Solid State Physics
APS –VI SEM
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Q.1 Calculate the free-electron energy bands in the reduced zone for the face-centred cubic structure with lattice parameter ***a***, along the [100] direction.

Q.2 Construct the first Brillouin polyhedron for the face-centred and body-centred Bravais lattices in reciprocal space.

Q.3 Find the atomic scattering factor for solid hydrogen, given the charge density $\rho_a(r_a) = e\left|\Psi_{100}(r_a)\right|^2 = \left(e/\pi a_o^3\right)e^{-2r_a/a_o}$ where $\Psi_{100}(r_a)$ is the normalized s-state function and $a_0 = 0.53\text{A}^{\text{o}}$ is the Bohr radius.

Q.4 The Curie formula for the paramagnetic susceptibility $\chi = C/T$ is only valid under certain conditions. What are these conditions, and why is this so?

Q.5 (a) Assume that an atom consists of a uniform sphere of negative charge with radius *R* surrounding a positive point charge. Show that the atomic polarizability is equal to $4\pi\epsilon_0 R^3$. The negative charge in the sphere should be taken to remain uniform in an applied field.
(b) Use this to calculate the atomic polarizability for Ne and compare it to the experimental value of 4.3×10^{-41} Fm^2. Take the atomic radius of Ne to be 0.51 Å.

Q.6 Consider a general diatomic chain with two different masses m1 and m2 as well as two different spring constants k1 and k2 and lattice constant a. Calculate the dispersion relation for this system.

Q.7 A ring is made of 1mm diameter lead wire formed into a circle of 10cm diameter. The ring is in the superconducting state and has a 100 A$^{\text{o}}$ current flowing in it. It is observed that there is no detectable change in the current of a little as 1Micro Ampere. Calculate the experimental upper limit for the resistivity of lead in the superconducting state.

Q.8 Show that $\vec{\nabla} \times \vec{J}_s = -\frac{n_S e^2}{m}\vec{B}$, $\vec{J}_S$ is current density of super-electrons.

Q.9 Graphite has a layered crystal structure in which the coupling between the carbon atoms in different layers is much weaker than that between the atoms in the same layer. Using Debye Model of specific heat, show that the specific heat is proportional to T^{33}.

Q.10 Explain Kronig-Penny Model.