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M.Sc. (Third Semester)
EXAMINATION, Dec. - Jan., 2021-22
PHYSICS
Paper Third
(SOLID STATE PHYSICS - I)

[Time : Three Hours] *[Maximum Marks : 80]*

[Minimum Pass Marks : 16]

Note : Attempt all sections as directed

Section - A
(Objective / Multiple Choice Questions)

(1 Mark each)

Note : Attempt all questions.

Choose the correct answer.

P.T.O.

1. The energy of the lowest band at K = 0, when the kroing-Penney potential P<<1 is

(A) $\frac{4\pi^2 ma}{h^2 P}$

(B) $\frac{h^2 P}{4\pi^2 ma}$

(C) $\frac{4\pi^2 mP}{h^2 a}$

(D) $\frac{h^2 a}{4\pi^2 mP}$

2. The expression for fermi-derac distribution function is

(A) $f(E) = \frac{1}{1+e^{\beta(E-\mu)}}$

(B) $f(E) = \frac{1}{1-e^{\beta(E-\mu)}}$

(C) $f(E) = \frac{1}{1+e^{(E-\mu)}}$

(D) $f(E) = \frac{1}{e^{(E-\mu)}}$

3. The range of ware vector K, that corresponds to the first Brillouin zone in metal is:

(A) $\frac{-a}{\pi} \text{ to} + \frac{a}{\pi}$ (B) $\frac{-\pi}{2a} \text{ to} \frac{+\pi}{2a}$

(C) $\frac{-\pi}{a} \text{ to} + \frac{\pi}{a}$ (D) $\frac{-a}{2\pi} \text{ to} \frac{+a}{2\pi}$

4. A particles of 3-dimensional solid are bosonic in nature have fequency ω are related by $\omega \alpha k^2$ the specific heat of the system at two temperature is proportional to.

(A) $T^{1/2}$ (B) $T^{3/2}$

(C) T^3 (D) T

5. The effective mass of a Bloch electron is a function of K and μ given by:-

(A) $m^* = \frac{h^2}{4\pi^2}\left(\frac{d^2E}{dK^2}\right)^{-1}$

(B) $m^* = \frac{4\pi^2}{h^2}\left(\frac{d^2K}{dE^2}\right)^{-1}$

(C) $m^* = \frac{h^2}{4\pi^2}\left(\frac{d^2K}{dE^2}\right)^{-1}$

(D) $m^* = \frac{4\pi}{h}\left(\frac{d^2K}{dE^2}\right)^{-1}$

6. The London penetration depth is given by :-

(A) $\lambda = \left[\frac{m}{n_s \mu_0 e^2}\right]^{v2}$ (B) $\lambda = \left[\frac{n_s}{m \mu_0 e^2}\right]^{v2}$

(C) $\lambda = \left[\frac{n_s}{m^2 n_{s^2} \mu_0}\right]^{v2}$ (D) None of the above

7. The number of optical phonon branches for two atoms basis in the primitive cell is [in 3-dimension]

(A) 1

(B) 2

(C) 3

(D) 8

8. The density of charge carriers in a pure semiconductor is proportional to:

(A) $\exp\left(\frac{-Eg}{K_B T}\right)$

(B) $\exp\left(\frac{-2Eg}{K_B T}\right)$

(C) $\exp\left(\frac{-Eg}{K_B T^2}\right)$

(D) $\exp\left(\frac{-Eg}{2K_B T}\right)$

9. In the original BCS model of superconductivity the dependence of Tc on isotope mass is-

(A) $Tc \alpha M^{-1}$

(B) $Tc \alpha M$

(C) $Tc \alpha M^{-1/2}$

(D) $Tc \alpha M^{1/2}$

10. The expression for fermi temperature is

(A) $T_F = \frac{E_F}{K_B}$

(B) $T_F = \frac{K_B}{E_F}$

(C) $T_F = \frac{1}{K_B}$

(D) $T_F = \frac{1}{E_F}$

11. The fermi level for an n-type semiconductor is nearer to

(A) Conduction band

(B) Valence band

(C) Middle of energy gap

(D) None of the above

12. The value of the radius of fermi sphere (K_F) is proportional to:

(A) $N^{3/2}$

(B) $N^{2/3}$

(C) $N^{1/2}$

(D) $N^{1/3}$

13. According to the free electron model the average kinetic energy of electron at an absolute temperature T μ [in 3-dimension]

(A) $\frac{1}{2}KT$

(B) $\frac{3}{2}KT$

(C) $\frac{5}{2}KT$

(D) $\frac{7}{2}KT$

14. The magnetic susceptibility of a superconductor is:

(A) Positive and small

(B) Positive and unity

(C) Negative and unity

(D) Positive and unity

15. The superconducting energy gap is of the order of

(A) $K_B T_C$

(B) $2K_B$

(C) $2T_C$

(D) None of the above

16. When $T = T_C$ the penetration depth becomes to:

(A) Infinite

(B) Zero

(C) Half

(D) None of the above

17. Hall constant R_H is

(A) $R_H = -ne$

(B) $R_H = \frac{-1}{ne}$

(C) $R_H = \frac{-ne}{m}$

(D) $R_H = \frac{m^2}{ne^2}$

18. The dependence of the mobility of charge carriers in a semiconductor is given by:

(A) $\mu \alpha \frac{1}{T}$

(B) $\mu \alpha \frac{1}{T^{3/2}}$

(C) $\mu \alpha T^{3/2}$

(D) $\mu \alpha T^2$

19. Second exuted state energy of the electron in a potential well of length "L" is:

(A) $E_n = \frac{\hbar^2}{2m}\left(\frac{n\pi}{L}\right)^2$

(B) $E_n = \frac{\hbar^2}{2m}\left(\frac{\pi}{L}\right)^2$

(C) $E_n = \frac{4\hbar^2}{2m}\left(\frac{\pi}{L}\right)^2$

(D) None of the above

20. Ehe essential condition for superconductor is:

(A) $T > T_C$ and H = 0

(B) $T < T_C$ and $H > H_C$

(C) $T < T_C$ and $H < H_C$

(D) None of the above

Section - B

(Very Short Answer Type Questions)

(2 Marks each)

Note : Attempt all questions.

1. Explain the Bloch theorem.
2. What is meissner effect?
3. What is zone boundary?
4. Define A.C Josepshon effect.
5. Give the concept of holes.
6. Discuss the zone scheme.
7. Explain how cooper pairs are formed in superconductor.
8. Explain phonon momentum.

Section - C

(Short Answer Type Questions)

(3 Marks each)

Note: Attempt all questions.

1. What is a kronig-penney model? Explain it.
2. What is Band gap of semiconductor crystal. Discuss the direct and indirect band gap.
3. Differentiate the Type-I and Type-II superconducter.
4. What is a coherence length?
5. What do you mean by quantization of elastic wave?
6. What is an optical and acoustic mode?
7. Explain how to destruct the superconductivity by external magnetic field.
8. Explain the free electron model.

Section - D

(Long answer type questions)

(4 Marks each)

Note : Attempt any five questions.

1. Derive the equation of motion of charse carrier in semi-conductor cristal and explain the physical derivation of
   $$F = \hbar \frac{dk}{dt}$$
2. Write the vibrational spectrum of linear diatomic latitice and it consists of two branches. Discuss main features of vibration.
3. Derive London's equation and show that these equation can account for a perfect diamagnetism property of an ideal superconducter.
4. What is fermi surface? Explain how are these constructed and studied experimentally.
5. Salve wave equation for an electron in periodic potential and explain origin of energy band gap in solid.
6. A wire of lead having a diameter of 1mm at 4.2k. The critcal temperature for lead is 7.18k and $H_C(0) = 6.5 \times 10^4 \, {}^{Amp}/_{m}$. Then caclulate the critical current of wire.
7. Obtain expression for intrinsic carrier concentration in semiconductor.