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**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

(b) For solids, the optical and acoustic branches coincide and forbidden band vanishes at  $k = \pm \frac{\pi}{2a}$ , 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)  $\chi = \frac{C}{T + T_c}$

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

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

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

- (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 :

2×5=10

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

$$a = b = 10 \text{ \AA}, c = 7 \text{ \AA} \text{ and } \alpha = \beta = \gamma = 90^\circ$$

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  $a$ ,  $\frac{b}{3}$  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

( 6 )

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

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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