[194/A34] SEAT No._____ No. of Printed Pages : 2

SARDAR PATEL UNIVERSITY

M. Sc. (Physics) 4th Semester Examination
Thursday, 25th October, 2018
Time: 02:00 pm to 05:00 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) In the free electron model the mass of the electron
(a) $\hbar^2\left(\frac{d^2E}{dk^2}\right)$ (c) $\hbar\left(\frac{d^2E}{dk^2}\right)^{-1}$
(b) is much greater than m_e (d) is constant

(2) A plasma oscillation in a metal is a _____excitation of the conduction electrons.
(a) collective transverse (c) collective longitudinal
(b) transverse (d) longitudinal

(3) Near the forbidden band the curvature of E versus k becomes
(a) positive (c) zero
(b) negative (d) constant

(4) A Bloch function $|\psi_k\rangle$ can be represented in terms of plane waves as
(a) $\sum_g a_g\left|\vec{k}-\vec{g}\right\rangle$ (c) $\sum_g a_g\left|\vec{k}-\vec{g}\right\rangle\left\langle\vec{k}-\vec{g}\right|$
(b) $\sum_g a_g\left\langle\left|\vec{k}-\vec{g}\right\rangle\right|$ (d) $\exp(ikNa)$

(5) The classical Debyr-Huckel screening length is proportional to
(a) $\left(N_0e^2/T\right)^{-1/2}$ (c) $\left(N_0e^2/T\right)^{1/2}$
(b) $\left(N_0e^2/T\right)^{2}$ (d) $\left(N_0e^2/T\right)$

(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) $1/(A_e*hc)$ (d) hc/A_e

(7) The critical temperature of superconductor change with
(a) temperature (c) isotopic mass
(b) electric field (d) size

(8) For superconductor, energy gap which is centered about Fermi surface
(a) is undefined (c) remains unchanged with temperature
(b) decreases with increase of temperature (d) increases with increase of temperature

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

1 Explain origin of energy gap.
2 Draw a neat diagram and explain Umklapp process.
3 Explain how conductors, semiconductors and insulators are classified.
4 Give a schematic diagram showing the first and second Brillouin zones for a square lattice.
5 Show with the help of a diagram how an OPW is obtained.
6 Define Fermi gas and Block function.
7 Explain ultrasonic attenuation.
8 Describe the origin of energy gap.
9 Explain isotope effect.

Q:3 (a) Write notes on (i) plasma optics (ii) origin of energy gap. [6]

(b) Formulate the Kronig-Penny model and establish the relation, [6]

$$p\frac{\sin(\alpha \cdot a)}{(\alpha \cdot a)} + \cos(\alpha \cdot a) = \cos(k \cdot a).$$

OR

(b) Write notes on (i) electrostatic screening (ii) screened Coulomb potential. [6]

Q:4 (a) Explain the plane wave method of energy band calculation and list its merits and demerits. [6]

(b) Explain various zone schemes and give a detailed classification of materials based on band theory of solids. [6]

OR

(b) Write a note on tight binding method. [6]

Q:5 (a) Write the names of experimental methods for mapping the Fermi surface. Write note on dHvA effect. [6]

(b) (i) Write note on anomalous skin effect. [6]
(ii) Deduce the relation $\Delta A = {2\pi eH}/{\hbar c}$.

OR

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

Q:6 (a) Derive the expression for coherence length as well as London's penetration depth. [6]

(b) Write notes on (i) Meissner effect (ii) Fullerenes. [6]

OR

(b) Explain the formation of Cooper pair and list out salient features of BCS theory of superconductivity. [6]

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(2)