

Roll No. ....

Total Pages : 03

**MDE/M-20**

**4654**

**CONDENSED MATTER PHYSICS AND  
NANOTECHNOLOGY  
Paper-IV**

Time : Three Hours]

[Maximum Marks : 55

**Note :** Attempt *Five* questions in all, selecting *one* question from each Unit. Q. No. **1** is compulsory.

**(Compulsory Question)**

1. (a) Comment whether phonon is a boson or fermion.  
Can it exist outside a crystal lattice ? **3**
- (b) What effects are induced due to increase in surface  
area of nanoparticles ? **3**
- (c) What is a superlattice ? Explain. **2**
- (d) What do you understand by the term 'resonant  
tunneling' ? Explain. **3**

**Unit I**

2. Explain, what do you understand by Fermi Surface ?  
Give details of how the fermi surface can be measured  
experimentally using the de Haas-van Alphen effect. **11**

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3. (a) Give the outline of determining cohesive energy for a metal by using Wigner-Seitz method. 4
- (b) Obtain and plot the dispersion relation for elastic waves along a symmetry direction for a cubic crystal with a monoatomic basis. Illustrate the atomic displacements for the mode  $K = \pm \frac{\pi}{a}$  ( $a$  is the lattice parameter). 7

## Unit II

4. (a) What are carbon nanotubes ? Discuss the chirality of carbon nanotubes. 4
- (b) Explain dielectric screening. Obtain an expression for dielectric constant using Thomas-Fermi theory of scattering. 7
5. Why Hartree equations are inadequate ? Elucidate Hartree-Fock approximation in detail. 11

## Unit III

6. Determine the electronic states in quantum dots and how they are different from quantum wires. Also draw a schematic of dispersion relation and density of states for quantum dots. 11

7. Discuss the phenomenon of tunnelling in planar barrier structure : single as well as double barrier case. **11**

#### **Unit IV**

8. (a) What are surface emitting lasers ? Discuss its basic principle with proper schematic. **8**  
(b) What are ballistic injection devices ? Explain. **3**
9. Explain the principle, working and applications of quantum wire laser. **11**