2020

PHYSICS

(Major)

Paper : 6·2

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

(Mathematical Methods–IV)

(Marks : 15)

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

   (a) What is the rank of a tensor which represents a quantity that does not change when axes are rotated ?

   (b) In an N-dimensional space, how many terms is contained in each expression represented by $A^{ij}_{p}\ B^{q}_{lr}\ C^{rt}_{sq}$?

   (c) Evaluate $\delta^{l}_{m}\ \delta^{m}_{n}\ \delta^{n}_{l}$ in 4-dimensional space.

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

(a) Show that δ^{μ}_{ν} is an invariant tensor and transforms as a mixed tensor of rank two.

(b) If A^{ijk}_{lm} is tensor, test and mention type and rank of tensors A^{ijk}_{jk}, A^{ijm}_{lm}.

(c) Illustrate "The inner product of tensors can be thought of as outer product followed by contraction."

(d) Show that gradient of a scalar field is a covariant vector.

(e) If A^{i}_{j} is a mixed tensor of rank two, show that A^{i}_{i} is also a tensor.

3. Answer ***any one*** from the following : 5×1=5

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

(b) The Cartesian components of the acceleration vector are $a_x = \frac{d^2x}{dt^2}$, $a_y = \frac{d^2y}{dt^2}$, $a_3 = \frac{d^2z}{dt^2}$. Find the radial component a_r of the acceleration vector in spherical polar co-ordinates. 5

(c) (i) Prove that the sum of two tensors of the same type is also a tensor. 3

(ii) If $A_{\lambda\mu}$ is a skew-symmetric tensor, show that

$$\left(B^{\mu}_{\nu} B^{\sigma}_{\tau} + B^{\mu}_{\tau} B^{\sigma}_{\nu}\right) A_{\mu\sigma} = 0 .$$ 2

(Solid State Physics)

(Marks : 45)

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

(a) Crystalline state is a —

(i) low energy state

(ii) high energy state

(iii) medium energy state

(iv) None of the above

(b) Coordination number of *NaCl* structure is :

(i) 8

(ii) 6

(iii) 10

(iv) 12

(c) In solids the strongest bond is —

(i) ionic

(ii) covalent

(iii) metallic

(iv) hydrogen

(d) According to Quantum theory of free electrons, the molar specific heat of free electron is —

(i) $C_v = \frac{3}{2}Nk$

(ii) $C_v = (0.01)\frac{3}{2}Nk$

(iii) $C_v = (0.01)Nk$

(iv) $C_v = (0.001)\frac{3}{2}Nk$

(e) The magnetic susceptibility χ of a superconductor has —

(i) a positive value

(ii) $\chi \to 0$ as $T \to T_c$

(iii) $\chi \to \infty$ as $T \to T_c$

(iv) a negative value

(f) Hysteresis is a property of —

(i) paramagnetic substances

(ii) ferromagnetic substances

(iii) diamagnetic substances

(iv) all of them

(g) One Bohr Magneton is equal to —

(i) 9.27×10^{-24} *amp* m^2

(ii) 9.27×10^{-24} *amp*/m^2

(iii) 9.27×10^{-24} *amp*/cm^2

(iv) 9.27×10^{-24} *amp* cm^2

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

(a) Calculate the packing factor for SC structure.

(b) Deduce a relation between the density of crystalline material and lattice constant in a cubic lattice.

(c) A paramagnetic material has a magnetic field strength of $10^4 A/m$. If the susceptibility of the material at room temperature is 3.7×10^{-3}, calculate the magnetization and flux density of the material.

(d) State Bloch theorem.

6. Give short answers of the following questions : ***(any two)***

(a) Write down Bragg's law in X-ray diffraction and define the different terms used in the equation. From the equation estimate the wavelength of X-ray that can be used for analysis of crystal diffraction. What is glancing angle ? 2+2+1=5

(b) What are Miller indices ? How are they determined ? Explain with the help of an example. 1+4=5

(c) Explain Meissner effect. Outline some applications of superconductivity. 2+3=5

(d) What do you mean by *p*-type and *n*-type semiconductor ? How does the conductivity of semiconductor vary with temperature ? Show schematically the position of Fermi level at *OK* in *p*-type and *n*-type semiconductor. 2+1+2=5

7. Answer the following questions :

(a) What do you mean by cohesive energy ? Evaluate Madelung constant for an infinitely long one-dimensional ionic crystal consisting of singly charged alternate positive and negative ions. State the significance of Madelung constant. 2+6+2=10

Or

(b) On the basis of Weiss theory, obtain Curie-Weiss law. Show that ferromagnetic substances become paramagnetic above a critical temperature. 8+2=10

(c) Write short note on : ***(any one)*** 10

(i) Intrinsic and extrinsic semiconductors

(ii) Kronig-Penney model

(iii) Different types of crystal bonding