注意：考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。

國立清華大學 109 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
　　　　　　甲組

科 目 代 碼：3001

考 試 科 目：物理冶金

一作答注意事項一

1. 請核對答案卷（卡）上之准考證號、科目名稱是否正確。

2. 作答中如有發現試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。

3. 考生限在答案卷上標記「▟由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。

4. 答案卷用盡不得要求加頁。

5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。

6. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

1. (Q1: 29%) Alex Wu is an undergraduate student. Since he is interested in X-ray diffraction technique, he joined in the X-Lab for his senior project. Prof. X, principal investigator of X-Lab, gave him two single crystal (hcp) zinc bars. One bar was straight but another was curved which looks deformed slightly by certain bending tool previously. One mission for Alex was the annealing of the two bars. After annealing, the shape of the bar bent originally varied which surprised Alex. So he named the interesting sample as specimen A. On the other hand, the straight bar was still straight. Alex's second mission was to perform X-ray analysis by using the Laue diffraction method on the heat-treated specimens. (In fact, powder diffraction is a more popular method than Laue method for polycrystal materials.) Laue pattern of the annealed specimen A which Alex acquired has been shown in Figure 1. Prof. X showed Alex another Laue pattern of specimen A before annealing. Prof. X asked Alex to notice that all the spots were elongated originally without discrete dots, and then gave Alex some assignments: (a) What kinds of the phenomenon happened on specimen A after annealing? (4%) (b) Please draw the difference in macroscopic level and in microscopic level related to the dislocation before and after annealing according to the change in Laue diffraction schematically (6%); (c) explain the driving force of this phenomenon (3%); (d) discuss the reason on the change of dislocation arrangement (3%); (e) Discuss if the hardness of annealed specimen A changes (4%); (f) which kind of condition do these spots satisfy?(3%) (g) Compare the difference between Laue method and powder method (at least three differences) (3%); (h) Using the power method, the diffraction result of the specimen A before and after annealing on the intensity-diffraction angle correlation plot will change as well. Please draw the two results on the same plot and explain the difference of the peak shape schematically. (3%)
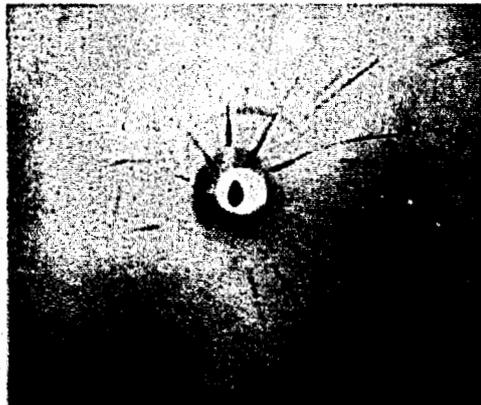

Figure 1

<u>**<total grade of 29/100>**</u>

2. (Q2: 28%) Figure 2 is a copper-zinc diffusion couple annealed for a short time at a temperature of about 400°C with does show a thin layer of the β' phase. (a) Please draw the free energy versus zinc composition curve for all phases corresponding to 400°C which identity the phase region as shown in Figure 3 (8%); (b) please draw the variation of zinc partial molar free energy across copper-zinc phase diagram in Figure 3. (8%) (c) Please draw the variation of copper composition as a function of distance across the diffusion couple in a figure 2 (8%); (d) Explain the reason why there no dual phase region in Figure 2. (4%)
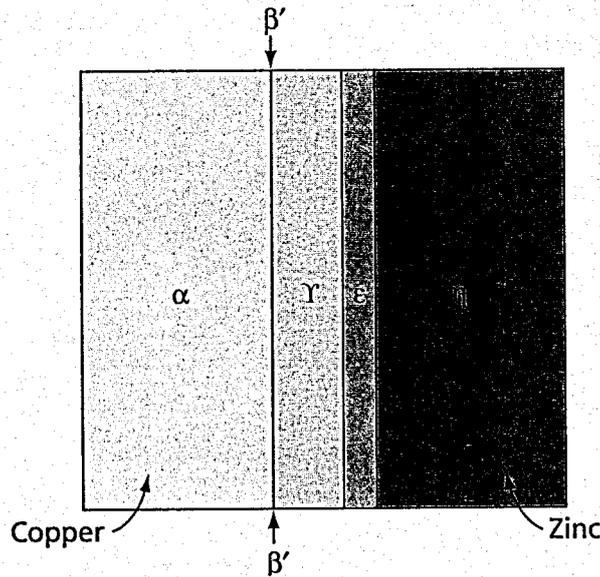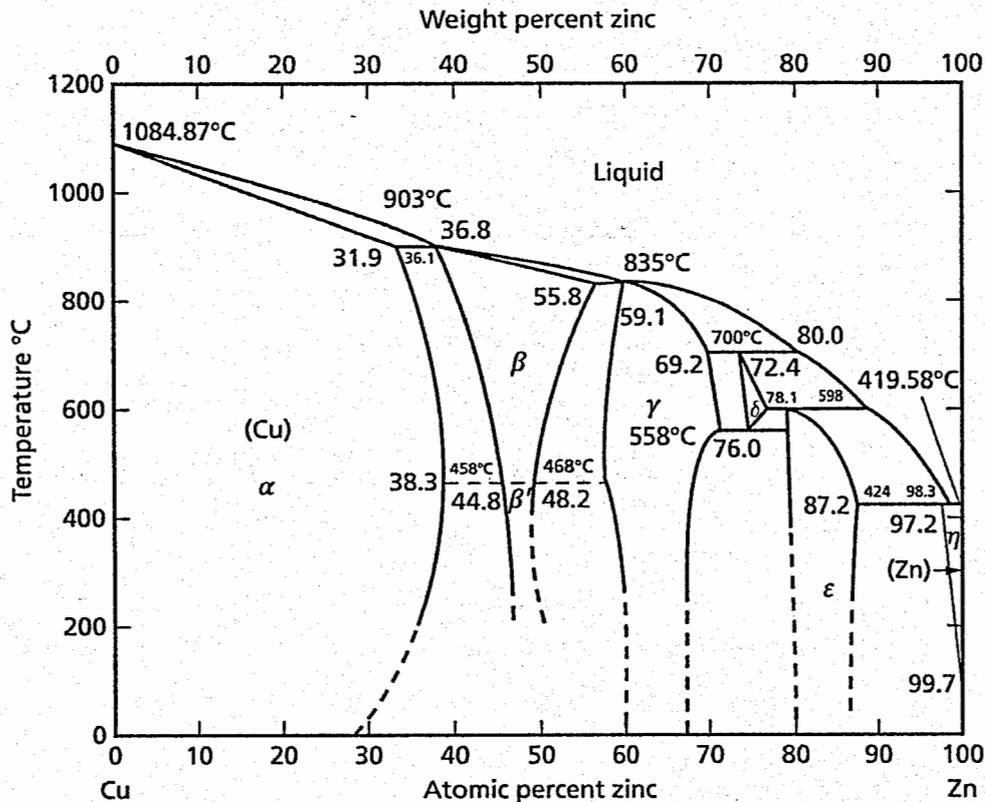

Figure 2

Figure 3

<total grade of 57/100>

3. (Q3: 27%) Mary Lin works in R&D division at a startup company in aerospace field. Board of this company agrees to invest more on the development of super binary alloy with superior mechanical properties. She gets some pure aluminum and Al-2wt%Cu alloy for her preliminary investigation of the influence of heat-treatment on the mechanical performance. Firstly, she proposes to perform different heat-treatment on the Al-Cu alloy followed by shearing tests. The pure aluminum plays the role of the control group in this investigation. Assuming you are the team leader who guides Mary to predict the mechanical behavior in advance. Please draw stress-strain curves in the same correlation chart of shear stress-shear strain relationship including the following cases: (a) pure aluminum (3%); (b) solid solution annealing followed by quenching of the alloy (3%); (c) aged to peak hardness of the alloy (3%); (d) the alloy aged to form GP zones (3%); (e) Overaged alloy (3%). Also, explain the hardening mechanism to the corresponding condition of heat-treatment mentioned above it might happen. (12%)

<total grade of 84/100>

4. (Q4: 16%) One Black Hawk helicopter crashed in January 2, 2020. Nan-Fang-Ao bridge collapsed in October 1st, 2019. Assuming you are in the Safety Commission in charge of the root cause of severe accidents. It is suspected that the two fatal events were caused by the material degradation related to creep and fatigue of critical components. (a) What is "creep" and "fatigue" of metal? (4%) (b) You have the reference of SN curve on hand as in Figure 4. Known the potentially failed component on the helicopter was made of an aluminum alloy. Which curve could be close to its true behavior? According to the curve, define the fatigue strength for this component to help modify the rule of maintenance. (3%) (c) Known the potential failed component on the of the bridge is made of the steel. Which curve could be close to its true behavior? According to the curve, define the fatigue limit for this component to help modify the rule of maintenance as well. (3%) (d) Describe the features of the fatigue fracture surfaces. (2%) (e) Draw a strain-time curve for creep and explain the mechanical behavior in each stage. (4%)
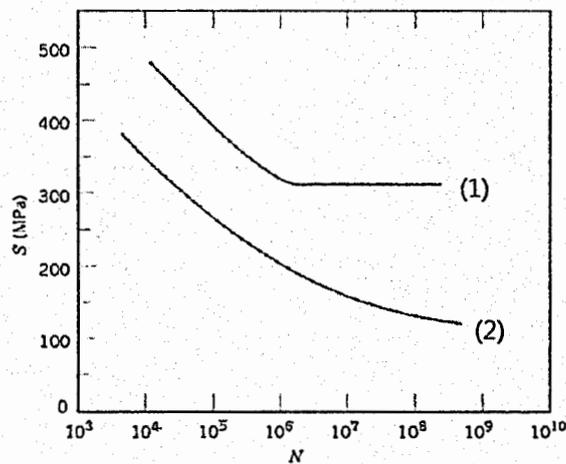
Figure 4

<total grade of 100/100>