GOVERNMENT ZIRTIRI RESIDENTIAL SCIENCE COLLEGE

Subject : PHYSICS
Paper Name : Solid State Physics
Paper No. : PHY/VI/CC/21a
Semester : VI

A. Multiple Choice Questions:

1. If m is the mass of each of an array of identical, equidistant atoms with interatomic spacing a, f is the force constant and k is the wave vector. Then the dispersion relation for monoatomic linear lattice is
   a) $\omega = 2\sqrt{\frac{f}{m}}\left|\sin\frac{ka}{2}\right|$
   b) $\omega = 2\sqrt{\frac{m}{f}}\left|\sin\frac{ka}{2}\right|$
   c) $\omega = 2\sqrt{\frac{f}{m}}|\sin ka|$
   d) $\omega = 2\sqrt{\frac{m}{f}}|\sin ka|$

2. C_s and w_k are the velocity of sound and angular frequency of the kth mode of vibration respectively. The energy of phonon is given by
   a) $\hbar C_k = \hbar w_s k$
   b) $\hbar w_k = \hbar C_s k$
   c) $\hbar w_k = \frac{\hbar}{C_s k}$
   d) $\hbar C_s = \frac{\hbar}{w_k k}$

3. In vibration of monoatomic linear lattice at low frequencies, i.e. $k = 0$, the long wavelength limit. Which one is correct for the group velocity v_g and phase velocity v_p?
   a) $v_g > v_p$
   b) $v_g < v_p$
   c) $v_g = v_p$
   d) $v_g = 2v_p$

4. In vibrational modes of diatomic linear lattice, the first brillouin zone limits the value of wave vector k to the range between
   a) $-\frac{3\pi}{2a}\ and + \frac{3\pi}{2a}$
   b) $-\frac{2\pi}{a}\ and + \frac{2\pi}{a}$
   c) $-\frac{\pi}{a}\ and + \frac{\pi}{a}$
   d) $-\frac{\pi}{2a}\ and + \frac{\pi}{2a}$

5. The frequencies in the first brillouin zone for optical branch and acousical branch are respectively
   a) $\omega_+ = \sqrt{\frac{2f}{m}} \quad and \quad \omega_- = \sqrt{\frac{2f}{M}}$
   b) $\omega_+ = \sqrt{\frac{f}{m}} \quad and \quad \omega_- = \sqrt{\frac{f}{M}}$
   c) $\omega_+ = \sqrt{\frac{f}{2m}} \quad and \quad \omega_- = \sqrt{\frac{f}{2M}}$
   d) $\omega_+ = \sqrt{\frac{2f}{3m}} \quad and \quad \omega_- = \sqrt{\frac{2f}{3M}}$

6. The magnetic susceptibility is independent of temperature in which magnetic material?
   a) diamagnetic
   b) ferromagnetic
   c) paramagnetic
   d) ferrimagnetic

7. The complicated temperature dependence of susceptibility of paramagnetic materials is explained by
   a) Langevin theory
   b) Weiss theory
   c) Curie theory
   d) none of the above

8. If n is the number of atoms each having permanent magnetic moment m. Then according to Langevin theory of paramagnetism, the magnetization M at low temperature will be
   a) $M = \frac{m}{n}$
   b) $M = \frac{n}{m}$
   c) $M = mn$
   d) $M = m^n$

9. A paramagnetic salt contains $10^{28} ions/m^3$ with magnetic moment of *1 Bohr magneton*. The paramagnetic susceptibility in a uniform magnetic field of $10^6 A/m$ at room temperature is
   a) 0.87 x 10^{-2}
   b) 8.7 x 10^{-4}
   c) 8.7 x 10^{-2}
   d) 0.87 x 10^{-4}

10. In quantum theory of paramagnetism, the susceptibility is given by the relation

a) $\chi = \frac{N^2 p^2 \mu_B^2}{2k_B T}$
b) $\chi = \frac{N p^2 \mu_B^2}{3k_B T}$
c) $\chi = \frac{N p^2 \mu_B^2}{2k_B T}$
d) $\chi = \frac{N p^2 \mu_B^2}{3k_B T^2}$

11. The expression for Clausius-Mossotti equation is
a) $\frac{\epsilon_r - 1}{\epsilon_r + 2} = \frac{N\alpha}{3\epsilon_0}$
b) $\frac{\epsilon_r + 1}{\epsilon_r - 2} = \frac{N\alpha}{3\epsilon_0}$
c) $\frac{\epsilon_r - 1}{\epsilon_r - 2} = \frac{N\alpha}{3\epsilon_0}$
d) $\frac{\epsilon_r + 1}{\epsilon_r + 2} = \frac{N\alpha}{3\epsilon_0}$

12. The relation between polarization vector $\vec{P}$ and electric displacement vector $\vec{D}$ is given by
a) $\vec{D} = \varepsilon_0 \vec{P} + \vec{E}$
b) $\vec{D} = \varepsilon_0 \vec{E} + \vec{P}$
c) $\vec{D} = \varepsilon_0 \vec{E} - \vec{P}$
d) $\vec{D} = \varepsilon_0 \vec{P} - \vec{E}$

13. The internal field or local field $\vec{E}_{loc}$, i.e. the field acting at the location of an atom in a dielectric material is given by
a) $\vec{E}_{loc} = \vec{P} + \frac{\vec{E}}{3\varepsilon_0}$
b) $\vec{E}_{loc} = \vec{P} - \frac{\vec{E}}{3\varepsilon_0}$
c) $\vec{E}_{loc} = \vec{E} + \frac{\vec{P}}{3\varepsilon_0}$
d) $\vec{E}_{loc} = \vec{E} - \frac{\vec{P}}{3\varepsilon_0}$

14. An example of non-polar molecule is
a) H_2O
b) N_2O
c) CO
d) CO_2

15. The value of depolarirization factor for sphere is
a) 3
b) 2
c) $\frac{1}{3}$

d) $\frac{1}{2}$

16. The effective mass of an electron is given by
    a) $m^* = \frac{h^2}{d^2E/dk^2}$
    b) $m^* = \frac{d^2E/dk^2}{h^2}$
    c) $m^* = \frac{d^2k/dE^2}{h^2}$
    d) $m^* = \frac{h^2}{d^2k/dE^2}$

17. Kronig-Penney model is
    a) real model
    b) approximate model
    c) both (a) and (b)
    d) none of the above

18. Which is the correct expression for Bloch theorem?
    a) $\psi(x) = e^{ikx}$
    b) $\psi(x) = e^{-ikx}$
    c) $\psi(x) = u(x)e^{ikx}$
    d) $\psi(x) = u(x)e^{-ikx}$

19. In *E*-*k* diagram
    a) each portion of the curve represents allowed band of energies
    b) the curves are horizontal at the top and bottom
    c) the curves are parabolic near the top and bottom with curvatures in opposite direction
    d) all of the above

20. The effective mass of an electron is maximum when it is in the
    a) lower energy levels of an allowed band
    b) higher energy levels of an allowed band
    c) both (a) and (b)
    d) energy levels corresponding to a point of inflection in allowed band

21. Superconductivity is exhibited at
    a) Mercury at 4.2 K
    b) Hydrogen at 4.2 K
    c) Magnesium at 4.2 K
    d) Potassium at 4.2 K

22. A superconducting tin has a critical temperature of *3.7 K* at zero magnetic field and a critical field of *0.0306 T* at *0 K*. The critical field at *2 K* is

a) 0.261 *T*
b) 0.0261 *T*
c) 2.61 *T*
d) 2.061 *T*

23. If $H_C(0)$ is the critical field at *0K*. Then the critical magnetic field at temperature *T* is
a) $H_C(T) = H_C(0)\ \left[1 - \left(\frac{T}{T_C}\right)\right]$
b) $H_C(T) = H_C(0)\ \left[\left(\frac{T}{T_C}\right) - 1\right]$
c) $H_C(T) = H_C(0)\ \left[1 - \left(\frac{T}{T_C}\right)^2\right]$
d) $H_C(T) = H_C(0)\ \left[\left(\frac{T}{T_C}\right)^2 - 1\right]$

24. The maximum known crtical field for type-I superconductor is of the order of
a) 100 *T*
b) 10 *T*
c) 1 *T*
d) 0.1 *T*

25. At temperature $T < T_C$, the London's penetration depth $\lambda_L(T)$ can be expressed as
a) $\lambda_L(T) = \frac{\lambda_L(0)}{\sqrt{1-\left(\frac{T}{T_C}\right)^4}}$
b) $\lambda_L(T) = \frac{\lambda_L(0)}{\sqrt{1-\left(\frac{T}{T_C}\right)}}$
c) $\lambda_L(T) = \frac{\lambda_L(0)}{\sqrt{\left(\frac{T}{T_C}\right)^4-1}}$
d) $\lambda_L(T) = \frac{\lambda_L(0)}{\sqrt{\left(\frac{T}{T_C}\right)-1}}$

B. Fill up the blanks:

1. The quantum of energy in an eleastic wave is called __________

2. For one dimensional periodic lattice, the extreme values of wave vector in the first brillouin zone is __________

3. For the optical branch at *k = 0*, vibration of atoms are in opposite direction and __________ are inversely in the ratio of the masses.

4. The value of *1 Bohr magneton is* __________ Am^2.

5. The magnetic materials which do not possess permanent magnetic moment is __________ materials.

6. The expression for susceptibility, i.e., $\chi = \frac{C}{T}$ is known as __________ law.

7. The ratio between the absolute permittivity of the medium (ϵ) to the permittivity of free space (ϵ_0) is called __________

8. The process of producing electric dipoles by an electric field is called __________

9. The net polarizability of dielectric material results from three main contributions, which are, orientational polarizability, ionic polarizability and __________ polarizability.

10. The energy gap gor germanium *Ge* is __________ *eV*.

11. In an insulator, the __________ band is completely filled.

12. In Kronig-Penney model, the widths of allowed bands increases and forbidden bands decreases with increase of __________

13. A superconductor exhibits perfect diamagnetism, then $\chi =$__________

14. The electron pairs in a superconductor are called __________

15. The intermidiate state between a superconducting and normal conductor is called __________ state.

Key Answers

A. Multiple Choice Questions:

1. a) $\omega = 2\sqrt{\frac{f}{m}}\left|\sin\frac{ka}{2}\right|$
2. b) $\hbar w_k = \hbar C_s k$
3. c) $v_g = v_p$
4. d) $-\frac{\pi}{2a}\ and + \frac{\pi}{2a}$
5. a) $\omega_+ = \sqrt{\frac{2f}{m}} \quad and \quad \omega_- = \sqrt{\frac{2f}{M}}$
6. a) diamagnetic
7. b) Weiss theory
8. c) $M = mn$
9. d) 0.87 x 10^{-4}
10. b) $\chi = \frac{Np^2\mu_B^2}{3k_BT}$

11. a) $\frac{\epsilon_r - 1}{\epsilon_r + 2} = \frac{N\alpha}{3\epsilon_0}$
12. b) $\vec{D} = \varepsilon_0 \vec{E} + \vec{P}$
13. c) $\vec{E}_{loc} = \vec{E} + \frac{\vec{P}}{3\varepsilon_0}$
14. d) CO_2
15. c) $\frac{1}{3}$
16. a) $m^* = \frac{h^2}{d^2E/dk^2}$
17. b) approximate model
18. c) $\psi(x) = u(x)e^{ikx}$
19. d) all of the above
20. d) energy levels corresponding to a point of inflection in allowed band
21. a) Mercury at 4.2 K
22. b) 0.0261 T
23. c) $H_C(T) = H_C(0)\left[1 - \left(\frac{T}{T_C}\right)^2\right]$
24. d) 0.1 T
25. a) $\lambda_L(T) = \frac{\lambda_L(0)}{\sqrt{1 - \left(\frac{T}{T_C}\right)^4}}$

B. Fill up the blanks:

1. phonon
2. $\pm\frac{\pi}{a}$
3. amplitude
4. 9.27 x 10^{-24}
5. diamagnetic
6. Curie
7. dielectric constant/relative permittivity/ϵ_r
8. polarization
9. electronic
10. 0.7
11. valence
12. energy
13. -1
14. cooper pair
15. vortex