TDC (CBCS) Odd Semester Exam., 2020
held in March, 2021

PHYSICS

(5th Semester)

Course No. : PHSHCC-502T

(Solid State Physics)

Full Marks : 50
Pass Marks : 20

Time : 3 hours

The figures in the margin indicate full marks for the questions

SECTION—A

1. Answer any *ten* of the following questions : 2×10=20

(a) Define a primitive cell.

(b) How many lattice points are there in a unit cell of f.c.c. lattice structure?

(c) Find the Miller indices for the planes with intercepts $3a$, $3b$, $2c$ along $\vec{a}$, $\vec{b}$ and $\vec{c}$ directions.

(d) A three-dimensional lattice has the basis vectors

$$\vec{a} = \hat{i} - \hat{j},\ \vec{b} = 2\hat{i} + \hat{j} \text{ and } \vec{c} = \hat{k}$$

Find the basis vectors of the reciprocal lattice.

(e) State two differences between photons and phonons.

(f) Discuss lattice heat capacity.

(g) Explain Dulong and Petit law.

(h) Discuss the basic drawbacks of Einstein model of specific heat.

(i) The magnetic field strength in a piece of metal is 10^6 ampere per meter. Find the flux density and the magnetisation in the material. Assume that the magnetic susceptibility of the metal is $-0{\cdot}5\times10^{-5}$.

(j) Why are ferrites used for high frequency applications?

(k) Using Hund's rule, calculate the spectroscopic splitting factor (g) for Cr^{3+}.

(l) Why is steel used for making permanent magnet?

(m) Show that $P = E\varepsilon_0(\varepsilon_r - 1)$, where P is electric polarization.

(n) For argon gas, $N = 10^{19}$ cm^{-3}, $z = 18$ and $r = 10^{-8}$ cm, calculate the electronic polarization for an applied field of 10 kV/cm.

(o) Discuss piezoelectricity.

(p) What is meant by complex dielectric constant?

(q) Discuss Bloch theorem.

(r) From the band theory of solid, explain why the conductivity of semiconductors increases with the increase in temperature.

(s) What do you mean by H_C or the critical field in superconductivity? Also show the variation of H_C with temperature.

(t) Discuss Cooper pairs.

SECTION—B

Answer *any* **five** questions

2 *(a)* Define atomic packing fraction (or factor). Calculate its value for a simple cubic and face-centred cubic structure. 1+1+1

(b) Discuss powder method of X-ray diffraction study. Why is the diameter of Debye-Scherrer camera 57·3 mm or a multiple of it? 2+1

3. *(a)* Why are X-rays used for crystal structure analysis? 1

(b) Derive Bragg's law of crystal diffraction. How does Bragg reflection differ from ordinary reflection? 3+2

4. Show that the dispersion relation for the lattice waves in a monoatomic lattice of mass m, spacing a and nearest neighbour interaction C is

$$\omega = 2\sqrt{\frac{C}{m}}\sin\left|\frac{1}{2}\vec{k}a\right|$$

where ω is the angular frequency and $\vec{k}$ is the wave vector. Also calculate the allowed values of the wave vectors and discuss Brillouni zones. 3+2+1

5. Derive lattice specific heat according to Debye's model. Also discuss the high and low temperature limits. 4+1+1

6. What are paramagnetic materials? Describe the classical theory of paramagnetism. 1+5

7. Derive the Curie-Weiss law of ferromagnetism and obtain the expression for the critical temperature. 4+2

8. Deduce Clausius-Mossotti relation and explain its use in predicting the dielectric constant of solids. 4+2

9. Deduce Langevin-Debye equation. Discuss how this equation may be used to obtain information on molecular structure. 5+1

10. *(a)* Explain the differences between the type-I (soft) and type-II (hard) superconductors. 2

(b) Show that for a superconducting state, both perfect diamagnetic and zero resistivity are two independent properties. 4

11. *(a)* Explain the phenomenon of penetration of magnetic field in a superconductor and also define penetration depth. 3

(b) Discuss Meissner effect with neat diagram. 3

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