1.(a) Assume that the potential energy between atoms could be represented by the following relation

$$U(r) = -\frac{A}{r} + \frac{B}{r^{10}} \quad \cdots(1)$$

where A and B are constants. Write an expression for the elastic modulus between two atoms in terms of A and B. Make a sketch of the force-distance curve between two atoms, and illustrate the feature of the curve that corresponds to the elastic modulus of the solid in which the atoms reside. (6%)

(b) For all types of bonding, the relationship of the potential energy between atoms is similar to equation (1) in (a). Please discuss the relationships of potential energy well with elastic modulus, thermal expansion coefficient, and melting temperature. (6%)

2.(a) Give Fick's first law and identify the terms. Is it correct to interpret this law as follows — the jump rate of individual solute atoms increases as the concentration gradient increases and thus the flux increases? (3%)

(b) Measurement of the electrical resistivity of gold wires have indicated that the equilibrium vacancy concentration decreases two orders of magnitude when the temperature is reduced from 900°C to 523°C. Calculate the internal energy change associate with the formation of each vacancy in gold, and compute the fraction of lattice site that are vacant at the melting temperature (1063°C). (5%)

3. (a) Please explain why metal containing dislocations are so much weaker than their theoretical strength. (5%)

(b) At the ultimate tensile strength, the load $P = A\sigma$ is a maximum (A: area and σ: stress). Show that the criterion for necking of a tensile specimen can be written $d\sigma/d\epsilon = \sigma$ (ϵ: strain) and that if $\sigma = \sigma_0 \epsilon^n$, necking occurs when $\epsilon = n$. (5%)

(背面仍有題目,請繼續作答)

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4. The average dislocation velocity in a sample of iron can be expressed as $v=(\tau/\tau_0)^{40}$, where τ is the average shear stress in the sample and τ_0 is 15,000 psi.

(a) Why must this expression be modified or discarded at high stresses? (2%)

(b) Estimate the stress at which a sample of iron would begin to deform plastically. (4%)

(c) Estimate the fractional change in the flow stress that would accompany a fractional increment in the strain rate on the sample $\Delta\dot{\epsilon}_p/\dot{\epsilon}_p = 0.5$. (4%)

5. Second-phase inclusions are known to put an upper limit on the grain size of a metal. Please derive the Zener's relationship of $\frac{r}{R}=\frac{3}{4}f$, where r is the radius of the inclusions, R the radius of curvature of the average grain, and f the volume fraction of inclusions. Please also discuss the assumptions made in deriving this relationship and the effects of the morphology of inclusions on the grain growth. (10%)

6. 相圖(Phase Diagram)爲材料製程中之一重要技術資料，請敘述兩種製作相圖之實驗方法及相關原理。 (10分)

7. 鐵達尼號之悲劇發生於二十世紀初，當時之船身鋼材品質不佳，爲其沉沒之原因之一，請問其鋼材之缺點爲何及有效之改善方法。(5分)

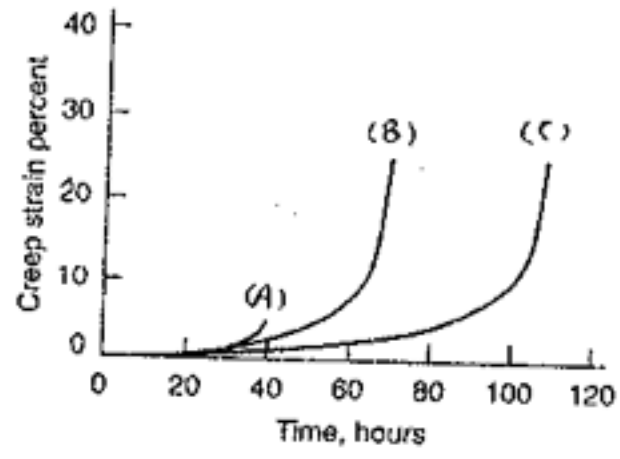
8. 右圖爲三種成分相同但晶粒組織不同之超合金試片之潛變強度(Creep Strength)測量結果。

(a) 請簡述超合金(Superalloys)之特性及主要用途？大致可分爲幾類？爲何具有此類特性之原因？(5分)

(b) 請問何謂潛變？其基本之機制爲何？(5分)

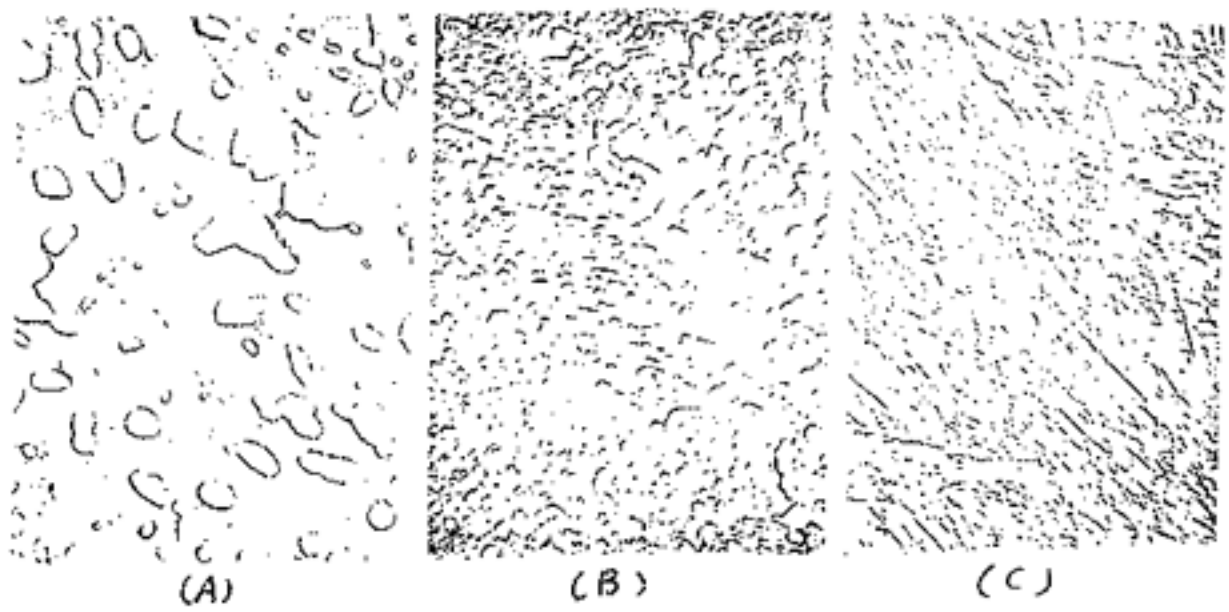
(c) 請分別列出此三類試片應爲何種組織，並解釋爲何依此順序？(5分)

(d) 請分別敘述此三類試片之製作方法及其要點？(5分)



9. (a) 下圖爲0.75%含碳量之鋼在三種不同溫度回火(Temper)不同時間後之金相圖，請判斷何者之溫度回火最高，何者之硬度最高，其順序爲何？並解釋依何原理作此判斷。(5分)

(b) 解釋何謂回火？上圖中之各種相分別爲何種組織。(5分)



10. The surface energy of a pure metal liquid is 600 ergs/cm^2; the volume of an atom of this metal in the liquid is 2.7 x 10^{-25} cm^3; and the free energy difference between an atom in the vapor and liquid is –2.37 x 10^{-22} J. Under these conditions, what would be the critical radius of a droplet, ro, in nm and the free energy of the droplet, ΔG_{ro}, in J? What would happened if the liquid consist with some alloying elements?

(5分)