

SEAT No. _____

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[23]

SARDAR PATEL UNIVERSITY

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M. Sc. (Physics) 4th Semester ExaminationMonday, 6th November, 2017

Time: 10:00 am to 01:00 pm

Subject: PS04CPHY02 [Theoretical Solid State Physics]

Total Marks: 70

Note: (1) Figures to the right indicate marks.
 (2) Symbols have their traditional meaning.

Q:1 Attempt all of the following Multiple choice type questions. [01 mark each] [08]

- (1) The energy corresponding to a free electron is given by
 (a) $\frac{h^2 k^2}{8\pi^2 m}$ (c) $\frac{h^2 k}{8\pi^2 m}$
 (b) $\frac{h k^2}{8\pi^2 m}$ (d) $\frac{h^2 k^2}{4\pi^2 m}$
- (2) A plasma oscillation in a metal is a _____ excitation of the conduction electrons.
 (a) collective transverse (c) transverse
 (b) collective longitudinal (d) longitudinal
- (3) Near the forbidden band the curvature of E versus k becomes
 (a) negative (c) zero
 (b) constant (d) positive
- (4) The distance from the centre to boundary of the first Brillouin zone is
 (a) $\frac{2\pi}{a}$ (c) $\frac{\pi}{a}$
 (b) $\frac{\pi}{2a}$ (d) 2π
- (5) The classical Debye-Huckel screening length is proportional to
 (a) $(N_0 e^2 / T)^{-1/2}$ (c) $(N_0 e^2 / T)^{1/2}$
 (b) $(N_0 e^2 / T)^2$ (d) $(N_0 e^2 / T)$
- (6) Change in $1/H$ through a single period of oscillation $\Delta(1/H)$ is proportional to
 (a) $1/A_e$ (c) A_e
 (b) $1/(A_e \cdot hc)$ (d) hc/A_e
- (7) For a superconducting material, transition temperature T_c varies with the average isotopic mass M as,
 (a) $T_c \propto M^{-1}$ (c) $T_c \propto M^{-1/2}$
 (b) $T_c \propto M^{-2}$ (d) $T_c \propto M^{1/2}$
- (8) The width of energy gap in a superconductor at 0°K is nearly
 (a) $300k_B T_c$ (c) $3T_c$
 (b) $k_B T_c$ (d) $3.5k_B T_c$

Q:2 Answer any 7 of the following 9 questions briefly. [02 marks each] [14]

- 1 Explain Umklapp scattering.
- 2 Explain electrostatic screening.
- 3 How is a reciprocal lattice obtained from direct lattice?
- 4 Using suitable schematic diagrams explain briefly the zone schemes.
- 5 Explain briefly the dHvA effect.
- 6 What anomalous skin effect ?
- 7 Explain the origin of energy gap in superconductors.
- 8 Explain with the help of a suitable diagram the term 'coherence length'.
- 9 Give in brief the experimental survey of superconductivity.

Q:3 (a) State and prove Bloch theorem. [6]

- (b) Derive an expression for the band effective mass of an electron and interpret the concept of hole. [6]

OR

- (b) Write a note on Kronig Penny model. [6]

Q:4 (a) Explain the formation of energy bands. Describe the empty lattice method. [6]

- (b) What is orthogonalized plane wave? Obtain an expression for OPW form factor. [6]

OR

- (b) Describe the APW method of band structure calculation. [6]

Q:5 (a) What is Fermi surface? Describe the Harrison's method of constructing Fermi surface. [6]

- (b) Name various methods for the experimental mapping of Fermi surface and discuss cyclotron resonance in detail. [6]

OR

- (b) Obtain an expression for the Lindhard screening function. Also determine its limiting values for $q \rightarrow 0$ and $q \rightarrow \infty$. [6]

Q:6 (a) Explain Josephson effects and derive expression for current density across superconductor-insulator-superconductor junction. [6]

- (b) Explain the formation of Cooper pair. Enumerate the important features of BCS theory of superconductivity. [6]

OR

- (b) Define Superconductivity. Explain in detail how superconductors are classified into class-I and class-II superconductors. [6]

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