SARDAR PATEL UNIVERSITY

M. Sc. (Physics) 2nd Semester Examination
Thursday, 25th October, 2018
Time: 10:00 am to 01:00 pm
Subject: PS02CPHY22 [Theoretical Condensed Matter 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)   Which of the following combination of three quantum numbers give 6 fold degenerate level.
   (a)   (1,1,1)   (c) (1,1,3)
   (b)   (2,2,1)   (d) (1,2,3)

(2)   Hall field is proportional to _____.
   (a)   current density   (c) magnetic field and current density
   (b)   Hall coefficient   (d) magnetic field

(3)   In the Kronig-Penny model of a linear lattice, if the strength of the periodic potential increases, the width of the allowed bands
   (a)   increases   (c) remains constant
   (b)   decreases   (d) changes periodically

(4) $P = \sum_{cl} |\psi_{cl}\rangle\langle\psi_{cl}|$ is known as
   (a)   projection operator   (c) pseudopotential
   (b)   unitary operator   (d) opw operator

(5)   Dielectric constant of a material is defined as
   (a) $\varepsilon_r = C_0/C$ (c) $\varepsilon_r = C/C_0$
   (b) $\varepsilon_r = -C_0/C$ (d) $\varepsilon_r = -C/C_0$

(6)   Dielectric constant and polarizability are _____ quantities respectively.
   (a)   microscopic, microscopic   (c) macroscopic, microscopic
   (b)   macroscopic, macroscopic   (d) microscopic, macroscopic

(7)   London's first equation is not in agreement with _____ theory.
   (a)   BCS   (c) Meissner
   (b)   GL   (d) Josephson

(8)   The energy gap in a superconductor is equal to_____.
   (a) Δ (c) $2/\Delta$
   (b) 2Δ (d) $\Delta/2$

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

1 An electron confined to move in a three dimensional potential of box of length 0.6 Å. Find the lowest energy of the electron.
2 Explain Fermi-Dirac statistics.
3 Differentiate between conductors, semiconductors and insulators.
4 Explain symmetry properties of the energy function.
5 What is Brillouin zone? How can it be constructed in one dimension?
6 Describe ferromagnetic order in brief.
7 With the help of energy band diagram briefly explain direct and indirect band gap.
8 Explain the term "coherence length of a superconductor".
9 Differentiate between hard and soft superconductors.

Q:3 (a) Setup the Schroedinger equation for an electron moving in one dimensional [6] potential and solve it to obtain $E_n = h^2n^2/8ma^2$. Find the value of normalization constant and sketch the wave function.

(b) Write a note on quantum state and degeneracy.   [6]

OR

(b) Write notes on (i) Electrical conductivity and Ohm's law (ii) Wiedmann- [6] Franz law.

Q:4 (a) Describe the nearly free electron method of band structure calculation.   [6]

(b) Explain the orthogonalized plane wave method.   [6]

OR

(b) Write a note on effective mass of an electron.   [6]

Q:5 (a) Draw a suitable schematic diagram and explain the following expressions [6] for a semiconductor.
(i) $K_h = -K_e$ (ii) $V_h = V_e$ (iii) $m_h = -m_e$

(b) Define polarizability and derive the Clausius Mossotti relation.   [6]

OR

(b) Derive Langevin's equation for diamagnetic material.   [6]

Q:6 (a) What is Josephson tunneling? Show that current of superconductor pair [6] across the junction depends on the phase difference.

(b) Write notes on (i) Meissner effect (ii) single particle tunneling.   [6]

OR

(b) Write notes on (i) flux quantization (ii) fullerenes.   [6]

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