3.40J / 22.71J

Modern Physical Metallurgy

Problem Set 2
Due 03.11.04

1. Vacancies in Cu
(a) Calculate the equilibrium concentration of vacancies in pure Cu at room temperature, using the Boltzmann representation derived in class.

(b) What is the percent change in the number of vacancies if you cool this Cu sample to 10K, and what is the inter-vacancy distanice if we assume these are evenly distributed in the material?

(c) What is the percent change in the number of vacancies (compared to room temperature) if you heat this Cu sample to 1200K?

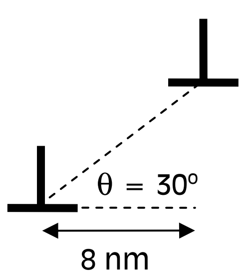
(d) In this 1200K example, would you be sure to find a vacancy within a sample volume of 10 nm^3? If so, how many should you find? If not, why not?

2. Compare the equilibrium vacancy concentration of the elemental metals listed below, each at 5K below their melting temperatures. Why do you think the concentrations rank the way they do?

Metal	**T_m [K]**	**H_f [eV]**
Ag	1234	0.92
Ni	1726	1.40
Pt	2042	1.40

3. Draw and label the Burgers vector within the unit cell representations of Cu, Fe and Mn, all at room temperature. For each, calculate the magnitude of the Burgers vector, noting that **b** is a function of *a* as discussed in class.

4. Dislocation-dislocation interactions
(a) For the dislocation configuration below, determine the glide and climb forces on the bottom dislocation induced by the top one.



(b) If this configuration were found in Al, and the internal lattice resistance force per unit length of this Al were 1 x 10^{-4} N/m, would the bottom dislocation move at room temperature?

5. Screw dislocations

(a) Find the magnitude and orientation of the maximum force per unit length on a screw dislocation subject to a far-field applied stress $\sigma_{xz} = \sigma_{zx}$.

(b) Assuming that this force is greater than the internal resistance to motion within the crystal, show which direction the screw will move.

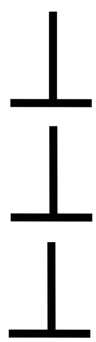
(c) In a real FCC crystal, what would the possible Burgers vectors and line directions be for this screw defect if it we choose to consider only the (111) slip plane? Pick one of these and predict which plane the screw would move to if it needed to leave the (111) plane.

(d) Explain the following statement: The motion of screw dislocations is less restricted than the motion of edge dislocations.

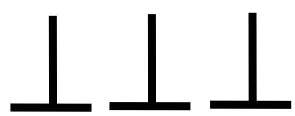
6. Stable dislocation configurations

(a) Using what you've learned about dislocation-dislocation interactions, explain in detail which of the following edge dislocation configurations is more stable, and why.

(i)



(ii)



(b) Give at least 2 examples of the more stable configuration that are found in metals.