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5 SEM TDC PHYH (CBCS) C 12

2021

(Held in January/February, 2022)

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 :
 $1 \times 5 = 5$

(a) Every reciprocal lattice vector is

(i) parallel to lattice plane

(ii) normal to lattice plane

(2)

- (iii) inclined at an angle of 45° to the lattice plane
 - (iv) None of the above
- (b) According to Dulong and Petit's law, the molar specific heat capacity of a solid at temperature T is
- (i) $\frac{1}{2}k_B T$
 - (ii) $3R$
 - (iii) $\frac{3}{2}R$
 - (iv) $3k_B T$
- (c) Which of the following materials does not have permanent magnetic dipoles?
- (i) Antiferromagnetic
 - (ii) Paramagnetic
 - (iii) Diamagnetic
 - (iv) Ferromagnetic

2. Answer any

- (a) Draw the structure
- (b) Define a cell be

(3)

(d) Temperature dependence of polarizability is observed in case of

- (i) ionic polarization
- (ii) orientation polarization
- (iii) electronic polarization
- (iv) space charge polarization

(e) The slope of the logarithm of conductivity ($\ln \sigma$) versus $1/T$ plot is a measure of

- (i) mobility
- (ii) resistivity
- (iii) band gap
- (iv) carrier concentration

2. Answer any five from the following : $2 \times 5 = 10$

(a) Draw the (110) plane for a simple cubic structure.



(b) Define a primitive unit cell. Can a unit cell be primitive?

(4)

- (c) What is phonon? Which statistics does it obey?
- (d) Does dielectric constant vary with frequency of applied field? Write the relation between optical constants and complex dielectric constant of a medium.
- (e) What are Curie law and Curie temperature?
- (f) Draw the potential experienced by an electron in Kronig-Penney model.
- (g) What are the conditions for a material to be a superconductor?
3. (a) Show that f.c.c. lattice is reciprocal to b.c.c. lattice. 3
- (b) Draw the dispersion curve for a linear diatomic lattice showing acoustical and optical modes. 2
- (c) Give the qualitative interpretation of the band structure of electronic energy levels in a semiconductor. 3

(Continued)

$$\omega = 2\sqrt{\frac{B}{m}} \left(\sin \frac{ka}{2} \right) \quad 2\sin \frac{ka}{2} = (e^{ika} - e^{-ika})$$

$$\frac{\beta}{\alpha} = \frac{4a}{ka} \quad (5)$$

$$u_n = u_0 e^{i(kn)}$$

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- 3
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- 3
4. (a) Show that in a cubic crystal of side a , the inter-planar spacing between consecutive parallel planes of Miller indices (hkl) is $d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$.

Calculate the inter-planar spacing d of planes (111) in a simple cubic lattice of side a . 4+1=5

Or

State Bragg's law of crystal diffraction. If X-ray of wavelength 1.75 \AA is diffracted at an angle of 30° in the first-order reflection from $(1, 1, 1)$ planes of a crystal, what is the spacing between the adjacent planes of the crystal? Calculate the interatomic spacing. 5

- (b) How does Debye's theory of heat capacity of solids differ from those of Einstein's theory? Discuss the predictions of this model for very high and very low temperatures and state the Debye T^3 law. 2+2=4

Or

Derive the expression for the dispersion relation for a linear monoatomic chain of atoms. 4

5. (a) Discuss the $B-H$ loop and explain it with the help of domain theory. 4

(6)

(b) Develop the Clausius-Mosotti relation for elemental dielectric system by determining Lorentz field.

4

(c) Explain the meaning and origin of piezoelectricity. Give an example of a crystal that is piezoelectric but not ferroelectric.

4+1=5

Or

Q What are ferroelectric materials? Explain the ferroelectric nature with the example of barium titanate. Mention two of its applications.

1+3+1=5

6. Find the intrinsic carrier concentration of germanium if its conductivity is $2.13 \text{ ohm}^{-1} \text{ m}^{-1}$. Given that electron and hole mobilities as $\mu_e = 0.39 \text{ m}^2 \text{ V}^{-1} \text{ s}^{-1}$ and $\mu_p = 0.19 \text{ m}^2 \text{ V}^{-1} \text{ s}^{-1}$

3

Or

What is Hall effect? Write the expression for Hall coefficient. State its significance.

7. (a) Define penetration depth related to superconductor when it is placed in an external magnetic field.

1

22P/16

(Continued)

(7)

- (b) What do you mean by flux exclusion in a superconductor? Distinguish between type-I and type-II superconductors using Meissner effect. 1+3=4

Or

Describe the effect of an external magnetic field on superconducting state of material. What is critical magnetic field and how does it vary with temperature? What is its value at the critical temperature? 4

$$\text{C}_1 = \rho_{\star\star\star} P$$
$$P = (B - B_0) B_0$$
$$\text{C}_2 = \rho_{\star\star} P$$
$$P = B_0 (B_0 - B_c)$$

~~AS~~