Q.1.　Answer the following short questions:　　　　　　　　(6x5=30)

a) What is Born-Oppenheimer approximation? Explain it briefly. Also, write Hamiltonian term and Schrödinger equation involving assumptions/variables of Born-Oppenheimer approximation.

b) Explain free electron gas model. Write assumptions of classical free-electron theory.

c) State Bloch theorem. Explain the concept of Bloch electron and Bloch wave-functions.

d) Explain at least two physical phenomenon's which cannot be explained on the basis of free electron model.

e) Explain the concept of effective mass of an electron. What are the factors which make the consideration of effective mass important?

f) Discuss electron-electron interactions in solids. How screening the Hartree-Fock approximation reduces the importance of electron-electron interactions.

Answer the following questions.　　　　　　　　　　(3x10=30)

Q. 2 Describe nearly free electron model and explain how this model helps in forming the energy band gaps in solids.

Q. 3 Explain an augmented-plane wave (APW) method in detail. Solve Schrödinger wave-equation and explain the limitations of APW method in calculating the band structure of solids.

Q. 4 Define the term pseudopotential. Assume plane-wave like function, $f_n(k,r)$ and establish orthogonality condition for acceptable wave-functions. For a monoatomic crystal, write Hamiltonian with pseudopotential term and establish Schrödinger equation involving atomic pseudopotentials.