WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 5th Semester Examination, 2021-22

PHSACOR12T-PHYSICS (CC12)

SOLID STATE PHYSICS

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
Answers must be precise and to the point to earn credit.
All symbols are of usual significance.

Question No. 1 is compulsory and answer any *two* from the rest

1. Answer any ***ten*** questions from the following: $2\times10 = 20$

(a) "Crystals are common in nature" — True or False. Explain briefly.

(b) Calculate the coordination number for SC, and BCC crystal.

(c) Discuss the construction of the first two Brillouin zones for a square lattice.

(d) Derive Bragg's relation from Laue's equations.

(e) The forbidden energy band is 0.75 eV in germanium. To what wavelength of light is this substance transparent? [$h = 6.6\times10^{-34}$ Jsec]

(f) Calculate the glancing angle on the plane (110) of a cubic rock salt crystal (a = 2.81Å) corresponding to second order diffraction maxima of wavelength 0.71 Å.

(g) What is Einstein temperature? Calculate the Einstein temperature given Einstein frequency as 9×10^{11} Hz.

(h) A single electron in an energy band may have positive or negative effective mass: True or False. Give proper logic.

(i) The resistivity of aluminium at room temperature is 2.62×10^{-8} ohm. Calculate the drift velocity and their mobility.

(j) Draw the susceptibility vs. temperature graph for dia, para and ferromagnetic materials.

(k) A paramagnetic substance has 10^{28} atoms/m^3. The magnetic moment of each atom is 1.8×10^{-23} Am^2. Calculate the paramagnetic susceptibility at 300 K.

(l) What is the physical significance of the hysteresis loop in magnetic or dielectric materials?

(m) Define Hall coefficient. Why it is positive in metals?

(n) Why does dielectric loss occur?

2. (a) Explain orientational polarization giving proper examples. 2

   (b) Derive an expression for the electronic polarizability of an atom on the basis of classical theory. 4

   (c) Show that the diamagnetic susceptibility of an element is independent of temperature. 4

3. (a) The conductivity of a metal decreases with rise of temperature, whereas the conductivity of a semiconductor increases with increase of temperature. Explain both the cases clearly giving appropriate examples. 2

   (b) Consider the local field at an atomic site in a cubic structure in terms of the polarization $\vec{P}$ produced by the applied electric field $\vec{E}$. Hence, arrive at the Clausius-Mossotti relation for non- polar dielectric medium. 1+3

   (c) Derive Curie-Weiss law from Weiss's Molecular theory of magnetism. Sketch the variation of the magnetic susceptibility with temperature above the Curie point. 3+1

4. (a) Show that the Einstein's relation for the heat capacity per k.mol of a solid reduces to the classical value of $3R_u$, for the condition when $k_BT \geq h\nu$. 3

   (b) Obtain the dispersion relation for one-dimensional diatomic lattice. Hence, explain the concept of optical branches. 3+2

   (c) Calculate the effective mass as a function of k for a one-dimensional crystal of lattice constant 'a' having dispersion the relation $E(k) = E_0 - \alpha - 4\beta\cos ka$, where $\cos ka$, E_0, α, β are constants. 2

5. (a) The intrinsic carrier density of Ge at 27°C is $2.4\times10^{17}\ \text{m}^{-2}$. Calculate its intrinsic resistivity, if the electron and hole mobilities are $0.35\ \text{m}^2\ \text{V}^{-1}\text{s}^{-1}$ and $0.18\ \text{m}^2\ \text{V}^{-1}\text{s}^{-1}$; respectively. 3

   (b) State Wiedemann Franz law and give its physical significance. 2

   (c) The Hall voltage for the metal sodium is 0.001 mV, measured at I = 100 mA, B = 2.0 Weber/m^2 and the width of the specimen is 0.05 mm. Calculate the number of carriers per cubic meter in sodium. 2

   (d) Write the domain hypothesis of Weiss and explain the physical origin of domain formation from the general thermodynamic principle. 1+2

N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within* 1 *hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

——×——