2019

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) What is the direction of the components of a covariant vector in spherical coordinate system?

(b) Write the type of product of a covariant vector and a contravariant tensor.

(c) Mention why the sum of A^{ik} and B_{mnp} is not possible.

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

(a) Show that the contraction of second rank mixed tensor results in an invariant.

(b) Show that Kronecker delta is a mixed tensor of rank 2.

(c) If A^{mn}_{pq} is a mixed tensor, what will be the type of A^{mm}_{pq} and A^{mn}_{pp}? Justify your answer.

(d) If A^{ij} is an antisymmetric tensor and B_i is a vector, show that $A^{ij} B_i B_j = 0$.

(e) Illustrate, with examples, the statement "Only tensor quantities can occur in the mathematical formulation of physical laws".

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

(a) Show that the property of anti-symmetry of a tensor between a pair of dissimilar indices is not invariant under coordinate transformation. 5

(b) The Cartesian components of velocity of a particle are $\frac{dx}{dt}, \frac{dy}{dt}$ in two dimensions. Find its components in spherical polar coordinates. 5

(c) Show that the subtraction of two contravariant tensors of third rank is also a tensor. Mention its number of components in three dimensions. 4+1=5

(Solid State Physics)

(*Marks* : 45)

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

(a) Which of the following substances is a crystalline solid?

(i) Isotropic substance

(ii) Anisotropic substance

(iii) Supercooled liquid

(iv) Amorphous solid

(b) Crystals having low-melting points are in

(i) van der Waals' bond

(ii) ionic bond

(iii) covalent bond

(iv) metallic bond

(c) The number of atoms assigned to the unit cell of a body-centred cubic lattice is

(i) 8

(ii) 1

(iii) 3

(iv) 2

(d) The number of different Bravais lattices in three dimensions is

(i) 3

(ii) 14

(iii) 167

(iv) unlimited

(e) The scale of periodicity of the potential for the ions in a perfect crystal is

(i) 10^{-12}m

(ii) 10^{-10}m

(iii) 10^{-4}m

(iv) 10^{-8} m

(f) The current in a superconductor produces voltage drop across it which is

(i) very large

(ii) zero

(iii) small

(iv) large

(g) The presence of impurities in metals causes

(i) increase

(ii) no change

(iii) decrease

(iv) first increase then decrease

of the thermal conductivity

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

(a) For a cubic crystal lattice what do the following represent?

(i) <111>

(ii) [010]

(iii) (111)

(iv) {100}

(b) Explain whether the existence of domains reduce or increase the overall magnetic energy of a ferromagnetic substance.

(c) Write the conditions to observe peaks of scattered intensity during scattering of X-rays from a crystal.

(d) For a 2-D square lattice of side 0·02Å calculate the momentum of the electron corresponding to the boundary of the first Brillouin zone.

6. Answer any *two* from the following questions : 5×2=10

(a) Deduce formula for effective mass of an electron. What is the physical meaning of negative effective mass? 4+1=5

(b) What causes superconductivity? Define Cooper pairs. What type of magnetism is exhibited by a superconductor? Draw magnetic field lines depicting Meissner effect. 2+1+1+1=5

(c) Explain Langevin's theory of paramagnetism. Find the susceptibility when the Curie constant is 0·2 and the difference in critical temperature and paramagnetic Curie temperature is 0·025. 4+1=5

(d) State the principle followed by electrons in a Fermi gas. Mention the differences between type—I and type—II superconductors. Are covalent solids good conductors of electricity? 2+2+1=5

7. Answer the following questions : 10×2=20

(a) Explain Bragg's law. Show how it is used to investigate crystal structure of NaCl. Prove that every reciprocal lattice vector is normal to a set of parallel planes of the direct lattice. 2+5+3=10

(Continued)

Or

(b) Discuss qualitatively the motion of electrons in a periodic lattice and explain how it leads to the origin of energy bands and forbidden bands in solids. 10

(c) Using classical theory, obtain an expression for electrical conductivity of metal. Discuss Wiedemann-Franz law quantum mechanically. Can this law be applied to determine thermal conductivity of liquids? 4+5+1=10

Or

(d) Discuss Boltzmann's equation of state for electrons in a metal. Derive an expression for the electronic specific heat of metals. 5+5=10

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