PROBLEM SET 1

(Due Tues., Feb. 12, 2008)

1. [Kittel, 1.1] Find the angles between the tetrahedral bonds of the diamond lattice.

2. Derive the Bragg condition:

   a) Prove that the reciprocal lattice vector $\mathbf{G} = h\mathbf{a}^* + k\mathbf{b}^* + l\mathbf{c}^*$ is perpendicular to the (hkl) lattice plane.

   b) Show that the distance between two parallel planes of the lattice is: $d(hkl) = 2\pi/|\mathbf{G}|$.

   c) Now show that the result derived in class: $2\mathbf{k}\bullet\mathbf{G} = G^2$ is equivalent to the more familiar Bragg condition: $2d\sin\theta = n\lambda$.

3. [Kittel, 2.5] The crystal structure of diamond can be considered as a simple cubic lattice with a basis of 8 atoms (conventional cube cell).

   a) Find the structure factor S for this basis.

   b) Find the zeroes of S and show that the allowed reflections of the diamond structure satisfy: $(v_1 + v_2 + v_3) = 4n$, where all indices are even and n is any integer, or else all indices are odd.

4. Determine the Bragg angles for the (111), (220), (311), and (400) reflections of germanium using "Copper K_α" X-rays ($\lambda = .154$ nm).

5. [Kittel 2.6] For the hydrogen atom in its ground state, the electron density is: $n(r) = (\pi a_0^3)^{-1}\exp(-2r/a_0)$, where a_0 is the Bohr radius. Calculate the atomic form factor.

6. Find any paper published within the past 20 years that includes an X-ray diffraction measurement to characterize a strained epitaxial semiconductor layer. Give a brief description of just this aspect of the paper, i.e. show the X-ray diffraction data and the conclusions that were reached from it.

   [**Literature search rules** This type of assignment will occur with some regularity in this course. Please do not turn in complete xerox copies of articles. Include only important exerpts and/or figures (always include any figure captions). Most importantly, always give a complete citation of any paper you reference.]