Industrial Development Corporation, assuming that you are assigned to develop the super-light and tough missile case on a battleship with your colleagues. (a) Basing on the phase diagram (**Figure 1**), please describe the receipt of Al-Cu alloy (Cu denote the dopant) for precipitation hardening (**8%**); (b) phase diagram for the precipitates θ1, θ2, θ3, θ4, and GP zone was shown in **Figure 1**, please draw the cooling curves (TTT curve) of these phases as a function of cooling time (**5%**); (c) please describe the phase transformation pathways and the hardening curves as a function of aging time at the selected temperatures (**5%**); (d) please explain the mechanisms of the precipitation hardening (**5%**); (e) In the missile cast, the precipitates are core (α phase) – shell (β phase) nanodisk; where the diameter and thickness of core is Dc and Tc, respectively) with the shell thickness of T_S. Considering cases for the homogeneous and heterogeneous nucleation of these precipitates, please derive the free energy changes of the system when interface energies of the precipitates are denoted as γ (i) (for example free energy at core-shell interface is $\gamma(\alpha,\beta)$) (**9%**). (f) for meet the super-light and tough criteria, the missile case is produced by drawing the metal into thin film with severe cold working and annealing. please describe the mechanisms and characters for the microstructure evolutions of the missile case upon cold work the thermal treatments (**12%**) <90/100>

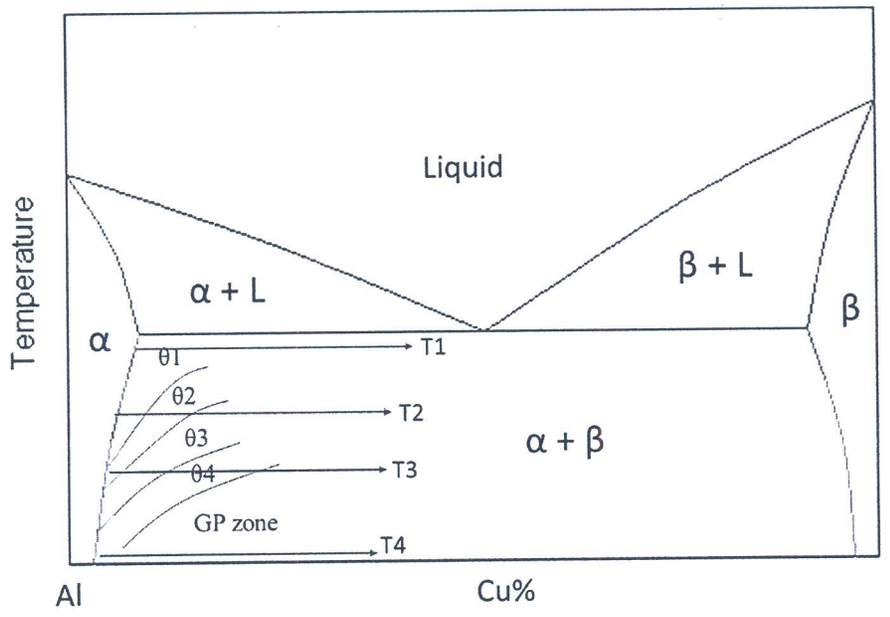

Figure 1. The phase diagram for Al-Cu system.

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4. Please explain the mechanisms of strain field of (a) solid solubility atoms (**3%**) and (b) dislocations (**3%**) in crystal by graphical and test explanations. (c) describe the interactions between solid solubility atom and dislocations by dislocation atmosphere theory (**4%**) <100/100>