

- Copper has an FCC crystal structure, with $a_0=0.361$ nm. Calculate

 - the planar density for the (010) plane in FCC copper (5%); and
 - the length of the **Burgers vector** in FCC copper. (5%)
- What are the Miller indices of the slip directions:

 - on the (111) plane in an FCC unit cell? (6%)
 - on the (011) plane in a BCC unit cell? (4%)
- Consider a binary phase diagram in Figure 1. This phase diagram has five points where three-phase coexist.

 - List the coordinates of composition (weight percent) and temperature for a **peritectic** reaction. (3%)
 - List the coordinates of composition (weight percent) and temperature for a **eutectoid** reaction. (3%)
 - List the coordinates of composition (weight percent) and temperature for a **monotectic** reaction. (4%)

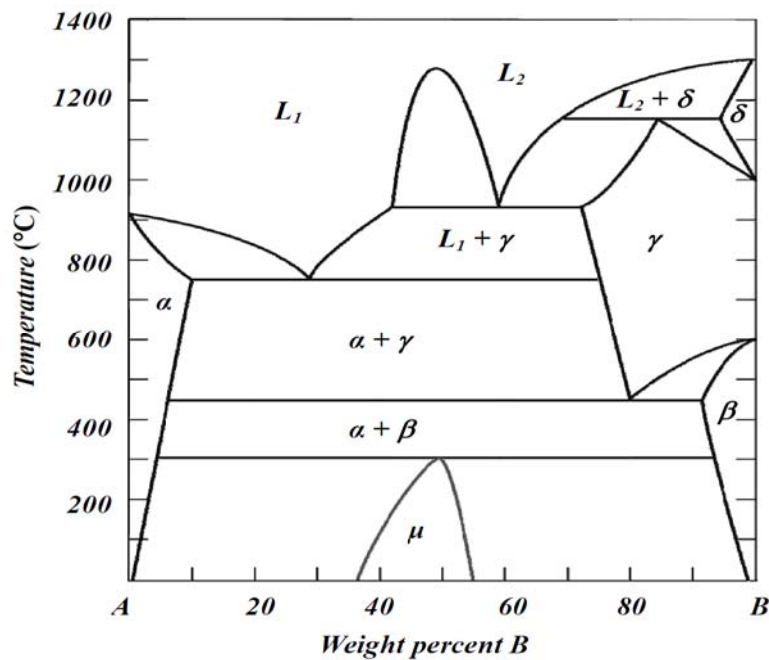


Figure 1 A binary phase diagram

4. (a) What is the Gibbs phase rule? (4%)
(b) Determine the degrees of freedom in the A-80%B alloy shown in Figure 1 at
(i) 1200°C, (ii) 800°C, and (iii) 450°C. (6%)
5. (a) Describe the ductile to brittle transition temperature (**DBTT**). (5%)
(b) What kind of materials has a distinct **DBTT**, and what has not? (5%)
6. (a) What is the critical resolved shear stress? (4%)
(b) Derive the relationship between the resolved shear stress and the applied tensile stress for a single crystal of metal cylinder. (using common parameters A , F , σ , τ , λ and ϕ ; λ is the angle between the slip direction and the applied force, ϕ is the angle between the normal to the slip plane and the applied force.) (6%)
7. Explain the following terms: intrinsic semiconductor, n-type semiconductor, direct bandgap semiconductor, and indirect bandgap semiconductor. (10%)
8. Describe 3 types of crystalline defects and their respective roles in strengthening metals. (The names of strengthening mechanisms should be included in your answer.) (10%)
9. (a) Indicate all the octahedral sites in one FCC unit cell. (6%)
(b) Calculate the number of octahedral sites that uniquely belong to one FCC unit cell. (4%)
10. Describe the main processing steps for steel production from iron ore to molten steel. (Main materials, equipments, and reactions should be included in your answer.) (10%)