

**B.Sc. PHYSICS
FIFTH SEMESTER
SOLID STATE PHYSICS
BSP – 502**

**SET
A**

[USE OMR SHEET FOR OBJECTIVE PART]

Duration: 3 hrs.

Full Marks: 70

Time: 30 min.

Marks: 20

[Objective]

Choose the correct answer from the following:

1X20=20

- Which of the following materials exhibit long-range order?
 - Polycrystals
 - Single crystals
 - Amorphous materials
 - Ceramics
- Which one of the following is the packing fraction of a bcc structure?
 - 0.55
 - 0.68
 - 0.73
 - 0.84
- Which one of the following are the Miller indices of a plane of a plane that makes intercepts of $2a$, $7b$, $3c$ in a simple cubic lattice?
 - (21 6 14)
 - (21 14 6)
 - (6 14 21)
 - (14 6 21)
- Which one of the following indicates the first Brillouin zone in a one-dimensional monatomic lattice? (Symbols have usual meaning)
 - $-\frac{2\pi}{a} < k < \frac{\pi}{a}$
 - $-\frac{\pi}{a} < k < \frac{\pi}{a}$
 - $-\frac{2\pi}{a} < k < \frac{2\pi}{a}$
 - $-\frac{\pi}{a} < k < \frac{2\pi}{a}$
- Basis means a group of
 - Atoms
 - Ions
 - Molecules
 - All of these
- Ionic bond is found in
 - Oxygen
 - Sodium chloride
 - Xenon
 - Diamond
- Which one of the following is the maximum value of frequency for vibration of linear monatomic lattice? (Symbols have usual meaning)
 - $\left(\frac{4C}{M}\right)^{\frac{1}{2}}$
 - $\frac{4C}{M}$
 - $4CM$
 - $(4CM)^{\frac{1}{2}}$

8. The energy quantum of lattice vibrations is
 a. Photons
 b. Vibrons
 c. Phonons
 d. Magnons
9. Polarization is defined as dipole moment per unit
 a. Length
 b. Area
 c. Volume
 d. Time
10. A type-I superconductor exhibits
 a. Diamagnetism
 b. Paramagnetism
 c. Ferromagnetism
 d. Anti-ferromagnetism
11. The Fermi energy is defined as
 a. the lowest occupied energy level
 b. the highest occupied energy level
 c. Somewhere in between the highest and lowest occupied energy levels
 d. none of these
12. The conduction electrons are
 a. spread throughout the crystal
 b. tightly bound to the atoms
 c. localized in a particular region
 d. delocalized in a particular region
13. The velocity 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
14. 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
15. The susceptibility for a paramagnetic material is
 a. Positive
 b. Negative
 c. Zero
 d. ∞
16. The Hall coefficient for hole rich systems is
 a. Positive
 b. Negative
 c. Zero
 d. None of these
17. Ferromagnetism occurs
 a. Below the Curie temperature
 b. Above the Curie temperature
 c. Only at absolute zero
 d. At the melting point
18. Diamagnetism is due to the
 a. Orbital motion of electrons
 b. Spin of electrons
 c. Both orbital motion and spin of electrons
 d. None of these
19. The band gap is largest for
 a. Metals
 b. Semiconductors
 c. Insulators
 d. None of these
20. For paramagnetic materials
 a. $\chi \propto 1/T$
 b. $\chi \propto 1/T^2$
 c. $\chi \propto 1/T^3$
 d. $\chi \propto 1/T^4$

(Descriptive)

Time : 2 hrs. 30 min.

Marks : 50

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

1. a. Determine the electron concentration for Na with the expression 3+4+3
=10
$$N = Z_v \frac{\rho M N_A}{M'}$$

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

b. Derive the expression for the electrical conductivity $\sigma = \frac{Ne^2\tau}{m^*}$
(symbols have their usual meanings) based on free-electron model.

c. Compute σ for Na. [Given: $\frac{m^*}{m_0} = 1.2$, $m_0 = 9.1 \times 10^{-31}$ kg, $\tau = 3.1 \times 10^{-14}$ s]
2. a. Outline some differences between amorphous and crystalline solids. 4+1+3+
2=10

b. Define unit cell. Explain lattice translation vectors with an example.

c. What is a Brillouin zone?
3. a. Define atomic packing fraction. Calculate the atomic packing fraction of a simple cubic crystal structure. 1+4+5
=10

b. Explain ionic and covalent bonds with suitable examples.
4. a. What are phonons? Discuss acoustical and optical phonons. 1+4+5
=10

b. Explain how did Debye's correct the classical and Einstein's theories of specific heat?
5. a. Discuss the concept of local electric field of an atom. 4+6=10

b. Define the terms: (i) dielectric constant, (ii) susceptibility and (iii) polarizability

6. a. In the free-electron gas model the electron-ion and electron-electron interactions are ignored. Why? 5+3+2=10
- b. What are the dissimilarities between ordinary gas and free-electron gas?
- c. What are the failures of the free-electron gas model?
7. From the classical theory of *paramagnetism* derive the Curie law. 10
8. a. With proper diagram discuss the two independent processes through which magnetization occurs in ferromagnetic materials. 5+5=10
- b. Explain the hysteresis loop using an $M - H$ curve.

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