(*b*) Explain the electron-phonon interaction and its effect on superconducting property. What is quantum tunnelling effect.

2016

CONDENSED MATTER AND MATERIALS PHYSICS-I

Time : Three Hours] [*Maximum Marks* : 80

Answer from both the Sections as directed. The figures in the right-hand margin indicate marks.

SECTION-A

1. Answer any **four** of the following : 4×4

(*a*) Show that in tight-binding method of band calculation, the dispersion relation is

$$E\left(\vec{k}\right) = E_0 - \alpha - \beta \sum_m \exp\left(i\vec{k}\vec{r}_m\right)$$

where symbols have their usual meaning.

(*b*) Obtain the Boltzmann's transport equation for system of particles in dynamical equilibrium.

(*c*) Construct the Slater determinant for $2n$ closed electron system.

(*d*) How Generalised Gradient Approximation (GGA) is different from Local Density Approximation (LDA) ?

(*e*) Explain Type-I and Type-II superconductors. What is difference between both types ?

(*f*) What is Josephson's effect ?

OR

2. Answer **all** the questions from the following : 2×8

(*a*) Write four salient features of OPW method of band structure calculation.

(*b*) A superconducting lead has a critical temperature of 7.26*k* at zero magnetic field and a critical field of 8×10^5 A/m at OK, Find the critical field at 5k.

(*c*) What is concept of Fermi surface.

(*d*) Explain briefly the coherence length for electrons in superconductors.

(*e*) Explain the effects of isotopes on superconductors.

(*f*) Write the Schrödinger equation for helium atom.

(*g*) What is meaning of quasi-electron ?

(*h*) Explain briefly the concept of phonon drug.

SECTION-B

Answer **all** the questions : 16×4

3. (*a*) Explain the de Haas-Van Alphen effect for determination of geometrical shape of Fermi surface.

OR

(*b*) Obtain the expression of thermal conductivity of metals by using Boltzmann transport equation.

4. (*a*) Explain the general formulation of density functional theory. Also explain the Kohn-Sham equations.

OR

(*b*) Explain the self-consistent-field procedure. Show that electronic energy of a 2n-electron molecule is

$$E = 2\sum_{i=1}^{n} H_{ii} + \sum_{i=1}^{n}\sum_{j=1}^{n}\left(2J_{ij} - K_{ij}\right)$$

where J_{ij} and K_{ij} are coulomb and exchange integrals.

5. (*a*) Derive the London equations and describe how it's solution explain Meissner effect.

OR

(*b*) Explain the thermodynamics of super-conductors. Also find the Rutger's formula for specific heat of a superconductor.

6. (*a*) Explain the BCS theory of superconductors.

OR