

3.40J/22.71J Physical Metallurgy Problem set 5.  
(Glitches exorcised . Sorry for the confusion)

Problem A

A young scientist was given the task of limiting grain size during high temperature processing of aluminum sheet. Having taken 3.40J/22.71J in the past, this scientist recalled that fine particles tended to limit grain growth, and that finer particles were most effective. The scientist decided that the finest possible particle was single atoms, so introduced 0.1 at.% solute, rather than 0.1 vol% particles.

- a) Is this approach likely to be effective? Why or why not?
- b) Compare the effects of solute and particles on high temperature grain growth. For simplicity, answer in terms of disordered grain boundaries. A few equations would improve your explanation.

Problem B

Consider recrystallization in a metal cold worked to 40% reduction in area so that the nucleation rate in the untransformed volume is a constant, given by  $(N \dot{)} = (10^{20}) \exp(-80 \text{kJ}/RT)$  particles per meter cubed per second, and the constant isotropic growth rate is given by  $(G \dot{)} = \exp(-120 \text{kJ}/RT)$  meters per second.

- a) At a temperature of 1000K, calculate:  
(t sub r), the time for about 50% recrystallization.  
The mean grain diameter.  
(N sub v), the approximate number of grains per meter cubed when recrystallization is complete. (Approximate the grains as spheres)
- b) At what temperature would you obtain a nucleation rate one thousand times that calculated in a)?
- c) Suppose that instead of being coldworked 40%, the metal is coldworked 80%. What will be the approximate effect on nucleation rate, growth rate, time for 50% recrystallization, and number of grains per unit volume? Do not attempt to calculate these quantities, but state whether each would increase or decrease, greatly or moderately, and justify all your answers.

Given:  $R=8.3\text{J}/\text{mol.K}$