Quiz 4

Thursday, February 10, 2011

Your Name:

1. [10 points] A piece of 3-dimensional crystal has a volume of $(2\pi)^3\ \mu\text{m}^3$. The primitive cell has a volume of $(2\pi)^3\ \text{Å}^3$. In the primitive cell, there are 30 atoms. Assume the Born von Karman boundary condition. Answer the following questions. No proof is necessary. If you like or if necessary, you can get your answers by assuming a simple cubic crystal with a simple cubic primitive cell, but know that you should not have to do that -- your answers apply to a crystal with any Bravais lattice. In the following, we mean "a wave in the bulk of this crystal" when we say "a wave in this crystal".
   a. What is the $\vec{k}$-space volume per $\vec{k}$ point allowed for a wave in this crystal?
   b. How many distinct $\vec{k}$ points exist in a $\vec{k}$ space volume of 1 Å^{-3}?
   c. How many primitive bases make up this crystal?
   d. What is the volume of the primitive cell in the $\vec{k}$ space?
   e. How many distinct crystal momentum values are there for this crystal?
   f. How many phonon branches exist for this crystal?
   g. How many acoustical phonon branches? How about TA, LA? TA = transverse acoustical, and LA = longitudinal acoustical.
   h. How many optical phonon branches? How about TO, LO?
   i. How many phonons exist at the zero temperature?