Roll No. ..... Total Pages : 05

752203

May 2026

M. Sc. (Physics) (Second Semester)

Solid State Physics (PHP-106-V)

Time : 3 *Hours*] [*Maximum Marks :* 75

Note : It is compulsory to answer all the questions (1.5 marks each) of Part A in short. Answer any *four* questions from Part B in detail.

Part A

1. (a) Why are only certain sets of lattice planes observed in X-ray diffraction patterns ? **1.5**

(b) Why is reciprocal lattice more useful than direct lattice in diffraction problems ? **1.5**

(c) What happens to Brillouin zone size if lattice constant increases ? **1.5**

(d) Why does optical branch not exist in monoatomic lattice ? **1.5**

(e) Why is group velocity zero at Brillouin zone boundary ? **1.5**

(f) For what range of frequencies wave like solutions are forbidden for a vibrating diatomic linear chain of unequal masses ? **1.5**

(g) What is the physical meaning of negative effective mass ? **1.5**

(h) How is metal-semiconductor junction different from metal-metal junction ? **1.5**

(i) Why does Hall coefficient become negative for electrons ? **1.5**

(j) Why holes are treated as positive charge carriers ? **1.5**

Part B

2. (a) Derive the Laue condition and show its equivalence to Bragg's law. **5**

(b) Construct the first Brillouin zone for a 2D square lattice and discuss its symmetry. **5**

(c) For a BCC lattice, determine which reflections are absent using structure factor arguments. **5**

3. (a) Derive the expression for structure factor of FCC lattice and explain extinction rules. **5**

(b) Compare diffraction patterns of NaCl and KCl, commenting on atomic form factors. **5**

(c) X-rays of wavelength 1.54 Å are incident on a cubic crystal. If the first-order reflection occurs at 30°, calculate lattice spacing and identify possible plane. **5**

4. (a) Derive the dispersion relation for a diatomic linear chain and explain the origin of acoustic and optical branches. **8**

(b) Define a polaron and explain how electron-phonon interaction leads to its formation. Also discuss the impact of polarons on the transport properties of materials. 7

5. (a) Using Kronig-Penney model, explain how forbidden energy gaps arise. 5

(b) Prove that the motion of electron through a periodic potential of solids give rise to the band structure. 5

(c) A semiconductor has effective masses $m_e^* = 0.1$ m, $m_h^* = 0.5$ m. Discuss, how this affects carrier concentration and mobility. 5

6. (a) Show how De-Haas-Van-Alphen (dHvA) effect is useful in determining the Fermi surface of the materials. 8

(b) Explain reduced zone and extended zone schemes with suitable diagrams. 7

7. (a) Explain tight binding approximation and compare with nearly free electron model. 5

(b) Discuss electron-phonon interaction and formation of polarons and their effect on conductivity. 5

(c) Explain Quantum Hall Effect, highlighting why it leads to quantized conductivity. 5

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