1. **(a)** Consider the phase diagram for Cu and Ni (in Fig. 1) and alloy of composition C_o **at 1250°C**. C_α and C_L represent compositions of α and liquid, respectively; W_α and W_L represent mass fraction of α and liquid, separately. Derive the lever rule. **(5%)**

(b) The typical tensile stress-strain curves of a FCC metal single crystal is shown in Fig. 2. Curve a corresponds to the original tensile axis along [1 0 0]. On the other hand, Curve b corresponds to the original tensile axis along [3 2 1]. Explain why the strain-hardening of the FCC metal single crystal is orientation-dependent. **(5%)**

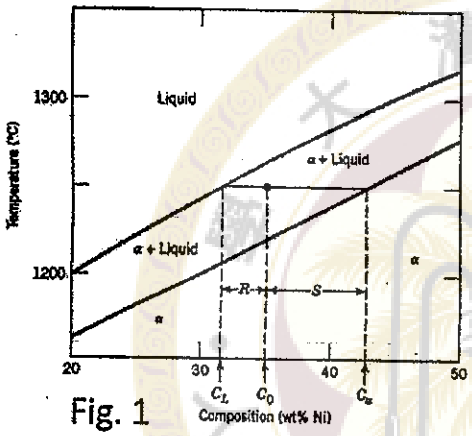

Fig. 1

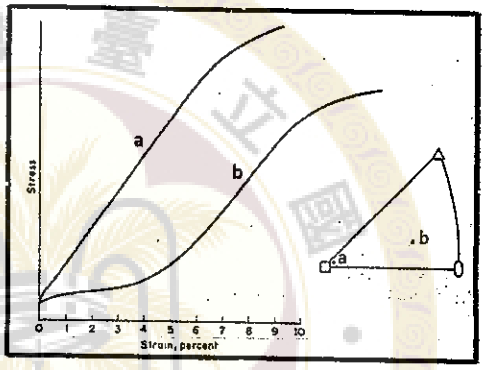

Fig. 2

2. **(a)** Briefly define Burgers vector for a dislocation. **(2%)**

(b) How to distinguish edge, screw and mixed dislocation according to the relative orientations of dislocation line and Burgers vector. **(3%)**

(c) To provide some perspective on the dimensions of atomic defects, consider a deformed metal specimen that has a dislocation density of 10^8 mm^{-2}. Suppose that all the dislocations in 100 mm^3 were removed and linked end to end. How far (in meter) would this chain extend? **(5%)**

3. **(a)** From X-ray diffractometry of a FCC metal, point out the indices of the planes, which are connected with the **first seven** respective diffraction peaks (from low angle to high angle). **(4%)**

(b) A pure metal crystal belongs to the cubic crystal system. From X-ray diffractometry measurements, it is known that the first seven diffraction peaks occurs at $\sin^2\theta$ = 0.137, 0.275, 0.412, 0.551, 0.688, 0.826, 0.962..., where θ is Bragg's angle. What is the crystal lattice (BCC, FCC or HCP)? Calculate and answer the question. **(6%)**

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4. **(a)** Briefly explain why BCC and HCP metal alloys may experience a ductile-to-brittle transition with decreasing temperature, whereas FCC alloys do not experience such a transition. **(3%)**

   (b) For plain carbon steels, the BCC ferrite has a maximum solubility, 0.02 wt% C, at 727°C. Under this condition, how many unit cell of BCC ferrite crystal lattice can contain 1 carbon atom? Calculate and answer the question. Atomic weight: C, 12; Fe, 55.85 **(7%)**

5. Sketch the chemical structure of atatic PMMA (poly (methyl methacrylate)) and syndiotatic PMMA. **(5%)** What kind of polymerization (addition polymerization or condensation polymerization) might be used to synthesis the atatic PMMA? Describe the mechanism of reaction. **(10%)** Could the atatic PMMA be served as fiber? Explain it in terms of structures? **(5%)**

6. What method(s) can you adopt during the processing of perovskite $BaTiO_3$ bulk ceramics in order to increase their electrical conductivity? Explain your answers. **(10%)**

7. Explain why the CTE (coefficient of thermal expansion) of LAS glass-ceramics is almost zero. **(10%)**

8. (a) Please plot and explain the curves of electron concentration versus temperature for n-type and intrinsic silicon. (b) As the dopant level of n-type silicon is increased would you expect the temperature at which a semiconductor becomes intrinsic to increase, to remain the same, or to decrease? Why? (c) Would you expect increasing temperature to influence the operation of p-n junction rectifiers and transistors? Please explain. **(10%)**

9. Please plot a schematic diagram and describe the operation of a silicon solar cell. Please also explain how the optical properties of silicon limit the efficiency of a silicon based solar cell. **(10%)**

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