PH207 - Solid State Physics

Problem set N. 2

Handed out 16/02 – Due in 26/02

1. The element Po forms a crystal with a simple cubic structure of spacing 3.34 A (1 A = 10^{-10} m). What is the maximal wavelength of radiation that is diffracted from a powder of that crystal?
   [*2 marks*]

2. Estimate the kinetic energy (in eV) of a neutron which might diffract from a typical crystalline lattice, given that for a neutron $mc^2 \simeq 1$ GeV and $hc \simeq 1.24$ GeV $\times$ fm. Recall: 1 fm = 10^{-15} m and 1 Gev = 10^9 eV. (hint: relate the momentum of the particle to its wavelength.)
   [*3 marks*]

3. In the X-ray powder diffraction pattern discussed in the lectures, only the first four lines were shown to be consistent with scattering from a simple cubic lattice. Extend the analysis to the next four lines at d=10.77, 11.93, 14.12 and 15.18 cm. At what values of d would line 9 and 10 been expected?
   [*5 marks*]

4. Consider a monoatomic BCC lattice as a simple cube with a basis and a reciprocal lattice vector $\vec{G} = (2\pi/a)(n_1, n_2, n_3)$, a being the lattice spacing. Prove that the corresponding structure factor is $2f$ if $n_1 + n_2 + n_3$ is even and 0 otherwise.
   [*3 marks*]

5. An experiment is carried out on metallic Na powder in a Debye-Scherrer camera. Knowing that: a) the radius of the camera is 10 cm; b) the radiation has wavelength $\lambda = 0.1$ nm; c) the structure is BCC and d) the spacing of the (non-primitive) cubic cell is 4.225 A, determine the position in space (i.e. d of problem 3) of the first three maxima in the diffraction pattern.
   [*7 marks*]