REV-01
MSP/20/25

2023/12

**SET A**

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

[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***

1. In the tight-binding model, it is assumed that the crystal potential is
   a. weak b. strong
   c. neither weak nor strong d. absent

2. For nonionic and nondipolar substances, the polarizability is entirely due to the
   a. ionic contribution b. dipolar contribution
   c. electronic contribution d. none of these

3. With increasing the magnetic field, the degeneracy of each of the Landau levels
   a. decreases b. increases
   c. remains same d. none of these

4. In the de Haas – van Alphen effect, the oscillatory behavior is observed in
   a. resistivity b. thermal conductivity
   c. magnetic moment d. polarizability

5. The criteria to observe integer quantum Hall effect
   a. low temperature, high magnetic field b. high temperature, high magnetic field
   c. high temperature, low magnetic field d. low temperature, low magnetic field

6. Meissner effect is the phenomenon of
   a. perfect diamagnetism b. paramagnetism
   c. ferromagnetism d. none of these

7. 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)
   a. $k\uparrow, k\uparrow$ b. $k\uparrow, -k\uparrow$
   c. $k\uparrow, -k\downarrow$ d. $k\downarrow, k\downarrow$

8. The binding energy of a Cooper pair is (in eV)
   a. $10^{-1}$ b. $10^{-2}$
   c. $10^{-3}$ d. $10^{-4}$

9. For a 1D chain, the energy dispersion relation is $E(k) = \varepsilon_p - \beta - 2\gamma\cos(ka)$. Assuming $E_p, \beta$ and $\gamma$ to be constants, the band width would be

a. $\gamma$ b. $2\gamma$

c. $4\gamma$ d. $5\gamma$

10. Josephson effect occurs in junctions like

a. Metal-insulator-metal b. Superconductor-insulator-superconductor

c. Insulator-superconductor-insulator d. Insulator-metal-insulator

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# 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**

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

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 $B = 0.1$ Tesla.

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 $\beta$ and $\gamma$ 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. 4+6=10
   **b.** Discuss the two-fluid model.

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