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

$$U(r) = -\frac{A}{r^n} + \frac{B}{r^m}$$

where A, B, n, and m are constants. Write expressions for the force, the elastic modulus, and the heat of vaporization (or sublimation) in terms of n, m, A, and r_0 (the equilibrium distance) between two atoms. (10%)

(b) Please illustrate the relation of physical properties (the melting temperature, the elastic modulus, and the thermal expansion coefficient) to potential energy well and explain in brief. (10%)

2. Consider a circular dislocation loop of radius R in a crystal. The loading mechanism produces a constant resolved shear stress τ_A which tends to expand the loop.

(a) Write an expression for the total energy E (strain energy + loading mechanism energy) as a function of R. (5%)

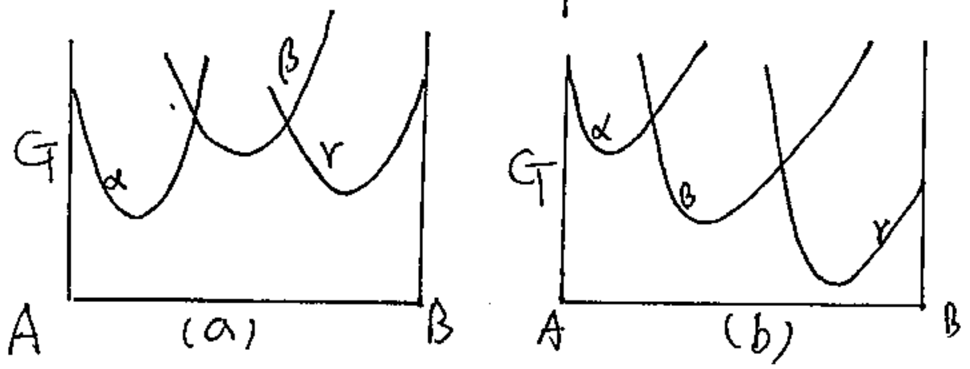
(b) With the aid of a suitable sketch, show that there is an equilibrium radius R for the loop, and also that the equilibrium is unstable. (5%)

3. Please use the dislocation model of yielding to explain the yield point phenomenon that is commonly observed in BCC metals and alloys and that is particularly important in low-carbon steels. (10%)

4. Please design an experiment to obtain the activation energy of the recovery of a metal single crystal and explain the physical meaning of the activation energy. (10%)

5. Explain why a Shockley partial dislocation with $\vec{b} = \frac{a}{6}\langle 112 \rangle$ changes the stacking sequence from FCC to HCP. (10%)

6.



Illustrate the stable phases through the composition range for Figs. (a) and (b). (10%)

7. Explain the up-hill and down-hill diffusion. (10%)

8. Show the characteritics of (a) the superconductor and (b) the second order transformation. (10%)

9. Explain why in pure metals solidification the supercooled liquid is required for the appearance of the protrusion. (10%)