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SARDAR PATEL UNIVERSITY

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M. Sc. (Physics) 2nd Semester ExaminationWednesday, 11th April, 2018

Time: 02:00 pm to 05:00 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) Carrier mobility is given by _____.
- (a) $\frac{m}{e\tau}$ (c) $\frac{e\tau}{m}$
 (b) $\frac{\tau}{me}$ (d) $\frac{em}{\tau}$
- (3) In aluminium the core states are associated with
- (a) $3s^2 3p^1$ (c) d shells
 (b) $1s^2 2s^2 2p^6$ (d) $1s^2 2s^2 2p^6 3s^1$
- (4) As a consequence of Bloch's condition we have
- (a) $\exp(ikNa) = 1$ (c) $\exp(ika) = 1$
 (b) $\exp(ikN) = 1$ (d) $\exp(kNa) = 1$
- (5) Dielectric constant of a material is defined as
- (a) $\epsilon_r = C_0/C$ (c) $\epsilon_r = C/C_0$
 (b) $\epsilon_r = -C_0/C$ (d) $\epsilon_r = -C/C_0$
- (6) Magnetic moments of nuclei are of the order of _____ times smaller than the magnetic moment of an electron.
- (a) 10^{-2} (c) 10^{-5}
 (b) 10^{-4} (d) 10^{-3}
- (7) London's first equation is not in agreement with _____ theory.
- (a) BCS (c) Meissner
 (b) GL (d) Josephson
- (8) Angular frequency of AC Josephson effect is _____.
- (a) $2\pi qV_0/h$ (c) $2\pi eV_0/h$
 (b) $4\pi eV_0/h$ (d) none of the above

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

- 1 Find the lowest energy of an electron confined to move in a three dimensional potential of box of length 0.5 \AA .
- 2 Explain relaxation time and mean free path.
- 3 Differentiate between conductors, semiconductors and insulators.
- 4 Draw a diagram representing the extended, reduced and periodic zone scheme.
- 5 Explain construction of Brillouin zone in one dimension.
- 6 Using a suitable diagram, explain indirect band gap in a semiconductor crystal.
- 7 Differentiate between ferromagnetic and anti-ferromagnetic material.
- 8 Explain briefly coherence length of a superconductor.
- 9 Explain briefly penetration depth for a superconductor.

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

(b) Write a note on density of states. [6]

OR

(b) Write notes on (i) Fermi-Dirac statistics (ii) Electron drift in an electric field. [6]

Q:4 (a) Formulate the Kronig-Penny model and establish the relation, [6]
$$p \frac{\sin(\alpha \cdot a)}{(\alpha \cdot a)} + \cos(\alpha \cdot a) = \cos(k \cdot a).$$

(b) Describe the tight binding method of band structure calculation. [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 for a semiconductor. [6]

(i) $K_h = -K_e$ (ii) $V_h = V_e$ (iii) $m_h = -m_e$

(b) Derive the expression for electric field of a dipole and local electric field at an atom. [6]

OR

(b) What is magnetization? With help of necessary diagram discuss in detail cooling by adiabatic demagnetization. [6]

Q:6 (a) Obtain the change in Gibbs free energy, entropy and specific heat at [6]
superconducting transition.

(b) Describe Bardeen-Cooper-Schrieffer theory of superconductivity in detail [6]

OR

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

