

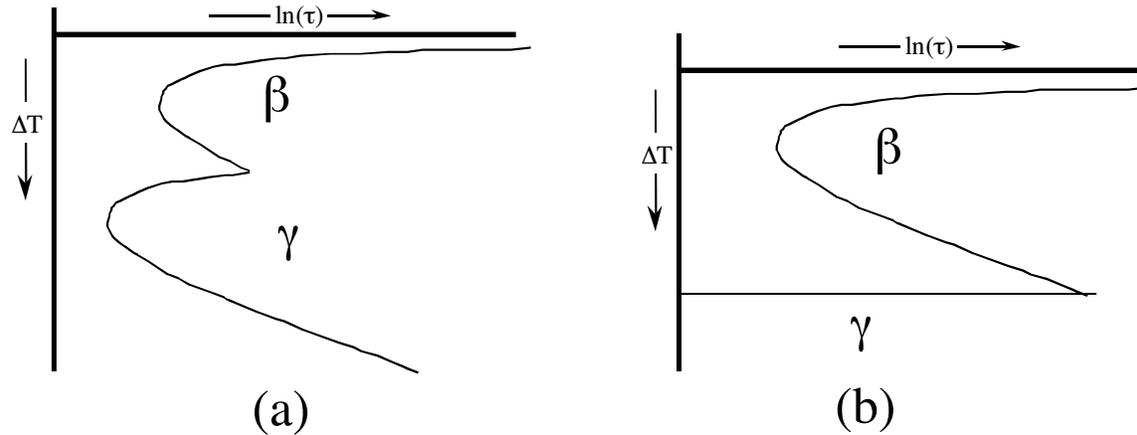
Engineering 45
The Structure and Properties of Materials
Midterm Exam
March 22, 2006

Problem 1: (35 points)

- (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, like AgI. What characteristic of these compounds would favor β -ZnS over other ionic structures?
- (d) Under what conditions might a metallic AB compound choose the β -ZnS structure?

Problem 2: (30 points)

- (a) Draw an edge dislocation in a simple cubic crystal.
- (b) Show how the glide of that dislocation produces plastic deformation.
- (c) Define the “climb” of an edge dislocation and explain why it is difficult for an edge dislocation to climb unless the temperature is high.
- (d) When a metal is severely deformed the diffusivity of substitutional species within it usually increases significantly, and remains high for some period of time after the deformation is finished. Why?

Problem 3: (35 points)

A one-component material has three possible structures, α , β and γ . At high T the system is α . If it is cooled slowly it transforms to β at $T < T_{\alpha\beta}$, and remains β for all lower temperatures. If it is cooled quickly it transforms to γ at $T_{\alpha\gamma} < T_{\alpha\beta}$.

(a) Suppose that both the $\alpha \rightarrow \beta$ and $\alpha \rightarrow \gamma$ transformations occur by nucleation and growth. Sketch plausible forms of the free energy vs. temperature curves for the three phases that might lead to this behavior.

(b) Are the kinetics of this transformation more likely governed by fig. (a) or fig. (b)? Explain.

(c) Now assume that phase α is a liquid, phase β is a crystalline solid and phase γ is a glass. Are the kinetics of the transformation more likely governed by (a) or (b) in this case? Explain.

(d) While it is possible to suppress the $\alpha \rightarrow \beta$ transformation by rapid cooling, it is not ordinarily possible to suppress the $\beta \rightarrow \alpha$ transformation by rapid heating. Why?