# Part I

Answer question 1-7 within 30 words (question 8 is not restricted).

1. Consider a binary system (alloy with A and B components) with two phases (α and β) in equilibrium. From the following free-energy-versus-composition figure (before equilibrium), describe the movements of A and B atoms (between two phases) and the changes of the partial molar free energies of A and B in different phases ($G_A{}^\alpha$, $G_A{}^\beta$, $G_B{}^\alpha$, $G_B{}^\beta$) when the system move in the direction of equilibrium. （6%）
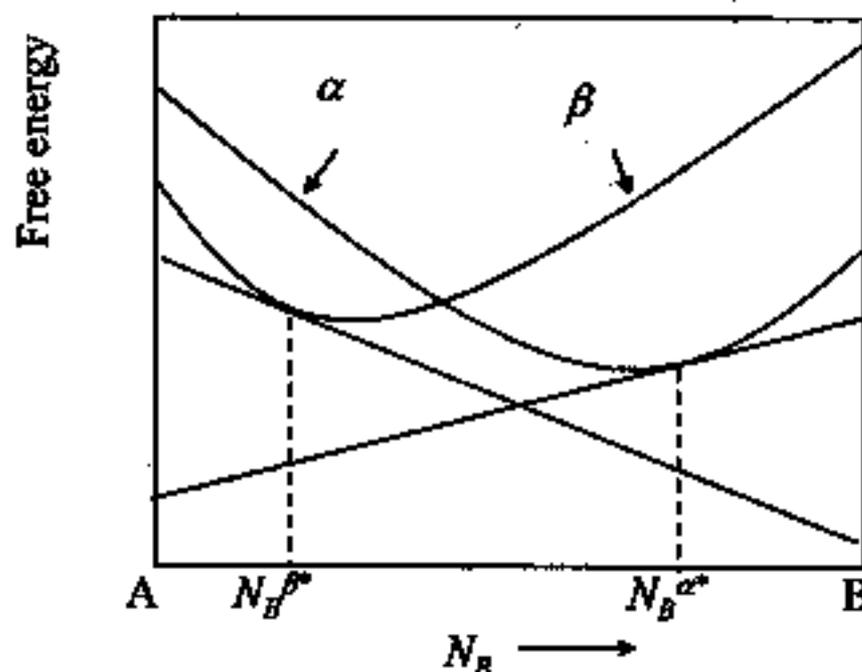
2. The phenomenon of sharp yield point in tensile stress-strain curve is a result of the interaction between interstitials and dislocations. How does the phenomenon change at very high temperature? And why? （6%）

3. Annealing of a material system with very small initial grain size causes the grain of the system to grow. The general grain growth law can be stated as $D=kt^n$, where D is the average grain size of the system, k the proportional constant, t the time of annealing, and n the exponent (equals to 1/2 for idea system). What is the effect of the annealing temperature on the value of n and why? （6%）

4. The activation energy for the motion of vacancy (in a crystal) includes migration energy and formation energy. Why do we have to consider the formation energy in the process? （6%）

5. In general, the dislocation movement is not smooth and continuous, but rather it occurs in steps. However, we still could determine the average velocity of dislocation (v). The velocity could be stated in form of $v=f(\sigma)\exp(-q/kT)$, where k is Boltzmann's constant, T the absolute temperature, q an activation energy, and $f(\sigma)$ a factor representing the stress dependence of the dislocation velocity. What do you think the measured q represent? （6%）

6. In general, the dissociation of a total dislocation 1/2[101] on the close-packed (111) planes of FCC crystals results in two partial dislocations (an extended dislocation). A distance could separate these two partial dislocations. What are factors that determine the distance of separation? （6%）

7. In the 100 standard stereographic projection of a cubic system, list the lines (planes) that pass through the (111) pole. Could you give a relation between the index of the pole (h k l) and the index of the planes (p q r)? （6%）

8. Describe the Debye model for crystals. Could you estimate the typical vibration frequency of an atom in a crystal (step-by-step)? （8%）

Part II

下面七題問題，請盡量在 50 字內簡單作答。 （可用圖說明）

9. 請簡述「析出強化」，Precipitation Hardening 的機制，即析出物與差排的作用過程。
（7%）

10. 請簡述當鋼鐵淬火後，形成「麻田散鐵相」，Martensite Phase, 為何會變硬？（7%）

11. 請問為何「熱浸鍍鋅鐵皮」，Galvanized Iron Plate，微觀組織中在鐵的基地上面會有數層（4 層）明顯的層狀結構？（7%）

12. 在氣相變為液相的結核過程，請簡述「臨界晶核尺寸」，Critical Radius，是如何隨著溫度下降而變化？ 為什麼會這樣變化？（7%）

13. 在固體擴散實驗中，經過時間 t ， 溫度 T 的擴散處理，可以量到試片內成份分佈曲線，$N_A(X)$，及預埋設鉬線，Marker，的移動距離，ΔX，請問如何由以上數據求出在鉬線位置的「內在擴散係數」，Intrinsic Diffussivity, D_A 與 D_B？ （9%）

14. 當金屬由固體轉換為液相，即溶解過程，Melting，有沒有「過熱現象」，Superheating，發生？原因是什麼？ （6%）

15. 碳原子在 α-Fe 中擴散的扭轉擺實驗中， Torsion Pendulum Test，請問如何找到碳原子擴散的活化能，Activation Energy ，Q？（請指出須改變那些參數，量測那些數據，如何演算）。 （7%）