**3 (Sem–6) PHY M 2**

**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 $\delta^{\mu}_{\nu}$ 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 $r, \theta$. 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 $\chi$ 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) $9.27 \times 10^{-24}$ *amp* $m^2$

(ii) $9.27 \times 10^{-24}$ *amp*/$m^2$

(iii) $9.27 \times 10^{-24}$ *amp*/$cm^2$

(iv) $9.27 \times 10^{-24}$ *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 $3.7 \times 10^{-3}$, 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