

Engineering 45
The Structure and Properties of Materials
Midterm Exam
March 19, 2014

Problem 1:

- (a) Describe the β -ZnS structure and show how it is related to the FCC structure.
- (b) The β -ZnS structure is adopted by many covalently bonded compounds, like GaAs. Why would this structure be favored? [Ga has valence 3, As has valence 5.]
- (c) The β -ZnS structure is also adopted by some ionic compounds, such as AgI. What features of the β -ZnS structure makes it suitable for ionic materials?
- (d) Consider a series of binary compounds (AB) that bond ionically, let R_A be the radius of the A ion and R_B the radius of the B ion. As the ratio R_A/R_B decreases from 1.0, the structure tends to change from CsCl to NaCl to β -ZnS. Why?

Problem 2:

(a) In a given crystal, interstitial species diffuse much more rapidly than substitutional species. Why?

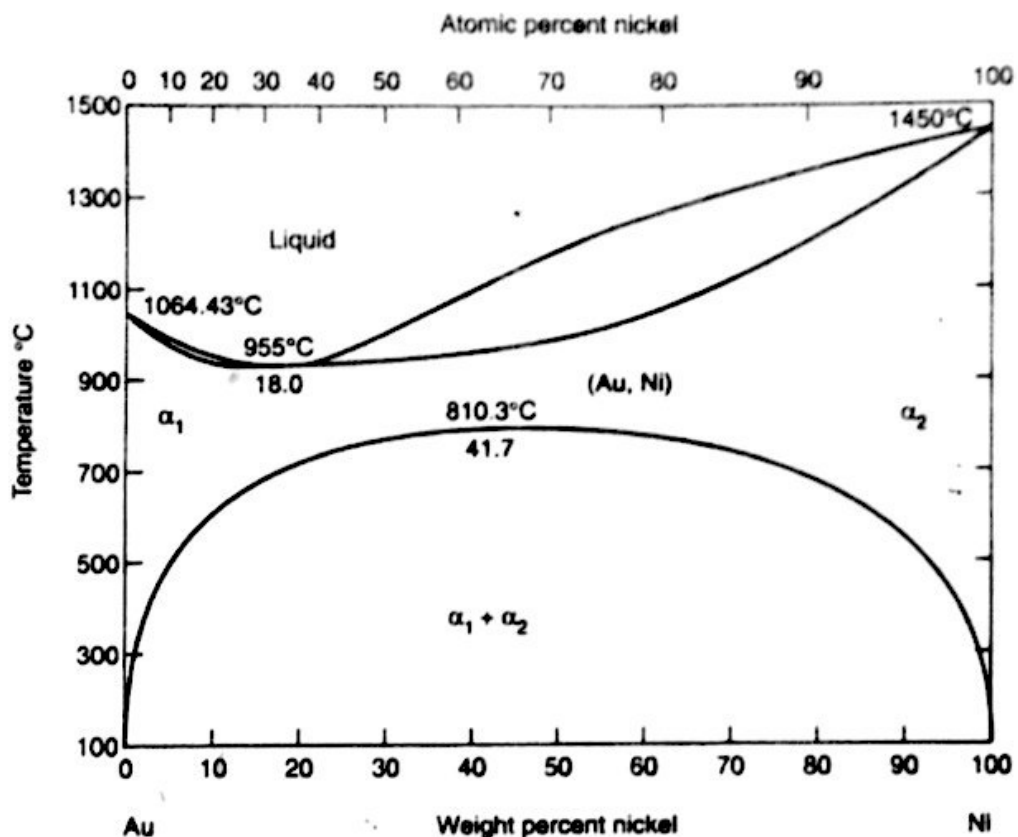
(b) Plot, schematically $\ln(D)$ vs. $1/T$ for an interstitial and a substitutional species in a polycrystalline solid, where D is the diffusivity and T is the absolute temperature.

(c) How would you determine the activation energies for diffusion from this plot? Why are the activation energies similar at low temperature?

(d) If you quench a crystalline solid from high temperature, the diffusivity of a substitutional species is very high immediately after quenching, but decreases with time until it asymptotes at the value appropriate to the final temperature. Why?

Problem 3:

A binary system Au and Ni has the complex phase diagram drawn below.



(a) Find the phases present, their compositions and the phase fractions for the following cases (x = weight percent Ni in the overall system):

$x = 10$	$T = 900^\circ\text{C}$
$x = 10$	$T = 300^\circ\text{C}$
$x = 50$	$T = 900^\circ\text{C}$
$x = 50$	$T = 1100^\circ\text{C}$

(Estimate any numbers you need.)

(b) Au has the fcc crystal structure. Reasoning from the phase diagram, what is the crystal structure of Ni? How do you know?

(c) Reasoning from the phase diagram, do Ni and Au form stronger bonds to themselves (Ni-Ni and Au-Au) or to one another (Ni-Au)? How do you know?

(d) Ni and Au form a solid solution at all compositions at high temperature, but not at lower temperature. Explain this behavior in terms of the interplay of energy and entropy.