

1. (20%) True or False: For each of the following statements, determine whether the statement is true or false and then reason your answer.

- (1) In an alloy, there is an equilibrium concentration for vacancies, but not for dislocations.
- (2) In alloys, the relative contribution of diffusion through high-diffusivity paths is always larger than that through lattice diffusion.
- (3) Heat treatment can markedly change the Young's modulus of carbon steel.
- (4) The planar density of FCC (111) is larger than that of FCC (110).

2. (20%) Based on the Cu-Zn binary phase diagram shown in Figure 1,

- (1) Write down all the invariant reactions.
- (2) What heat treatment is frequently performed when a brass plate or tube is processed into musical instruments, such as trumpet?
- (3) When a molten Zn - 5 at. % Cu liquid is slowly cooled down to room temperature, write down the phase evolution associated to the equilibrium solidification process. Note: at. % stands for atomic percent
- (4) Draw a schematic showing the microstructure when the molten Zn - 5 at. % Cu liquid is rapidly cooled down to room temperature.

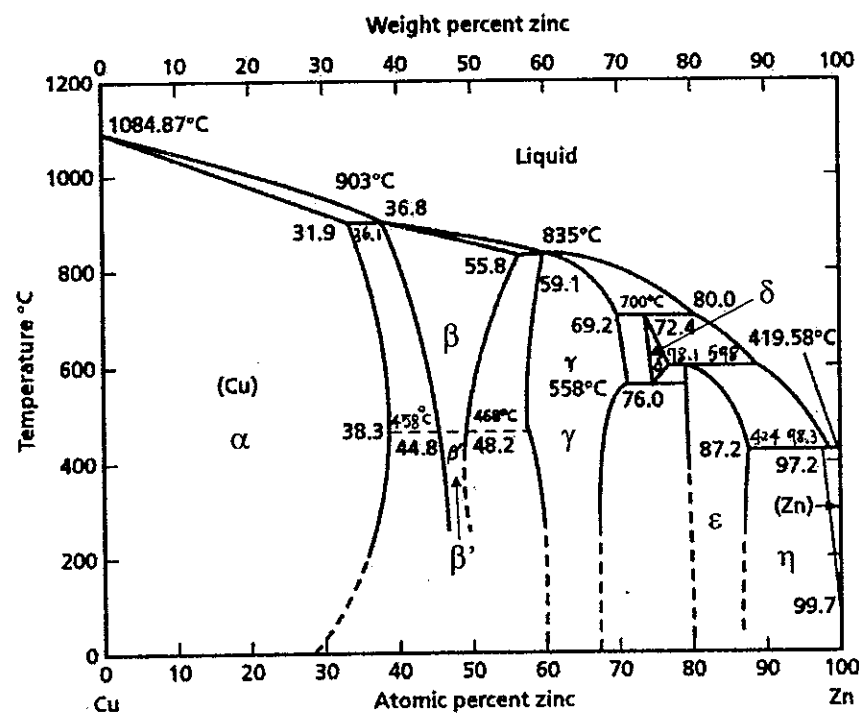


Figure 1 The Cu-Zn binary phase diagram.

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3. (10%) A four-point bending test was performed on an alumina specimen having a circular cross section of radius 4.0 mm. The specimen fractured at a load of 1000 N, when the distance between the upper supporting points and lower supporting points is 20 mm and 40 mm, respectively. Another three-point bending test is to be performed on a specimen of the same material, but one that has a square cross section of 7.0 mm length on each edge. The distance between the supporting points is 40 mm. At what load would you expect this specimen to fracture?
4. (10%) Consider a parallel-plate capacitor having an area of 3000 mm<sup>2</sup> and a plate separation of 5 mm, and with a material of dielectric constant 10 positioned between the plates. In order to reduce the size of the capacitor, a multilayered structure is prepared using the same dielectric. The dimensions of the capacitors are as following: the area of 30 mm<sup>2</sup>, the plate separation of 1 mm. What is the number of the layers for this multilayered structure?
5. Sketch the chemical structure for poly(hexamethylene adipamide)(nylon-6,6) and Poly(hexamethylene sebacamide)(nylon-6,10). (4%) Which one would have the higher melting temperature? Why? (6%)
6. (10%) At the upper yield point, a small neck forms within the gauge section of polymeric specimen. There is a resistance to continued deformation at this point, and specimen elongation proceeds by the propagation of this neck region along the gauge length. For ductile metals once a neck has formed, all subsequent deformation is confined to within the neck region. Why?
7. (14%) What is the device structure of Complementary Metal-Oxide-Semiconductor (CMOS)? What is the most common materials used in CMOS based semiconductor devices? Please describe the advantage and limitation of the materials used in semiconductor devices. What are the most possible semiconductor materials that will be used in future semiconductor devices? Please describe the reasons.
8. (6%) What are the most common materials used in solar cell industry? Please describe the advantages and limitation of the materials used in solar cell devices.

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