HW#8 due November 15

1. (a) Rewrite the expression for the total free energy change for nucleation (Equation 10.1) for the case of a cubic nucleus of edge length a (instead of a sphere of radius r). Now solve for both the critical cube edge length, a*, and ΔG^*.

(b) Is ΔG^* greater for a cube or a sphere? Why?

2. (a) For the solidification of Ni, calculate the critical radius r* and the activation free energy ΔG^*, if nucleation is homogeneous. Values for the latent heat of fusion and surface free energy are -2.53×10^{9} and 0.255 J/m^2, respectively. Use the supercooling value found in Table 10.1.

(b) Now calculate the number of atoms found in a nucleus of critical size. Assume a lattice parameter of 0.360 nm for solid nickel at its melting temperature.

Table 10.1

TABLE II. Summary of results of microscopic observations on supercooling of small droplets.

Metal	Source	Melting point °K (T_0)	Method of observation	Atmosphere	Flux	Particle size (microns)	Maximum super-cooling $(\Delta T_-)_{max}$	$(\Delta T_-)_{max}/T_0$
Selenium		493	Surface change	Hydrogen	None	75	25[a]	0.051
Bismuth	A	544	Surface change	Hydrogen	None	10–15	90	0.166
	B	544	Surface change	Hydrogen	None	20–50	90	
Lead	A	600.7	Surface change	Hydrogen or vacuum	None	15–50	67	0.151
	B	600.7	Surface change	Hydrogen	NaOH + KOH	10–20	69	
Antimony		903	Surface change	Hydrogen	None	15–30	135	0.150
Aluminum		931.7	Surface change	Hydrogen	None	50–100	48	
					NaOH	50–100	130	0.140
Germanium		1231.7	Surface change + blick	Helium	None	15	235	0.184
					Pyrex	400	219	
Silver		1233.7	Surface change	Helium	Pyrex	20–40	227	0.184
Gold	A	1336	Surface change + blick	Helium or vacuum	Pyrex	20–50	221	0.172
	B	1336	Surface change + blick	Helium or vacuum	None	40–50	230	
Copper		1356	Surface change + blick	Hydrogen or helium	None	15–50	236	0.174
Manganese		1493	Blick	Hydrogen	Pyrex	50	308	0.206
Nickel		1725	Blick	Helium	Pyrex	50–100	319	0.185
Cobalt		1763	Blick	Helium	None	20–50	330	0.187
Iron		1803	Blick	Helium	None	30–100	295	0.164
Palladium		1828	Blick	Helium	None	30–100	332	0.182

[a] Corresponds to maximum supercooling that could be reached such that crystallization did not occur on re-heating.

3. The kinetics of the austenite-to pearlite transformation obeys the Avrami relationship. Using the fraction transformed-time data given here, determine the total time required for 95% of the austenite to transform to pearlite.

Fraction Transformed	Time (s)
0.2	280
0.6	425

4. Briefly describe the simplest heat treatment procedure that would be used in converting a 0.76 wt.% C steel from one microstructure to the other, as follows:

(a) Martensite to spheroidite

(b) Bainite to pearlite

(c) Spheroidite to pearlite

(d) Tempered martensite to martensite