

M.Sc. PHYSICS
THIRD SEMESTER
CONDENSED MATTER PHYSICS- I
MSP - 303A

**SET
A**

[USE OMR FOR OBJECTIVE PART]

Duration: 1:30 hrs.

Full Marks: 35

(PART-A: Objective)

Time: 15 min.

Marks: 10

Choose the correct answer from the following:

1X10=10

- In the tight-binding model, it is assumed that the crystal potential is
 - weak
 - strong
 - neither weak nor strong
 - absent
- For nonionic and nondipolar substances, the polarizability is entirely due to the
 - ionic contribution
 - dipolar contribution
 - electronic contribution
 - none of these
- With increasing the magnetic field, the degeneracy of each of the Landau levels
 - decreases
 - increases
 - remains same
 - none of these
- In the de Haas - van Alphen effect, the oscillatory behavior is observed in
 - resistivity
 - thermal conductivity
 - magnetic moment
 - polarizability
- The criteria to observe integer quantum Hall effect
 - low temperature, high magnetic field
 - high temperature, high magnetic field
 - high temperature, low magnetic field
 - low temperature, low magnetic field
- Meissner effect is the phenomenon of
 - perfect diamagnetism
 - paramagnetism
 - ferromagnetism
 - none of these
- The binding energy is strongest in a Cooper pair, when the two electrons have the following states (k is the momentum and the arrow indicates the direction of spin)
 - $k \uparrow, k \uparrow$
 - $k \uparrow, -k \uparrow$
 - $k \uparrow, -k \downarrow$
 - $k \downarrow, k \downarrow$
- The binding energy of a Cooper pair is (in eV)
 - 10^{-1}
 - 10^{-2}
 - 10^{-3}
 - 10^{-4}

9. For a 1D chain, the energy dispersion relation is $E(k) = E_0 - \beta - 2\gamma \cos(ka)$. Assuming E_0, β and γ to be constants, the band width would be
- | | | | |
|----|-----------|----|-----------|
| a. | γ | b. | 2γ |
| c. | 4γ | d. | 6γ |
10. Josephson effect occurs in junctions like
- | | |
|---------------------------------------|--|
| a. Metal-insulator-metal | b. Superconductor-insulator-superconductor |
| c. insulator-superconductor-insulator | d. Insulator-metal-insulator |

(Descriptive)

Time : 1 hr. 15 mins.

Marks : 25

[Answer question no.1 & any two (2) from the rest]

1. a. The number of states in each Landau levels is given by 3+2=5

$$N = \frac{qBA}{2\pi h}$$

Where q, B, A are the electronic charge, magnetic field strength, and area of the sample, respectively. Find out N in a region of $A = 1 \text{ cm}^2$ at $B = 0.1 \text{ T}$ via.

- b. Draw the allowed electron orbitals in two dimensions in the absence and presence of magnetic field in the $k_x - k_y$ plane.
2. a. What are the sources of contribution to the local field E_{loc} , that was introduced by Lorentz. Discuss each term with a proper diagram. (No mathematical expression is required) 6+4=10
- b. What are the differences between the Maxwell field E and Lorentz field E_{loc} .

3. a. The energy of the band in the tight-binding model: 6+4=10

$$E(\vec{k}) = E_v - \beta - \gamma \sum e^{i\vec{k} \cdot \vec{x}_j}$$

Where β and γ are constants, \vec{x}_j is the position of the j -th atom relative to the atom at the origin.

Find the energy expression for a *simple cubic* lattice, using the nearest-neighbor approximation.

- b. Draw the first three Brillouin zones for a square lattice with lattice spacing a .
4. a. Write a short note on giant magnetoresistance. 5+5=10
- b. Write a short note on integer quantum Hall effect.

5. a. Draw the $H - M$ diagram for type-1 and type-2 superconductors.
b. Discuss the two-fluid model.

4+6=10

== *** ==