3.40J/22.71J Physical Metallurgy
Final Examination
3 hours

Closed Book, Closed Notes, except one, 8.5"x11" Spike sheet.
R = 8.3 J/mole K = 1.98 cal/mole K. k = 1.38×10^{-23} J/K

Do all eight problems, which are weighted equally. Show all your work and justify all assumptions and approximations. This exam is to be written in your choice of ink, except disappearing ink

1. Consider the recrystallation of an alloy in which all $10^{12}/m^3$ recrystallization nuclei are present as infinitesimal cubes at t = 0. The cube edge length grows at a rate of 10^{-4} m/s.
a. After what time will 1% of the sample be recrystallized?
b. At APPROXIMATELY what time will 50% of the sample be recrystallized?

2. Write a brief essay on hard magnetic storage materials. What characteristics are desired, and how are composition and processing tailored to achieve these?

3. Consider homogeneous nucleation from a dilute solid solution, such as Cu in Al.

a. The solvus temperature for a particular alloy lies at, say, 1000 K. Draw a schematic plot of LogJ (where J is the homogeneous nucleation rate of the equilibrium phase) vs. T for 300<T<1000 K. Per convention use T as the ordinate.
b. Homogeneous nucleation of a coherent transition phase may also occur. Strain energy reduces the solvus temperature to 900K, but the particle:matrix surface energy is only one quarter that in a. Again, draw a schematic plot of LogJ vs. T for 300K<T<1000 K. Use the same axes as in a.
c. Explain the similarities and differences in the two plots.

4. Describe as quantitatively as possible the effect(s) of solutes on the migration of grain boundaries. Then explain how such atmospheres affect recovery and recrystallization of alloys.

5. Solution strengthening is one of the four basic strengthening mechanisms. Describe, quantitatively as possible, how this mechanism works. Some solutes are far more effective strengtheners than others. Explain why this is so.

6. Define or describe the following:
Electromigration
Coincident site lattice
Coherent spinodal

7. A particle of a phase, β lies at an α:α grain boundary.

a. If $\gamma_{\alpha\alpha} = 0.5 J/m^2$, and $\gamma_{\alpha\beta} = -0.3 J/m^2$, what is ϑ?

b. What value of $\gamma_{\alpha\beta}$ would give $\vartheta = 0$?

8. The figure below gives the hardness of two tempered martensites. Both contain 0.35 wt. % C, but one contains 5 wt.% Mo as well. The hardnesses were measured at room temperature after a 1 hr tempering treatment at the temperature shown.

a. Explain the 'hump' in the hardness of the Mo-bearing steel.
b. Why is the hardness of the Mo-bearing steel so high, even after tempering at 600 C?