1. (a) What is the fractional volume change in iron as it transforms from BCC to FCC at 910°C. Assume that the lattice constants a = 0.2910 nm for BCC and a = 0.3647 nm for FCC. (5%)
(b) What is volume change if atoms of fixed radius pack as hard spheres? (5%)

2. (a) List all the slip systems in FCC crystal structures. (3%)
(b) Consider a single crystal of FCC metal oriented such that a tensile stress is applied along [0 1 0] direction. Calculate and determine the active slip systems available at the beginning of plastic deformation. (7%)

3. (a) Distinguish between grain shape and grain orientation in single-phase materials. (5%)
(b) Ductile-to-brittle transition temperatures were not given the same attention in the design of riveted ships as is now given in the design of welded ships. Why? (5%)

4. (a) Give schematic diagrams for band models to differentiate between n-type and p-type semiconductors. Show the donor and acceptor levels. (5%)
(b) Cite and compare the various types of charge carriers for semiconductors. (5%)

5. (a) How to measure the toughness of materials using the stress-strain curve? (5%)
(b) Give one example of sacrificial anode, and explain how it works. (5%)

6. (a) Derive the relationship between true stress and engineering stress, and the relationship between true strain and engineering strain. (5%)
(b)The typical creep curve is a plot of strain versus time at constant stress and constant elevated temperature. The resulting creep curve consists of three regions. Explain why in the second region (secondary creep, also termed steady-state creep), the creep rate is constant. (5%)

7. (a) What type of vacancies, anion or cation, must be introduce with MgF_2 in order for it to dissolve in LiF? What type must be introduce with LiF in order for it to dissolve in MgF_2? (5%)
(b) Distinguish between CsCl-type, NaCl-type, and ZnS-type structures with regard to coordination number and the number of ions per unit cell. (5%)

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8. (a) For molecules, the glass transition temperature is lower with slower cooling. Why? (5%)

   (b) Explain why the thermal-expansion coefficient is greater above T_g than below T_g. (5%)

9. Using Fe-Fe_3C phase diagram as shown in Fig. 1:

   (a) Consider 97.0 Fe – 3.0 C (wt%) alloy. What phases are present in equilibrium at 1149°C? What are their chemical compositions? What is the weight fraction of each phase? (5%)

   (b) Repeat for the same alloy at 728°C. (5%)

10. (a) What are the Miller indices of planes a, b and c in Fig.2. (3%)

    (b) What are the Miller indices of directions 1, 2 and 3 in Fig.3. (3%)

    (c) The phase diagrams depicted in Fig. 4 are all thermodynamically impossible as draw. Provide good physical arguments that specifically indicate what is wrong. (4%)

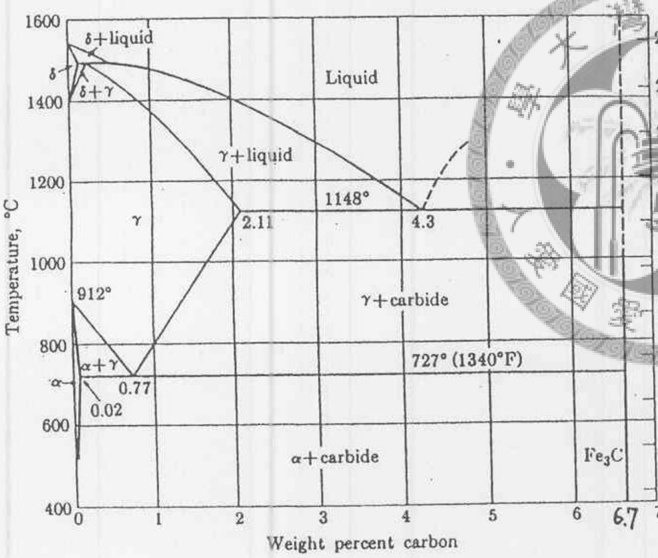

Fig. 1

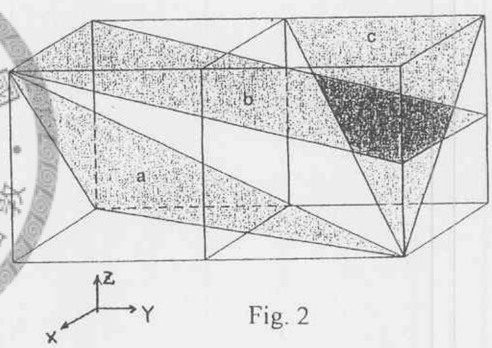

Fig. 2

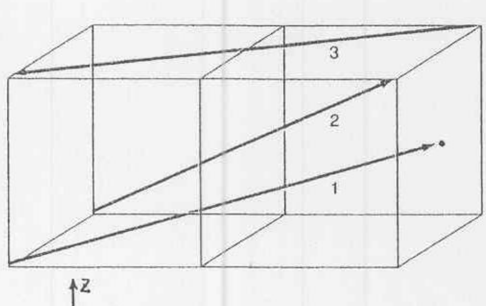

Fig. 3

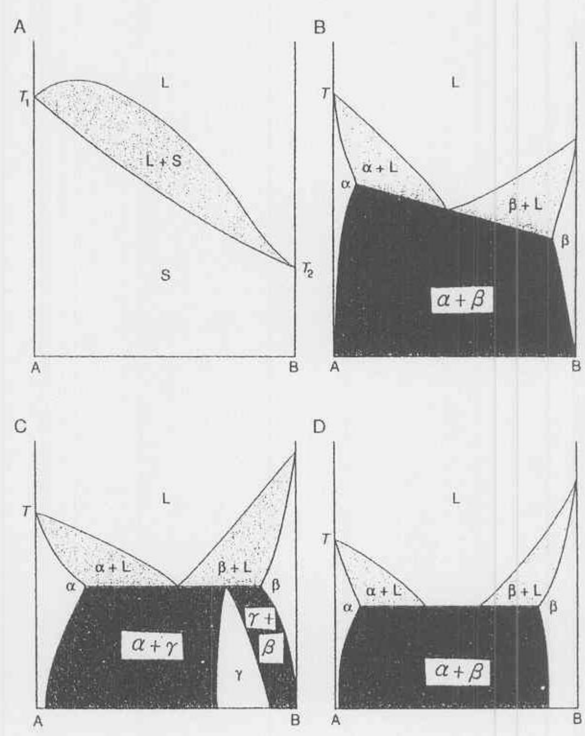

Fig. 4