



**2020/TDC (CBCS)/ODD/SEM/  
PHSHCC-502T/156**

**TDC (CBCS) Odd Semester Exam., 2020  
held in March, 2021**

**PHYSICS**

**( 5th Semester )**

**Course No. : PSHHCC-502T**

**( Solid State Physics )**

Full Marks : 50

Pass Marks : 20

**Time : 3 hours**

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

**SECTION—A**

**1. Answer any ten of the following questions :**

**2×10=20**

- (a) Define a primitive cell.
- (b) How many lattice points are there in a unit cell of f.c.c. lattice structure?
- (c) Find the Miller indices for the planes with intercepts  $3a$ ,  $3b$ ,  $2c$  along  $\vec{a}$ ,  $\vec{b}$  and  $\vec{c}$  directions.



- (d) A three-dimensional lattice has the basis vectors

$$\vec{a} = \hat{i} - \hat{j}, \vec{b} = 2\hat{i} + \hat{j} \text{ and } \vec{c} = \hat{k}$$

Find the basis vectors of the reciprocal lattice.

- (e) State two differences between photons and phonons.
- (f) Discuss lattice heat capacity.
- (g) Explain Dulong and Petit law.
- (h) Discuss the basic drawbacks of Einstein model of specific heat.
- (i) The magnetic field strength in a piece of metal is  $10^6$  ampere per meter. Find the flux density and the magnetisation in the material. Assume that the magnetic susceptibility of the metal is  $-0.5 \times 10^{-5}$ .
- (j) Why are ferrites used for high frequency applications?
- (k) Using Hund's rule, calculate the spectroscopic splitting factor (g) for  $\text{Cr}^{3+}$ .

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- (l) Why is steel used for making permanent magnet?
- (m) Show that  $P = E\epsilon_0(\epsilon_r - 1)$ , where P is electric polarization.
- (n) For argon gas,  $N = 10^{19} \text{ cm}^{-3}$ ,  $z = 18$  and  $r = 10^{-8} \text{ cm}$ , calculate the electronic polarization for an applied field of  $10 \text{ kV/cm}$ .
- (o) Discuss piezoelectricity.
- (p) What is meant by complex dielectric constant?
- (q) Discuss Bloch theorem.
- (r) From the band theory of solid, explain why the conductivity of semiconductors increases with the increase in temperature.
- (s) What do you mean by  $H_C$  or the critical field in superconductivity? Also show the variation of  $H_C$  with temperature.
- (t) Discuss Cooper pairs.





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SECTION—B

Answer any five questions

2. (a) Define atomic packing fraction (or factor). Calculate its value for a simple cubic and face-centred cubic structure. 1+1+1  
 (b) Discuss powder method of X-ray diffraction study. Why is the diameter of Debye-Scherrer camera 57.3 mm or a multiple of it? 2+1
3. (a) Why are X-rays used for crystal structure analysis? 1  
 (b) Derive Bragg's law of crystal diffraction. How does Bragg reflection differ from ordinary reflection? 3+2
4. Show that the dispersion relation for the lattice waves in a monoatomic lattice of mass  $m$ , spacing  $a$  and nearest neighbour interaction  $C$  is  

$$\omega = 2\sqrt{\frac{C}{m}} \sin\left|\frac{1}{2}ka\right|$$
 where  $\omega$  is the angular frequency and  $k$  is the wave vector. Also calculate the allowed values of the wave vectors and discuss Brillouin zones. 3+2+1

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5. Derive lattice specific heat according to Debye's model. Also discuss the high and low temperature limits. 4+1+1
6. What are paramagnetic materials? Describe the classical theory of paramagnetism. 1+5
7. Derive the Curie-Weiss law of ferromagnetism and obtain the expression for the critical temperature. 4+2
8. Deduce Clausius-Mossotti relation and explain its use in predicting the dielectric constant of solids. 4+2
9. Deduce Langevin-Debye equation. Discuss how this equation may be used to obtain information on molecular structure. 5+1
10. (a) Explain the differences between the type-I (soft) and type-II (hard) superconductors. 2  
 (b) Show that for a superconducting state, both perfect diamagnetic and zero resistivity are two independent properties. 4

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( Turn Over )



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11. (a) Explain the phenomenon of penetration of magnetic field in a superconductor and also define penetration depth. 3

(b) Discuss Meissner effect with neat diagram. 3

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7. Derive the Curie-Weiss law of paramagnetism and obtain the expression for the critical temperature. 4+2

8. Deduce Clausius-Mossotti relation and explain its use in predicting the dielectric constant of solids. 4+2

9. Deduce Langevin-Debye equation. Discuss how this equation may be used to obtain information on molecular structure. 2+4

10. (a) Explain the difference between the type-I (soft) and type-II (hard) superconductors. 2

(b) Show that for a superconducting state, both perfect diamagnetic and zero resistivity are two independent properties. 4