5 SEM TDC PHYH (CBCS) C 12

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(Nov/Dec)

PHYSICS

(Core)

Paper : C–12

(Solid-State Physics)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

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

1. Choose the correct option from the following :

    1×5=5

    (a) The effective number of atoms in the unit cell of hexagonal close-packed structure is

    (i) 6

    (ii) 8

    (iii) 12

    (iv) 9

(*Turn Over*)

(2)

(b) For solids, the optical and acoustic branches coincide and forbidden band vanishes at $k = \pm \dfrac{\pi}{2a}$, when (mass of light and heavy atoms are m and M respectively)

   (i) $m < M$

   (ii) $m > M$

   (iii) $m = M$

   (iv) $mM = 1$

(c) The ferromagnetic susceptibility is given by

   (i) $\chi = \dfrac{C}{T + T_c}$

   (ii) $\chi = \dfrac{CT}{T + T_c}$

   (iii) $\chi = C(T + T_c)$

   (iv) $\chi = \dfrac{C}{T - T_c}$

(3)

(d) In a dipolar dielectric, in absence of an electric field, the dipoles are

   (i) antiparallel

   (ii) parallel

   (iii) randomly oriented

   (iv) None of the above

(e) The temperature coefficient of resistance of a pure semiconductor is

   (i) negative

   (ii) positive

   (iii) zero

   (iv) None of the above

2. Answer any *five* from the following questions :

$2 \times 5 = 10$

(a) Define unit cell. If a unit cell has the following characteristics

   $a = b = 10$ Å, $c = 7$ Å and $\alpha = \beta = \gamma = 90°$

identify to which crystal system does the unit cell belong.

(b) Define geometrical structure factor. How is it related to atomic scattering factor?

(c) State Dulong and Petit law of specific heat of solid.

(d) What is optical absorption and infrared absorption in a dielectric?

(e) What is piezoelectricity? Give an example of a crystal that is piezoelectric but not ferroelectric.

(f) What is Hall effect? What important conclusion can be drawn from the Hall effect?

3. *(a)* Obtain the Miller indices of a plane which intercepts at a, $\dfrac{b}{3}$ and $2c$ in a simple cubic unit cell.   2

(b) Prove that the packing fractions for a simple cubic (SC) structure and for a body-centred cubic (b.c.c.) structure are 0·52 and 0·74 respectively.   3

Or

Calculate the separation between lattice planes in a simple cubic, face-centred cubic (f.c.c.) and body-centred cubic (b.c.c.) lattice.

(c) Derive Bragg's law of crystal diffraction. Give its significance.   2+1=3

(d) Discuss the Debye model of lattice heat capacity. What is Debye T^3 law?   4+1=5

4. *(a)* Obtain an expression for diamagnetic susceptibility using the Langevin's theory. What is the significance of negative susceptibility?   4+1=5

Or

What is ferromagnetism? Discuss the Weiss field theory of ferromagnetism. Discuss how magnetic susceptibility varies with temperature.   5

(b) Obtain an expression for dipolar polarizability at moderate temperature.   4

(c) Classify ferroelectric materials into different groups on the basis of symmetry. Give one example of each group.   4

5. *(a)* Discuss briefly the Kronig-Penney model for motion of electron in a crystal and its important conclusion.   4

(b) The intrinsic carrier concentration in a Si sample is 1.5×10^{16} atoms/m^3. It is doped with 10^{23} phosphorus atoms/m^3. Determine its hole concentration and conductivity. Given electron mobility = $0.135 \, m^2 \, V^{-1} \, s^{-1}$. 3

Or

What do you mean by mobility? Derive the expression for conductivity of intrinsic semiconductor. 1+2=3

6. *(a)* Explain soft and hard superconductors. 3

(b) What is penetration depth for a superconductor? What is its value at the critical temperature? 1+1=2

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