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SARDAR PATEL UNIVERSITY

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M. Sc. (Physics) 4th Semester Examination

Wednesday, 11th April, 2018

Time: 10:00 am to 01:00 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) The Fermi wave vector k_F is given by

(a) $(3\pi^2 V/N)^{1/3}$ (c) $(3\pi^2 N/V)^{2/3}$

(b) $(3\pi^2 V/N)^{2/3}$ (d) $(3\pi^2 N/V)^{1/3}$

(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) $2\pi/a$ defines the boundary between which Brillouin zones

(a) origin and first (c) first and second

(b) second and third (d) none

(4) A Bloch function $|\psi_k\rangle$ can be represented in terms of plane waves as

(a) $\sum_g a_g |\vec{k}-\vec{g}\rangle$ (c) $\sum_g a_g |\vec{k}-\vec{g}\rangle\langle\vec{k}-\vec{g}|$

(b) $\sum_g a_g \langle|\vec{k}-\vec{g}\rangle|$ (d) $\exp(ikNa)$

(5) The classical Debyr-Huckel screening length is proportional to

(a) $(N_0 e^2/T)^{-1/2}$ (c) $(N_0 e^2/T)^{1/2}$

(b) $(N_0 e^2/T)^2$ (d) $(N_0 e^2/T)$

(6) In aluminium the core states are associated with

(a) d shells (c) $3s^2\ 3p^1$

(b) $1s^2\ 2s^2\ 2p^6$ (d) $1s^2\ 2s^2\ 2p^6 3s^1$

(7) Superconductivity was discovered by _____ in 1911 at Leiden.

(a) London (c) Kammerlingh Onnes

(b) Landau (d) Bednortz and Muller

(8) The BCS energy gap is given by_____.

(a) $1/k_B T_C$ (c) $4.1 k_B T_C$

(b) $k_B T_C$ (d) $3.5 k_B T_C$

(P.T.O.)

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

1 Explain origin of energy gap.
2 Explain briefly band effective mass.
3 Explain how conductors, semiconductors and insulators are classified.
4 Differentiate between extended, reduced and periodic zone schemes using suitable diagrams.
5 Show with the help of a diagram how a OPW is obtained.
6 What are Friedel oscillations?
7 Explain the anomalous skin effect.
8 Describe soft and hard superconductor with appropriate diagram.
9 Explain isotope effect.

Q:3 (a) State and prove Bloch theorem. |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) Describe the empty lattice method. |6|

(b) Explain the tight binding method of energy band calculation. |6|

OR

(b) Describe the Plane wave method of band structure calculation.. |6|

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

(b) (i) Write note on magnetoacoustic effect. |6|
(ii) Deduce the relation $\Delta A = 2\pi eH/hc$.

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) Discuss the two fluid model of superconductor and derive London's equation and London's penetration depth. |6|

(b) Write notes on (i) Josephson effect (ii) Fullerenes. |6|

OR

(b) Discuss the thermodynamics of type-I superconductors near phase transition. |6|

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