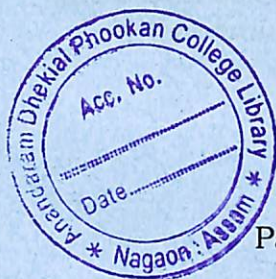


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3 (Sem-5/CBCS) PHY HC2



2024

**PHYSICS**

(Honours Core)

Paper : PHY-HC-5026

**(Solid State Physics)**

Full Marks : 60

Time : Three hours

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

1. Choose the correct answer of the following questions from the given options : 1×7=7

(a) Atomic packing factor of simple cubic structure is

(i)  $\pi$

(ii)  $\frac{\pi}{2}$

(iii)  $\frac{\pi}{4}$

(iv)  $\frac{\pi}{6}$

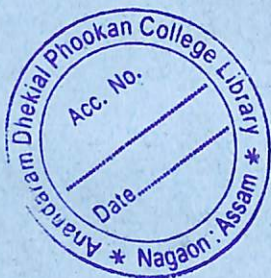
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(b) A phonon does not have momentum but a phonon with wave vector  $k$  when interacts with other particles and fields, behaves as if it has a momentum

- (i)  $\hbar k$
- (ii)  $hk$
- (iii)  $\frac{1}{2}\hbar k$
- (iv)  $\frac{1}{2}hk$

(c) Two paramagnetic substances have susceptibilities  $\chi_1$  and  $\chi_2$  at absolute temperatures  $T_1$  and  $T_2$  respectively, then the ratio of  $\chi_1$  and  $\chi_2$  equals to

- (i)  $\frac{T_2}{T_1}$
- (ii)  $\frac{T_1}{T_2}$
- (iii)  $\frac{T_2^2}{T_1^2}$
- (iv)  $\frac{T_1^2}{T_2^2}$



(d) The polarisation which is observed in all kinds of materials is

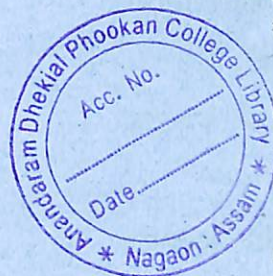
- (i) ionic polarisation
- (ii) dipolar polarisation
- (iii) electronic polarisation
- (iv) space charge polarisation

(e) Piezoelectric coefficients of ferroelectrics are

- (i) very small
- (ii) small
- (iii) large
- (iv) very large

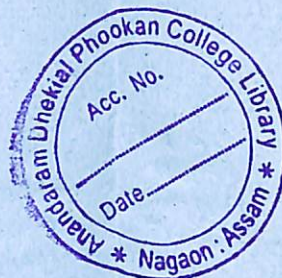
(f) For a sample having  $8 \times 10^{28} / m^3$  numbers of electrons per unit volume, the Hall coefficient will be

- (i)  $0.078 \times 10^{-9} m^3 / C$
- (ii)  $0.128 \times 10^{-9} m^3 / C$
- (iii)  $0.081 \times 10^{-9} m^3 / C$
- (iv)  $0.016 \times 10^{-9} m^3 / C$



(g) The critical temperature of mercury with isotropic mass  $199.5 \text{ amu}$  is  $4.185\text{K}$ . When its isotropic mass changes to  $203.4 \text{ amu}$ , the critical temperature will be

- (i)  $4.198\text{K}$
- (ii)  $4.169\text{K}$
- (iii)  $4.146\text{K}$
- (iv) None of the above



2. Answer the following questions :  $2 \times 4 = 8$

- (a) What is complex dielectric constant ?
- (b) Explain, what do you mean by first-order and second order phase transition in case of ferroelectric crystals.
- (c) Describe the significance of Block function.
- (d) Draw the unit cell of simple cubic lattice showing clearly the Miller indices of all its six faces.

3. Answer **any three** of the following questions :  $5 \times 3 = 15$

- (a) Show that the reciprocal lattice of a bcc lattice is a fcc lattice.
- (b) How lattice vibrations are quantized ? Name the various vibrational modes of a linear monoatomic lattice. Differentiate between normal processes and umklapp processes.  $2+1+2=5$
- (c) What do you mean by ferromagnetic domain ? Explain the role of Block wall in case of domain formation. What is magnetic energy and anisotropic energy ?  $1+2+2=5$
- (d) What do you mean by Fermi level ? What is Fermi sphere ? Write down the Fermi distribution function at temperature  $T$ . Give a schematic representation of this function at temperatures  $T_1$  and  $T_2$ , where  $T = 0^\circ \text{K}$  and  $T_2 > T_1$ .  $1+1+1+2=5$
- (e) Differentiate between Type I and Type II superconductors showing their magnetisation curves. What is intermediate state ?  $3+2=5$

4. Answer **any three** of the following questions: 10×3=30

- (a) (i) Show that Bragg's law in vector form when obtained from Ewald construction in reciprocal lattice is given by

$$G^2 + 2 \vec{k} \cdot \vec{G} = 0$$

where  $\vec{G}$  is reciprocal lattice vector. 7

- (ii) When X-rays of wavelength  $1.8 \text{ \AA}$  are used, the Bragg's angle corresponding to the first-order reflection from (1, 1, 1) planes in a crystal is  $45^\circ$ . Calculate the interatomic spacing for the crystal. 3

- (b) (i) Obtain Debye's  $T^3$  law of specific heat of solids. 7

- (ii) Evaluate the Debye frequency of a crystal lattice corresponding to Debye temperature  $350\text{K}$ . Given that Boltzmann constant is

$$1.38 \times 10^{-23} \text{ m}^2 \text{kg s}^{-2} \text{K}^{-1} \quad 3$$

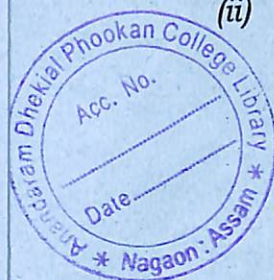
- (c) (i) Use Langevin's classical theory to show that the paramagnetic susceptibility is inversely proportional to temperature. 7

- (ii) The magnetic field of 20 CGS units produces a flux of 2400 CGS units in an iron bar of cross-section  $0.2\text{cm}^2$ . Calculate the permeability and susceptibility of this bar. 3

- (d) (i) Establish Clausius-Mossotti relation between polarisability and dielectric constant of a material. 7

- (ii) Calculate the induced dipole moment per unit volume of He gas placed in an electric field of  $6 \times 10^5 \text{ volt/m}$ . The molecular polarisability of He is  $2.33 \times 10^{-41} \text{ farrad-m}^2$  and the density of He is  $20.6 \times 10^{25} \text{ molecules/m}^3$ . 3

- (e) (i) Use free electron theory of metals to show that at constant temperature the ratio of thermal to electrical conductivity of metals is a constant. 7



- (ii) For a semiconductor, the intrinsic carrier density is  $1.5 \times 10^{16} \text{ m}^{-3}$ . If the mobility of electrons and holes are  $0.13$  and  $0.5 \text{ m}^2 \text{ V}^{-1} \text{ s}^{-1}$  respectively, calculate the conductivity. 3

- (f) (i) State the Curie-Weiss law. What do you mean by Ferroelectric Curie temperature? Explain in brief the significance of P-E hysteresis loop in case of ferroelectricity.

2+1+2=5

- (ii) Write down the London equations of superconductivity. Show that Meissner effect contradicts the Maxwell's equation. 2+3=5

