Problem 1

Iron has a BCC structure at room temperature. When heated, it transforms from BCC to FCC at 1185 K. The atomic radii of iron atoms at this temperature are 0.126 and 0.128 nm for BCC and FCC, respectively. What is the percentage volume change upon transformation from BCC to FCC? (8 points)

Problem 2

If a Bragg angle of 42.5° is observed for the first order diffraction from the {110} planes, of body-centered cubic niobium using copper kα 1 radiation (λ =0.1541nm) , what is the interplanar spacing of the {110} planes? (7 points)

Problem 3

(a) Determine the distance of separation between a positive ion and a negative ion, each carrying a charge equal to that of an electron, if their mutual force of attraction equals -5×10^{-9} N. (5 points)

(b) What is the coulomb potential energy of this ion pair? Give your answer in joules, calories, electron volts, and joules per mol of ion pairs. (5 points)

Problem 4

The critical resolved shear stress of an FCC metal is 1 MPa. A single crystal of this metal is pulled along [123]. (a) What slip systems will be activated first? (5 points) (b) What normal stress will cause plastic deformation? (5 points)

Problem 5

(a) A vanadium (V) crystal has a Burgers vector of length 2.62 Å. If the lattice parameter of V is 3.02 Å, determine whether V has the BCC or the FCC crystal structure. (5 points) (b) If a total dislocation in an FCC lattice has a Burgers vector a/2[-110] and lies in a (111) plane, indicate the Burgers vectors of the pairs of partial dislocations into which it may dissociate. (5 points) (c) Why such dissociation occurs? (5 points)

Problem 6

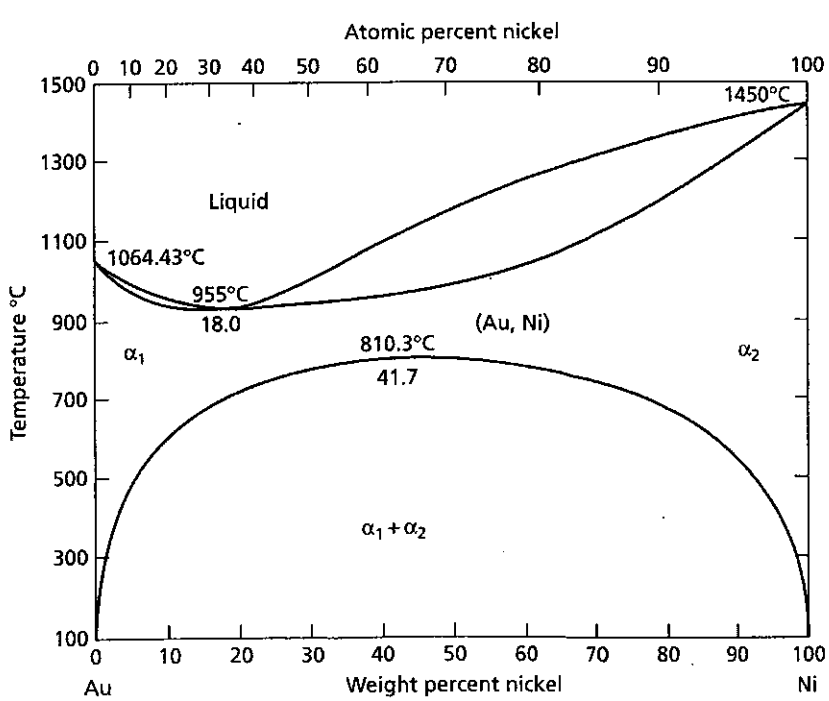
(a) What are the causes of thermal expansion coefficient (5 points)? (b) Please calculate the linear thermal expansion coefficient of Cu between 30° C and 700° C assuming the vacancy formation is the only cause for thermal expansion and Cu is isotropic. The vacancy formation energy of Cu is 83700 J/mole and R is 8.314 J/K·mole. (10 points)

Problem 7

If an aluminum sample is annealed for a long time, under conditions favoring the development of grooves along the lines where internal grain boundaries intersect the outer surface of the sample, a groove angle of 160° occurs. If the grain boundary energy for aluminum is 0.57 J/m2, what is the energy of the aluminum-air surface? (10 points)

Problem 8

A gold-nickel alloy containing 60 percent nickel is heated to 1100°C and allowed to come to equilibrium. Determine the amount and composition of the liquid and solid phases when equilibrium is attained. Define the congruent transformation and phase separation on cooling. (10 points)

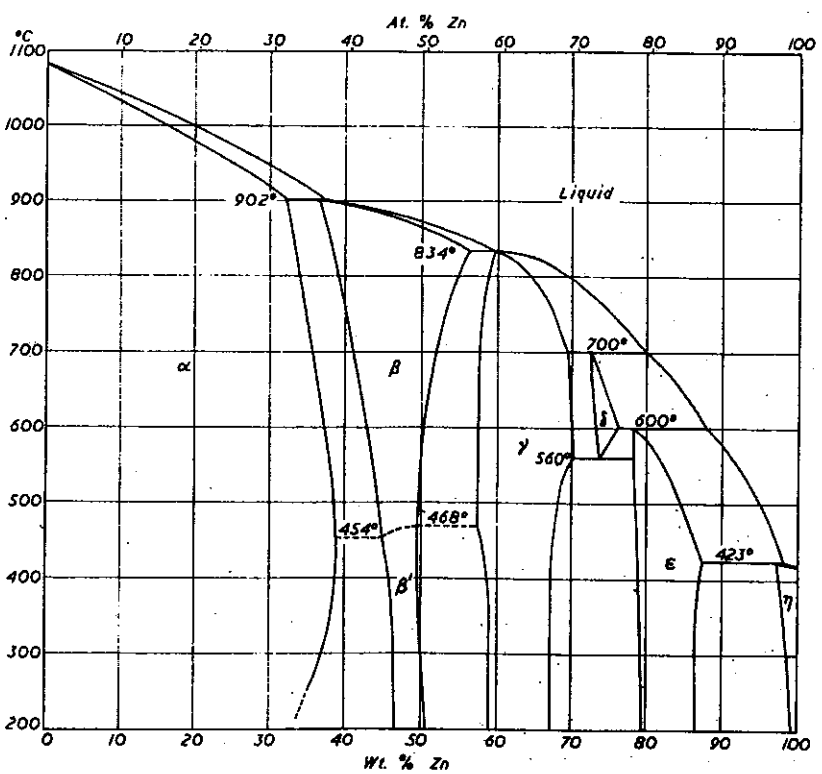


Problem 9

A diffusion couple of Cu-Zn is produced by permitting blocks of copper and zinc to lie in contact for several days at 400°C. Then it is rapidly cooled to room temperature. Given the Cu-Zn binary phase diagram and a corresponding micrograph of the reaction layers at the interface between Cu and Zn.

(a) Illustrate the correlation between the reaction layers formed in a Cu-Zn diffusion couple and the Cu-Zn phase diagram. Explain what and why you see on the micrograph and the corresponding region in the Cu-Zn phase diagram. (10 points)

(b) Give the activity versus composition curves for Cu and Zn. (5 points)



Cu-Zn