

Sc

[120]

SEAT No. \_\_\_\_\_

No. of Printed Pages : 2

SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

M. Sc. (Physics) 2<sup>nd</sup> Semester Examination

Wednesday, 20<sup>th</sup> March, 2019

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) For 1-d Fermi gas, which of the following is the correct relation between average energy per particle and Fermi energy?
- (a)  $2E_F/3$  (c)  $5E_F/3$   
(b)  $3E_F/2$  (d)  $3E_F/5$
- (2) The Fermi distribution function reduces to Boltzmann distribution function at
- (a) low pressure (c) high energy  
(b) low temperature (d) low energy
- (3) Under the free electron approximation,  $E$  versus  $k$  curve is \_\_\_\_\_.
- (a) spherical (c) linear  
(b) parabolic (d) constant
- (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) Which of the following represents the Curie's law of magnetism?
- (a)  $C/T = M/B$  (c)  $T/C = M/B$   
(b)  $C/T = B/M$  (d)  $C/T = M.B$
- (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) Transition from superconductor state to normal state is a \_\_\_\_\_ order transition.
- (a) first (c) mixed  
(b) second (d) options a & b both
- (8) According to Meissner effect, magnetic field  $B$  inside a superconductor \_\_\_\_\_.
- (a) should be 0 (c) should be infinite  
(b) should be 1 (d) varies with isotopic mass

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  $0.6 \text{ \AA}$ .
- 2 At what temperature we can expect a 10% probability that electrons in silver have an energy which is 1% above, the Fermi energy? The Fermi energy of silver is 5.5 eV.
- 3 Explain Wiedemann-Franz-Lorentz law.
- 4 Draw a diagram representing the extended, reduced and periodic zone scheme.
- 5 Explain the symmetry properties of the energy function  $E(k)$  in  $k$  space.
- 6 What is ferromagnetic order?
- 7 Explain the expression  $\varepsilon_n(K_h) = -\varepsilon_v(K_v)$  for semiconductor using suitable diagram.
- 8 Explain isotope effect in a superconductor.
- 9 What is the difference between type 1 and type 2 superconductors?

Q:3 (a) Setup the Schrödinger 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 quantum state and degeneracy. [6]

**OR**

(b) Write notes on (i) Electrical resistivity of metals (ii) Hall effect. [6]

Q:4 (a) Describe in detail, the construction of Brillouin zones in one and two dimensions and derive the necessary equations for the zone boundaries. [6]

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

**OR**

(b) Write a note on OPW method of band structure calculation. [6]

Q:5 (a) Write a note on effective mass in semiconductors and give its physical interpretation. [6]

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

**OR**

(b) What is paramagnetism? Explain the quantum theory of paramagnetism. [6]

Q:6 (a) Derive London's equation for superconductor and also deduce the expression for penetration depth. [6]

(b) How are Cooper pairs formed? Explain the important features of BCS theory of superconductivity. [6]

**OR**

(b) What is dc and ac Josephson effect? Explain the dc Josephson effect in detail. [6]

— X —