2015

PHYSICS

(Major)

Theory Paper : M-6.2

Full Marks – 60

Time – Three hours

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

GROUP – A

(Mathematical Methods)

1. Answer any *two* from the following : $1 \times 2 = 2$

   (a) Evaluate the following sum,

   $$\sum_{j=1,2,3} \delta^1_j \, A^j$$

   (b) Give two physical examples of a second rank tensor.

(c) Show that

$$\left(\delta^i_m\ \delta^k_p + \delta^i_p\ \delta^k_m\right) w_{ik} = w_{mp} + w_{pm}$$

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

(a) Show that $\delta^j_i\ U^i V^j$ behaves like dot product of $\vec{U} = U^1\hat{i} + U^2\hat{j} + U^3\hat{k}$ and

$\vec{V} = V^1\hat{i} + V^2\hat{j} + V^3\hat{k}$.

(b) If $T^{ij}_{mn} = A^{ij}\ B_{mn}$ is a mixed tensor of rank 4 constructed by outer product of A^{ij} and B_{mn} construct a tensor of rank O by the process of contraction.

(c) g_j is a symmetric covariant tensor in 3-dimention (i, j=1,2,3). Expressing it in a matrix form, show that it has 6 independent components.

(d) If $x = x^1$, $y = x^2$, $z = x^3$, show that

$$\sum_{i,j=1,2,3} \frac{\partial^2\phi}{\partial x^i \partial x^j}\ \delta^i_j = \nabla^2\phi$$

(e) What is the rank of the quantity $A^{ijkl}\ B_{ijkp}$? What do you mean by an invariant ?

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

(a) If A^i and B_i are two contravariant and covariant tensors respectively, show that $A^i\ B_i$ is invariant under coordinate transformation $x^i \to x'^i$.

(b) If $A^i + B^i = 0$ in a coordinate system x^i, show that $A'^i + B'^j = 0$ after a coordinate transformation, $x^i \to x'^i$.

(c) If $\frac{\partial x^p}{\partial x^q} = \delta^p_q$ and A_j is a covariant tensor of rank 1, show that

$C^i = B^{ij} A_j$ transforms like a contravarient tensor of rank 1 under coordinate transformation $x^i \to x'^i$. Here B^{ij} is an arbitrary contravariant tensor of rank 2.

GROUP – B

(Solid State Physics)

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

(a) All crystals must possess

(A) Translational symmetry

(B) Rotational symmetry

(C) Reflection symmetry

(D) Inversion symmetry

(b) Madelung constant relates to the strength of bonding energy in

(A) Van der Waals solids

(B) Hydrogen bonded solids

(C) Ionic solids

(D) Covalent solids

(c) Root cause of presence of energy bands in solids is

(A) bonding in solids

(B) periodicity of atoms / molecules

(C) presence of free electrons

(D) presence of ion cores

(d) In intrinsic semiconductors

(A) number of electrons is much larger than the number of holes

(B) number of holes is much larger than the number of holes

(C) These numbers are nearly equal

(D) These numbers are exactly equal

(e) Meissner effect ensures that a superconductor is

(A) a perfect conductor

(B) a perfect diamagnet

(C) a perfect insulator

(D) a perfect paramagnet

(f) The type of magnetism that is present in all materials is

(A) diamagnetism

(B) paramagnetism

(C) ferromagnetism

(D) ferrimagnetism

(g) Susceptibility of a ferromagnatic material is

(A) small positive quantity

(B) small negative quantity

(C) very large positive quantity

(D) nearly zoro.

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

(a) Differentiate amorphous and crystalline solids giving examples.

(b) What do you understand by cohesive energy of ionic crystals ?

(c) What are type-II superconductors ?

(d) Draw hysteresis loop for ferromagnetic material and label different parts.

3. Give short answers to any *two* of the following questions : 5×2=10

(a) Calculate the glancing angle on the cube surface of a rock salt crystal with a = 2.814A° corresponding to second order diffraction of 0·710 A° wavelength X-ray.

(b) Illustrate briefly the Sommerfeld free electron model for metals.

(c) Differentiate metal, insulator and semiconductor in terms of their electrical conductivity and its temperature dependence.

(d) What is Larmor frequency ? Calculate the Larmor frequency for the orbital momentum of the electron in a magnetic field $B=1 w/m^2$.

4. Answer any *two* questions from the following : 10×2=20

(a) What is a Bravais lattice ? What are different Bravais lattices in three dimension ? Explain with suitable example that no other Bravais lattices apart from those listed will be possible. 2+6+2=10

(b) Write an essay on bonding in solids. 10

(c) Obtain expressions for electrical and thermal conductivity of metals and thence derive Wiedemann-Franz relatio. 4+4+2=10

(d) What are ferromagnetic materials ? Illustrate in detail about Weiss molecular theory of ferromagnetism. 2+8=10