

Homework 2 - Phys 601

P1. Construct the Wigner-Seitz cells for all the five types of Bravais lattices.

P2. At about 13 deg C , gray tin (α - Sn) undergoes a phase transition to white tin (β -Sn). α - tin has a diamond structure with a lattice constant of 0.649 nm, while β - tin has a body-centered tetragonal structure with $a=0.583$ nm and $c=0.318$ nm. Evaluate the mass densities in two phases. Compare those values to the experimental values in literature.

P3. Calcium fluoride CaF_2 has a face-centered cubic lattice with a basis of F- at $(0,0,0)a$ and $(0,0,1/2)a$ and Ca^{2+} at $(\frac{1}{4},\frac{1}{4},\frac{1}{4})a$ in the conventional unit cell.

1. Find the coordination numbers of Ca^{+} and F- ions.
2. Compare the lattice spacing along $[111]$ direction between successive planes of Ca and F ions, respectively in terms of the lattice constant a .

P5. The electric field of the incident x-ray beam in a diffraction experiment is

$E_{inc}(r, t) = \epsilon_k E_o e^{i(kr - \omega t)}$. The equation of motion for a bound electron in the atom under the influence of E_{inc} is given by $d^2 r_j / dt^2 + \gamma dr_j / dt + \omega_j^2 r_j = -(e/m)\epsilon_k E_o e^{i(kr_j - \omega t)}$

1. Find the general solution to the equation of motion.
2. Derive the steady solution to the equation of motion.

P6. A 2D Bravais lattice has the primitive vectors (in nm)

$$a_1 = 0.4e_x, a_2 = 0.1e_x + 0.2e_y$$

1. Compute the primitive vectors of the reciprocal lattice.
2. Draw the reciprocal lattice and construct the 1st Brillouin zone.
3. Draw the planes with the Miller indices (11), (10) and (52).
4. Compute the distance between the closest (11) planes.

P7. For a simple hexagonal lattice, we can choose the following primitive vectors

$$a_1 = \frac{\sqrt{3}}{2}ae_x + \frac{1}{2}ae_y, a_2 = -\frac{\sqrt{3}}{2}ae_x + \frac{1}{2}ae_y, a_3 = ce_z$$

1. What volume does the primitive cell have?
2. Deduce the primitive vectors for the reciprocal lattice. How can the result be described in simple terms?
3. Sketch the 1st Brillouin zone.