2018

PHYSICS

(Major)

Paper : 6.2

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

(Mathematical Methods)

(*Marks* : 15)

1. Answer any *two* from the following : 1×2=2

(a) In the language of tensors, what is the type of gradient of a scalar field?

(b) What is the total number of independent components of anti-symmetric tensor a_{ik} in four dimensions?

(c) Mention whether tensors $a_i^{\mu} x^i$ and $a_i^{\nu} x^i$ are same or not.

2. Answer any *four* from the following : 2×4=8

(a) Under transformation of coordinates, mention whether anti-symmetric property of a mixed tensor is conserved or not. Explain with reason.

(b) If A^{ijp}_{km} is a tensor, show that A^{kmp}_{km} is a contravariant vector.

(c) Show that the contraction of the outer product of tensors C^m and D^q is invariant.

(d) What is the value of δ^i_i in 6-dimensional space? Also evaluate $\delta^i_j \delta^j_k \delta^k_l \delta^l$ in N-dimensional space.

(e) Prove that the sum of two tensors of the same type is also a tensor.

3. Answer any *one* from the following : 5

(a) Define inner product of two tensors. Justify whether the following statement is correct or not :
"Inner product of two tensors is same as their outer product followed by contraction." 1+4=5

(b) The Cartesian components of velocity vector of a fluid in motion in a two-dimensional plane are given by $v_x = x^2$, $v_y = y^2$. Find the components of the velocity vector in (r, θ) polar coordinates. 5

(c) Show that in cylindrical polar coordinates (ρ, ϕ, ζ)

$$\text{div } A^i = \frac{\partial A^\rho}{\partial \rho} + \frac{\partial A^\phi}{\partial \phi} + \frac{\partial A^\zeta}{\partial \zeta} + \frac{A^\rho}{\rho}$$ 5

(Solid State Physics)

(*Marks* : 45)

4. Choose the correct answer from the following : 1×7=7

(a) The coordination number of an SC structure is

(i) 2

(ii) 4

(iii) 6

(iv) 8

(b) If lattice parameters are $a = b = c$ and $\alpha = \beta = \gamma \neq 90°$, the crystal system is

(i) hexagonal

(ii) tetragonal

(iii) orthorhombic

(iv) trigonal

(c) The FCC structure

(i) is primitive

(ii) is non-primitive

(iii) may be either primitive or non-primitive

(iv) None of the above

(d) Miller indices (*hkl*) represent

(i) a set of parallel planes

(ii) a particular plane

(iii) a set of arbitrarily oriented planes

(iv) None of the above

(e) Bloch theorem is applicable to

(i) constant potential

(ii) periodic potential

(iii) infinite potential

(iv) None of the above

(f) If temperature increases, the electrical conductivity of semiconductor

(i) increases

(ii) decreases

(iii) remains constant

(iv) reduces to zero

(g) If the susceptibility of a material is independent of temperature, then it is

(i) paramagnetic

(ii) diamagnetic

(iii) ferromagnetic

(iv) ferrimagnetic

5. Give short answers of the following questions : 2×4=8

(a) Find the Miller indices of a plane having intercepts $8a, 4b$ and $2c$ on the respective crystallographic axes.

(b) A crystalline solid diffracts X-ray. Can the solid also diffract visible light? Justify.

(c) Calculate the mean free path of conduction electron of copper. (Given relaxation time $= 2 \cdot 47 \times 10^{-14}$ sec and average velocity of electrons $= 1 \cdot 154 \times 10^{5}$ m/s.)

(d) Define Fermi energy.

6. Give answers of the following questions (any *two*) : 5×2=10

(a) Explain the formation of metallic bond in solids. All metals are opaque to visible light and have high luster. Explain. 3+2=5

(b) What is superconductivity? Show schematically the variation of electrical resistivity with temperature for a superconductor. What is critical temperature? 2+2+1=5

(c) Discuss the important conclusions of Kronig-Penney model. 5

(d) What are ferromagnetic domains? Explain *B-H* curve with the help of domain theory of a ferromagnetic material. 1+4=5

7. Answer the following questions :

(a) Discuss the success and limitations of classical free electron theory of metals. Using classical theory, obtain an expression for resistivity of metal and comment on the result. 6+3+1=10

Or

(b) Discuss Langevin's theory of paramagnetism and obtain Curie law. 10

(c) Describe the seven-crystal system with diagram. 10

Or

(d) Distinguish among metal, semi-conductor and conductor on the basis of band theory. 10

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