2023
M.Sc.
4th Semester Examination
PHYSICS
PAPER – PHS-404A
Full Marks: 50
Time: 2 Hours

Solid State Physics-II

1. Answer any four (04) from the following. **4×2=8**

(a) The critical temperature for mercury with isotopic mass 199.5 is 4.185 K. Calculate its critical temperature when the isotopic mass changes to 203.4.

(b) Distinguish between soft and hard magnetic materials.

(c) On the basic of spin how the materials are classified as para, ferro, antiferro and ferrimagnetic?

(d) What is a Josephson junction and how does it work?

(e) Why good conductors like silver, copper are not superconductors?

(f) What is the London equation? Explain its significance in understanding superconductivity.

2. Answer any four (04) from the following. **4×4=16**

(a) What are ferromagnetic domains? The density and atomic weight of a substance are 7900 $kg\ m^{-3}$ and 56 respectively. Calculate the spontaneous magnetisation if its magnetic moment is $2.2\mu_B$. Given $\mu_B = 9.27 \times 10^{-24} JT^{-1}$. 2+2

(b) What are ferrites? Why they are superior over ferromagnets? State one application of ferrites. 1+2+1

(Turn Over)

(c) Obtain an expression for Pauli paramagnetic susceptibility of free electrons in metals.

(d) Outline the arguments behind the fact that two electrons in a lattice might experience an attractive interaction which can lead to the formation of Cooper pair.

(e) What is the order of superconducting phase transition without the magnetic field? Explain this nature with the help of the Ginzburg-Landau theory. 1+3

(f) Explain briefly how the BCS theory can lead to an energy gap in superconductivity. How is this gap different from normal semiconducting energy gap? 3+1

3. Answer any two (02) from the following **2×8= 16**

(a) (i) Why diamagnetism of ions is independent of temperature? Explain why it is universal in nature. (2+2)

(ii) Sketch the inverse of susceptibility of antiferromagnetic and ferromagnetic materials as a function of temperature in the same graph. 2

(iii) A magnetic material has a magnetisation of 3300 Am^{-1} and flux density of 0.0044 Wbm^2. Calculate the magnetising field and the relative permeability of the medium. ($\mu_0 = 4\pi \times 10^{-7} Hm^{-1}$) Also calculate the susceptibility. 2

(b) (i) What are magnons? Which statistics do they obey and why? Show that the ferromagnetic magnon specific heat at low temperature is proportional to $T^{3/2}$. 1+2+3

(ii) The susceptibility of a material at 400 K is $\mathbf{1.5 \times 10^{-5}}$. At what temperature the susceptibility will increase to. $\mathbf{8 \times 10^{-5}}$? 2

(c) From linearized Ginzburg–Landau equation derive the expression of upper critical field (B_{c2}) and define flux quantum (φ_0). What is their significance? 4+2+2

(d) Often the threshold field curve is represented quite well by a parabola:

$$H_c(T) = H_0[1-(T/T_c)^2]$$

Show that this relation leads to

$$S_n - S_s = \frac{H_0^2}{2\pi T_c}\left[\frac{T}{T_c} - (\frac{T}{T_c})^3\right]$$

and

$$C_n - C_s = \frac{H_0^2}{2\pi T_c}\left[\frac{T}{T_c} - 3\left(\frac{T}{T_c}\right)^3\right]$$

for entropy and heat capacity differences, per unit volume. 4+4 = 8

(All the symbols have their usual meanings)

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Internal Assessment-10