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3 (Sem 6) PHY M 2

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,

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

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

[Turn over

(c) Show that

$$(\delta_m^i \delta_p^k + \delta_p^i \delta_m^k) w_{ik} = w_{mp} + w_{pm}$$

2. Answer any *four* from the following :  $2 \times 4 = 8$

(a) Show that  $\delta_i^j U^i V^j$  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  $T_{mn}^{ij} = A^{ij} B_{mn}$  is a mixed tensor of rank 4 constructed by outer product of  $A^{ij}$  and  $B_{mn}$  construct a tensor of rank 0 by the process of contraction.

(c)  $g_j$  is a symmetric covariant tensor in 3-dimension ( $i, j=1,2,3$ ). 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

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

(e) What is the rank of the quantity  $A^{ijkl} B_{jkl}$  ?  
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  $x^i \rightarrow x'^i$ .

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

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

$C^i = B^{\bar{j}} A_j$  transforms like a contravariant tensor of rank 1 under coordinate transformation  $x^i \rightarrow x'^i$ . Here  $B^{\bar{j}}$  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 ferromagnetic material is
- (A) small positive quantity
  - (B) small negative quantity
  - (C) very large positive quantity
  - (D) nearly zero.

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  $a = 2.814 \text{ \AA}$  corresponding to second order diffraction of  $0.710 \text{ \AA}$  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  $B = 1 \text{ w/m}^2$ .

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