REV-01
MSP/37/42

2023/06

SET A

M.Sc. PHYSICS
SECOND SEMESTER
SOLID STATE PHYSICS
MSP – 202

[USE OMR FOR OBJECTIVE PART]

Duration: 3 hrs. **Full Marks: 70**

(Objective)

Time: 30 min. **Marks: 20**

Choose the correct answer from the following: ***1X20=20***

1. Which of the following materials exhibits long-range order?
   a. Polycrystals b. Single crystals
   c. Amorphous materials d. Ceramics

2. If a crystal is invariant under a rotation of 90^0, what fold of rotation axis will it possess?
   a. 1 b. 2
   c. 3 d. 4

3. Which one of the following are the Miller indices of a plane of a plane that makes intercepts of 2a, 3b, 7c in a simple cubic lattice?
   a. (21 14 6) b. (14 6 21)
   c. (21 6 14) d. (14 21 6)

4. Which one of the following is the packing fraction of a bcc structure?
   a. 0.52 b. 0.73
   c. 0.68 d. 0.83

5. The unit of dipole moment is
   a. Coulomb.metre b. Coulomb/metre
   c. Metre/Coulomb d. $Coulomb^2$.metre

6. Van der Waals bond is found in
   a. Helium b. Water
   c. Sodium d. Hydrochloric acid

7. Ionic bond is found in
   a. Oxygen b. Sodium chloride
   c. Xenon d. Diamond

8. Which one of the following is the maximum value of frequency for vibration of linear monatomic lattice? (Symbols have usual meaning)
   a. 4C/M b. $(\frac{4C}{M})^{\frac{1}{2}}$
   c. 4CM d. $(4CM)^{1/2}$

9. Polarization is defined as dipole moment per unit
   a. Length b. Area
   c. Volume d. Time

10. The conduction electrons are spread
    a. throughout the crystal
    b. tightly bound to the atoms
    c. localized in a particular region
    d. delocalized in a particular region.

11. The effective mass of a Bloch electron is
    a. proportional to the slope of the energy curve (E vs k plot)
    b. proportional to the curvature of the energy curve
    c. independent of energy curve
    d. any point on the energy curve

12. Usually holes lie
    a. near top of the valence band
    b. near bottom of the valence band
    c. near top of the conduction band
    d. near bottom of the conduction band

13. The finiteness of the electrical conductivity is due to the
    a. scattering on the surface of the metal
    b. scattering among the electrons themselves
    c. imperfection of the crystal
    d. scattering with the ions

14. and $_h$ are the thermal conductivities due to electrons and phonons, respectively. In metals, we usually have
    a. $= _h$
    b. $\sim 10_h$
    c. $= 10^2{}_h$
    d. $= 10^{-2}{}_h$

15. If the frequency of the signal is exactly equal to the cyclotron frequency, the rate of absorption is
    a. greatest
    b. lowest
    c. constant, independent of frequency
    d. none of these

16. Diamagnetism occurs due to
    a. Orbital motion of electrons only
    b. Spin of electrons only
    c. Both (a) and (b)
    d. None of these

17. Curie law for paramagnetic materials (symbols have their usual meanings)
    a. $=$
    b. $= /$
    c. $= /^2$
    d. $=$

18. Density of states for a 3D material varies with energy as
    a. $\sqrt{}$
    b.
    c. 0
    d. ^{2}

19. Ferromagnetism occurs
    a. Below the Curie temperature
    b. Above the Curie temperature
    c. At any temperature
    d. None of these

20. The Fermi energy lies in semiconductors
    a. at the bottom of the conduction band
    b. At the top of the valence band
    c. Within the conduction band
    d. Close to the middle of the band gap

Descriptive

Time : 2 hrs. 30 mins. **Marks : 50**

[Answer question no.1 & any four (4) from the rest]

1. a. Why are X-rays used for crystal structure analysis? **2+8=10**
   b. Derive Bragg's law of X-ray diffraction.

2. a. Outline some differences between crystalline and amorphous solids. **4+6=10**
   b. Describe different types of crystal symmetry operations.

3. a. Explain the formation of an ionic bond with an appropriate example. **5+5=10**
   b. Mention five properties of ionic solids.

4. a. What are superconductors? **2+8=10**
   b. Explain type- I and type-II superconductors with examples and magnetization curves.

5. a. Determine the electron concentration for Na with the expression $N = Z_v \frac{\rho_M N_A}{M'}$. **3+3+2+2 =10**

   [Given: $\rho_M = 0.971$ g/cc, $N_A = 6 \times 10^{23}$ /mol, $M' \approx 23$ g/mol]

   b. Compute the electrical conductivity for Na. [Given: $\frac{m^*}{m_0} = 1.2$, $m_0 = 9.1 \times 10^{-31}$ kg, $\tau = 3.1 \times 10^{-14}$ s]

   c. What are the basic assumptions of free-electron theory model?

   d. What are the failures of free-electron theory model?

6. a. Discuss the Bloch theorem. **5+5=10**

   b. From the Kronig-penny model, one can arrive at the following equation

$$P\frac{sin(\alpha a)}{\alpha a} + cos(\alpha a) = cos(ka),$$

where $P = \frac{mV_0 ba}{\hbar^2}$, which is a measure of the area $V_0 b$ of the potential barrier and $\alpha^2 = \frac{2mE}{\hbar^2}$.

Plot $\left[P\frac{sin(\alpha a)}{\alpha a} + cos(\alpha a)\right]$ versus αa for $P = 3\pi/2$. Indicate the allowed regions in your plot in view of the equation given above.

7. a. Discuss the thermionic emission process. 6+4=10
   b. Obtain the expression for the current density in thermionic emission process.

8. Derive the susceptibility for the paramagnetic materials for a two level system, i.e. $j = \frac{1}{2}$ using the quantum theory. 10

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