2014

PHYSICS

(Major)

Paper : 6.2

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

GROUP—A

(Mathematical Methods)

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

(a) Evaluate the following quantity in 4-dimension :

$$\sum_{i,\,j} \delta^{i}_{j}$$

(b) Define a scalar quantity.

(c) Name any two branches of physics where tensors are applied.

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

(a) Define transformation properties of a contravariant vector A^i and a covariant vector B_i.

(b) What do you mean by contraction of a mixed tensor? Contract A^{ij}_{klm} twice.

(c) Define inner product of two tensors. If R_{ij} and g^{ij} are two tensors, what is the rank of the quantity $g^{ij}R_{ij}$?

(d) Define coordinate transformation in N-dimensional space. If N is the dimension of space and r is the rank of a tensor, what is the number of components of the tensor?

(e) What is the rank of the quantity A^iB_j? If A_{ij} is a symmetric covariant tensor, which of the following is correct?

(i) $A_{ij} + A_{ji} = 0$

(ii) $A_{ij} + A_{ji} = 2A_{ij}$

(iii) $A_{ij} - A_{ji} \neq 0$

(iv) None of the above

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

(a) If $A^{ij} = p^iq^j$, obtain the transformation of A^{ij} if the coordinates are transformed from x^i to x'^i.

(b) If $\vec{A}$ and $\vec{B}$ are two ordinary vectors, then show that components of $\vec{A}\times\vec{B}$ form a second rank antisymmetric tensor.

(c) Show that the components of Kronecker delta δ^i_j do not change under coordinate transformation.

GROUP—B

(Solid-state Physics)

4. Choose the correct answer : 1×7=7

(a) Number of atom(s) per unit cell of an f.c.c. lattice is

(i) 1

(ii) 2

(iii) 3

(iv) 4

(b) Bonding between the atoms of silicon crystal is

(i) ionic

(ii) metallic

(iii) covalent

(iv) van der Waals

(c) Relation between electrical and thermal conductivity of metals is given by

(i) Wiedemann-Franz law

(ii) Boltzmann law

(iii) Mathiessen rule

(iv) Poisson's law

(d) Silicon can be made *p*-type semiconductor by doping with

(i) phosphorous

(ii) arsenic

(iii) aluminium

(iv) antimony

(e) The phenomena of expulsion of magnetic lines of force from the interior of a superconductor is known as

(i) Meissner effect

(ii) Josephson effect

(iii) Hall effect

(iv) Thompson effect

(f) Hysteresis is shown in

(i) nonmagnetic material

(ii) diamagnetic material

(iii) paramagnetic material

(iv) ferromagnetic material

(g) Susceptibility of a diamagnetic material is

(i) large and negative

(ii) large and positive

(iii) small and negative

(iv) small and positive

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

(a) What are nonprimitive unit cells?

(b) Differentiate between van der Waals and hydrogen bonding.

(c) Distinguish between intrinsic and extrinsic semiconductors from energy band diagram.

(d) What are ferromagnetic domains?

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

(a) Show that the first five terms in the series for Madelung constant of NaCl are

$$\alpha = 6 - \frac{12}{\sqrt{2}} + \frac{8}{\sqrt{3}} - \frac{6}{2} + \frac{24}{\sqrt{5}}$$

(b) Discuss about the position of Fermi level in intrinsic and extrinsic semiconductors under suitable limiting conditions.

(c) Give an account of the experimental results which distinguish the superconducting state from the normal state of a metal.

(d) An electromagnet with iron core achieves maximum magnetic field of 1·0 tesla. Obtain the magnetic interaction energy at a temperature of 300 K.

7. Answer any *two* essay-type questions from the following : 10×2=20

(a) Explain why X-rays can get diffracted from solids. Illustrate quantitatively how Bragg's law can be used for determination of lattice constants. 3+7=10

(b) Write down Boltzmann transport equation for electrons under external electric field. Solve it to obtain an expression for electrical conductivity in solids. 10

(c) Discuss the essential features of the electron energy band structure of solids on the basis of Kronig-Penny model. 10

(d) Illustrate in detail about type-I and type-II superconductors. 10

(e) Obtain an expression for paramagnetic susceptibility of free electrons on the basis of classical laws. Discuss its drawbacks and show how Pauli modified it. 6+2+2=10

★★★