Midterm Exam: Solid State Physics 476
Nov. 4, 2004

One cheat sheet, double sided. Point values are given with each question. Total midterm is worth 36 points with 6 available bonus points. Maximum mark will still be 100%.

1. Consider a hexagonal Bravais lattice.

   (a) What is the relationship between the lattice vectors (lengths and angles)? (2)

   (b) Draw a sketch of the plane perpendicular to the 6-fold symmetry axis with the lattice points. Also sketch in the unit cell. (2)

   (c) What does it mean to add a "basis"? Give the basis if this is a hexagonal close packed system. (2)

   (d) What is a screw transformation? Describe a screw transformation that transforms one of the basis points to another. (There may be a few options for this, pick whichever one you like.) Indicate the location of the screw axis on your previous diagram (4) (bonus: use the correct symbol 2)

2. Consider a body-centred cubic crystal structure with a lattice constant of 5.5 Å.

   (a) Draw a diagram of the unit cell and indicate where the (110) plane is. (2)

   (b) Give the length of the reciprocal lattice vector associated with the (110) plane. (hint: $\vec{G} = h\vec{A} + k\vec{B} + l\vec{C}$) Feel free to take some shortcuts if you know the values for $\vec{A}$ and $\vec{B}$. (2)

   (c) What is the Laue condition for scattering? If the magnitude of the wavevector of the incident radiation is 4 $\mathring{A}^{-1}$ Draw the appropriate scattering diagram showing initial $\vec{k_i}$, final -$\vec{k_f}$ and $\vec{G}$. Calculate the scattering angle, what we usually call 2θ. (6).

3. What is the Dulong-Petit law and what assumptions go into it? Briefly explain how it fails at low temperature with a sketch. What do the Einstein and Debye models say about the temperature dependence of the low temperature specific heat? (just an answer in words is fine) Which of these two models includes low energy modes? (8) (bonus: why do these modes contribute relatively little to the low temperature specific heat, two reasons, 4 points).

4. Draw a sketch of the phonon dispersion for a one-dimensional chain of atoms each with mass m, interaction constant k (or $m\omega_0^2$), and atomic separation a. Given functional forms and quantitative descriptions of important values where possible. (8)