B.E. End-semester (3rd Semester ETC, CST, EE, IT) Examination, 2013

PHYSICS (PH - 3401)

Full Marks: 70 Time: 3 hrs.

Answer Question no. 1 and any five from the remaining questions:

1.Answer any five questions:

i) Show that the total number of electronic states in a one dimensional crystal having N number of sites is 2N.
ii) What are type-I and type-II superconductors?
iii) State Wiedemann- Franz law regarding the free electron theory of metal.
iv) State the weaknesses of the Debye's theory of specific heat.
v) What is polarizability for a dielectric material?
vi) What do you mean by magnetic susceptibility?
vii) What is hysteresis effect in a ferromagnetic material? State the significance of hysteresis loop.

[5×2 = 10]

2. a) What is Meissner effect? How is it explained using London's equation?
b) Obtain London's equation assuming that the ground state of the superconducting phase be filled with Cooper pairs of constant density.

[(2+4)+6]

3. Consider an intrinsic semiconductor which is kept at temperature T.
a) Obtain expressions for the concentrations of electrons and hole in the conduction band.
b) Show that
$\mu = E_v + \frac{1}{2} E_g + \frac{3}{4} k_B T \ln (m_h^*/m_e^*)$
where the symbols carry their usual meaning.

[4+8]

4. a) State Dulong-Petit law of specific heat. Discuss its disagreement with experimental results.
b) Deduce Einstein's expression for the specific heat of solids and compare this with experimental results. Point out the limitations of Einstein's theory and discuss how these were improved by Debye.

[(2+1)+(5+1+1+2)]

5. a) Show that for a good conductor (conductivity $\sigma=\infty$) any free charge density within a conductor dissipates after considerable time. Write the Maxwell's equations within the conductor after this time. Show that the expression for skin depth for a conductor should be

$$Skin\ Depth = d = \omega\sqrt{\frac{\varepsilon\mu}{2}}\left[\sqrt{1+\left(\frac{\sigma}{\varepsilon\omega}\right)^2}-1\right]^{-\frac{1}{2}}.$$

b) State the limitations of classical free electron theory of metal.

[(3+2+5)+2]

6. a) What is molecular polarizability? Assuming the internal field solely arises due to polarization obtain Clausius-Mosotti relation.

b) An electron is moving round a nucleus along a circular orbit:

i) Show that it is equivalent to magnetic dipole of moment $\mu_m = -(e/2m)\,\mathbf{L}$, where $\mathbf{L}$ is its angular momentum, e the charge and m the mass.

ii) Show that if a magnetic field B is applied at an angle with the plane of orbiting electron, the plane precesses about the direction of the magnetic field with a frequency eB/(2m).

[2+6+(2+2)]

7. a) Find the energy of a magnetic dipole placed in an external magnetic field.

b) Show that the frequency of revolution of an electron around the nucleus in atom changes on applying magnetic field. Hence obtain an expression for susceptibility of a diamagnetic material.

[2+10]

8.a) Using simple model of atomic dipoles with permanent magnetic moments where dipole may orient itself parallel and anti-parallel to an external field, obtain an expression of susceptibility of a paramagnetic substance.

b) Assuming Weiss internal field in a ferromagnetic material, deduce Curie-Weiss law and find expression for the Curie point and Curie constant.

[5+7]
