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SARDAR PATEL UNIVERSITY

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M. Sc. (Physics) 4th Semester Examination

Tuesday, 25th October, 2016

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) Positive effective mass corresponds to

(a) $\frac{d^2E}{dk^2}$ positive (c) $\frac{d^2E}{dk^2}$ negative

(b) $\frac{d^2E}{dk^2}$ infinity (d) $\frac{d^2E}{dk^2}$ zero

(2) In the Kronig-Penny model of a linear lattice, if the strength of the potential barrier P increases, the width of the allowed bands

(a) increases (c) remains constant

(b) decreases (d) none of these

(3) For a monovalent metal, the area of first Brillouin zone corresponding to a square lattice of periodicity a is given by

(a) $2\pi/a^2$ (c) $4\pi^2/a$

(b) $(2\pi/a)^3$ (d) $4\pi^2/a^2$

(4) For wave vector k=0, all the states inside the first Brillouin zone are

(a) half filled (c) full

(b) free (d) empty

(5) Difference in area of classical orbits at adjacent allowed energies is

(a) $(2\pi eH/\hbar c)$ (c) $(2\pi eH/\hbar c)$

(b) $(2\pi H/\hbar c)$ (d) $(2\pi cH/\hbar H)$

(6) Explanation to theory of dHvA effect for Bloch electrons was pointed out by

(a) Landau (c) Bloch

(b) Onsager (d) Shoenberg

(7) Number of charge carriers thermally excited from valence band to conduction band is proportional to

(a) $\exp(-Ev/k_BT)$ (c) $\exp(-Eg/k_BT)$

(b) $\exp(Eg/k_BT)$ (d) $\exp(-Ec/k_BT)$

(8) The critical temperature Tc of superconductors varies with the isotopic mass as

(a) $M^{-\alpha}T_c = \text{constant}$ (c) $M^{\alpha}/T_c = \text{constant}$

(b) $MT_c = \text{constant}$ (d) $M^{\alpha}T_c = \text{constant}$

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

1 State Bloch's theorem. How is this theorem useful?

2 Give classification of solids based on energy gaps.

3 Draw diagrams properly representing the periodic, extended and reduced zone scheme.

4 Draw a figure to show the first, second and third Brillouin zone for a square lattice in two dimension.

5 Explain very briefly the de Hass-van Alphen effect.

6 What is anomalous skin effect?

7 Briefly explain about microwave and infrared properties in case of superconductors.

8 Explain fullerenes.

9 Differentiate between Type-I and Type-II superconductors.

Q:3 (a) Explain electrostatic screening and obtain the relation $\varepsilon(0,q) = 1 + \frac{q_s^2}{q^2}$. |6|

(b) Write notes on (i) Screened Coulomb Potential (ii) Longitudinal plasma oscillations. |6|

OR

(b) Formulate the Kronig-Penny model and obtain the relation $P\frac{\sin(\alpha a)}{\alpha a} + \cos(\alpha a) = \cos(ka)$. |6|

Q:4 (a) Write a note on Empty lattice method [6]

(b) What are the drawbacks of plane wave method? Describe the OPW method of band structure calculation. [6]

OR

(b) Discuss the APW method to determine the band structure. [6]

Q:5 (a) Write notes on (i) Fridel oscillations (ii) Free electron Landau levels. [6]

(b) List various methods of Fermi surface determination and describe in detail the cyclotron resonance. [6]

OR

(b) Write notes on (i) Electron ion potential and screening (ii) Lindhard dielectric function. [6]

Q:6 (a) Describe the flux quantization in a superconducting ring. [6]

(b) Explain the formation of cooper pair and give salient features of BCS theory of superconductivity. [6]

OR

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