
Problems:

1. Please derive an expression for the frequency-dependent relative permittivity (\( \varepsilon(\omega) \)) of a metal using the relaxation time approximation and the free electron model, assuming that the charge density has a simple oscillatory time-dependence \( e^{-i\omega t} \). Find an an expression for the plasma frequency and estimate its value for a typical metal such as copper.

2. **Effects of hydrostatic pressure.** When hydrostatic pressure is supplied to a metal, the Fermi energy of the metal increases because the electron density increases.

   (a) Derive an expression for the change in the Fermi energy within the free electron model

   (b) Compute the pressure that is required to change the Fermi energy for a factor of 1.000001 for Cu. The electron density in Cu is \( 8.47 \times 10^{28} \text{ m}^{-3} \).

   (c) Evaluate the change in the density of states at the Fermi surface for Cu when the Fermi energy is changed by a factor of 1.000001.

3. Marder Chapter 1 Problem #1 Honeycomb Lattice.

4. Marder Chapter 1 Problem #3 Nanotube Structure.

5. Marder Chapter 1 Problem #4 Allowed Symmetry Axes.

6. Marder Chapter 2 Problem # 4 Hexagonal Close-Packed Lattice.

7. Please sketch a rectangular lattice with \( a_2/a_1 = 2 \). On this sketch please indicate a pair of neighboring planes of each type: \((0,1), (1,2), (2,3), (1,2)\).
Questions:

1. What are quasicrystals? Please use a minimum of three sentences in your response.

2. Please explain why the initial discovery of quasicrystalline materials was met by disbelief among many in the solid state and crystallographic communities. Please use a minimum of three sentences in your response.

3. Please describe ways in which the diffraction pattern of a quasicrystal is similar and different to that of a conventional crystal.

4. Please describe two physical properties of quasicrystals that differ from those of their crystalline counterparts.

5. Please describe two possible applications of quasicrystals.

6. Please explain the challenges of distinguishing a quasicrystal from an icosahedral glass.