Roll No. .....

E–753

M. Sc. (Third Semester)
EXAMINATION, Dec.-Jan., 2020-21

PHYSICS

Paper Third

(Solid State Physics—I)

Time : Three Hours] [*Maximum Marks : 80*

[*Minimum Pass Marks : 16*

Note : Attempt all Sections as directed.

Section—A 1 each

(Objective/Multiple Choice Questions)

Note : Attempt all questions.

Choose the correct answer :

1. Quantum of lattice vibrational energy is :

   (a) Photon

   (b) Phonon

   (c) Electron

   (d) Proton

2. According to Kronig-Penny model, in the energy spectrum of electrons in solids, there are :
   (a) regular regions of only allowed energies
   (b) alternate regions of allowed and forbidden energies
   (c) regular regions of only forbidden energies
   (d) None of the above

3. The potential field in which the free electrons in a metal move is :
   (a) constant and repulsive
   (b) like a sinusoidal potential well
   (c) periodic whose periodicity vanishes at the crystal surface
   (d) periodic extended to infinity

4. The resistivity of an insulator is nearly :
   (a) 10^3 to $10^7 \Omega m$
   (b) 10^7 to $10^9 \Omega m$
   (c) 10^9 to $10^{11} \Omega m$
   (d) None of the above

5. Free electron gas theory assumes :
   (a) Electrons are free from Coulomb force
   (b) The Coulomb force of repulsion is negligible
   (c) Electrons are free to move anywhere
   (d) All of the above

6. Which of the following is a radiative semiconductor ?
   (a) Silicon
   (b) Gallium Arsenide
   (c) Germanium
   (d) None of the above

7. In a semiconductor, the energy gap between the valence band and conduction band is about :
   (a) 5 eV
   (b) 10 eV
   (c) 15 eV
   (d) 1 eV

8. The average energy of an electron in the conduction band of a metal at 0°K as a function of Fermi level (E_F) will be :
   (a) 1/5 E_F
   (b) 2/5 E_F
   (c) 3/5 E_F
   (d) 4/5 E_F

9. Atoms are arranged in a one-dimensional chain having lattice spacing *a*. If each atom is represented by the potential $V(x) = V_0 \, \delta(x)$, then the energy gap between the bands (assuming that the nearly free electron approximation holds good) will be :
   (a) $V_0 / 2$
   (b) V_0
   (c) $2 V_0$
   (d) $4 V_0$

10. For moderately doped CdSe semiconductor at room temperature, which of the following scattering mechanisms will dominate ?

    (a) Acoustic deformation potential scattering

    (b) Optical deformation potential scattering

    (c) Polar optical phonon scattering

    (d) Electron-plasmon scattering

11. If two-dimensional hexagonal lattice with lattice spacing a = 3 Å and sound velocity $c = 10^3$ m/s. The Debye frequency ω_D will be :

    (a) $1.1 \times 10^{13}\ \text{sec}^{-1}$

    (b) $2.2 \times 10^{15}\ \text{sec}^{-1}$

    (c) $0.6 \times 10^{13}\ \text{sec}^{-1}$

    (d) $1.1 \times 10^{16}\ \text{sec}^{-1}$

12. Phonon carries :

    (a) Zero spin

    (b) One spin

    (c) Two spin

    (d) Half spin

13. In superconductor, the Fermi energy level is :

    (a) Below the ground state

    (b) Midway between the ground state and first excited state

    (c) Above first excited state

    (d) At first excited state

14. The minimum amount of current passed through the body of superconductor in order to destroy the superconductivity is called :

    (a) Induced current

    (b) Critical current

    (c) Eddy current

    (d) Hall current

15. The binding energy for a Cooper-pair is :

    (a) 10^{-2} eV

    (b) 10^{-4} eV

    (c) 10^{-6} eV

    (d) 10^{-8} eV

16. The magnetic lines of force cannot penetrate the body of a superconductor, a phenomenon is known as :

    (a) Isotropic effect

    (b) BCS theory

    (c) Meissner effect

    (d) London theory

17. Which profile determines the effective mass of electrons ?

    (a) Energy *vs.* concentration

    (b) Energy *vs.* mass

    (c) Energy *vs.* momentum

    (d) Energy *vs.* structural design

18. Narrow valleys correspond to :

    (a) electrons with lower mass state

    (b) protons with lower mass state

    (c) electrons with higher mass state

    (d) protons with higher mass state

19. Mobility depends on :

    (a) concentration of impurity

    (b) temperature

    (c) electron efficient mass

    (d) All of the mentioned

20. The effective mass of GaAs is ..... than the mass of a electron.

    (a) 0.67 times greater

    (b) 0.67 times lesser

    (c) 0.067 times greater

    (d) 0.067 times lesser

Section—B $1\frac{1}{2}$ each

(Very Short Answer Type Questions)

Note : Attempt all questions. Each answer should be in 2-3 sentences.

1. What do you mean by energy band ?
2. What is square lattice ?

3. Define chemical potential.
4. Define hole orbits.
5. Define group velocity.
6. What is crystal momentum ?
7. Write the effect of temperature on entropy of superconductor.
8. Define London penetration depth.
9. What do you understand by valence band edge ?
10. Define intrinsic mobility.

Section—C $2\frac{1}{2}$ each

(Short Answer Type Questions)

Note : Attempt all questions. Each answer should be in about 75 words.

1. Explain empty lattice approximation.
2. Differentiate metals and insulators.
3. Explain different zone schemes.
4. What is tight binding ?
5. Explain the quantization of elastic waves.
6. Explain umklapp processes in phonons.
7. What is the difference between type-I and type-II superconductor ?
8. Write down the features of BCS ground state.
9. Give physical interpretation of effective mass.
10. Derive the relation for absolute thermoelectric power.

Section—D 4 each

(Long Answer Type Questions)

Note : Attempt all questions. Each answer should be in approx. 150 words.

1. Discuss Kronig-Penny model.

   Or

   Prove that the motion of an electron through the periodic potential of solids gives rise to band structure.

2. Describe the construction of Fermi surfaces.

   Or

   Discuss the De Hass-Van Alphen effect.

3. Explain the optical and acoustical branches of the dispersion relation for a diatomic lattice.

   Or

   Derive the expression for the thermal conductivity $k = \frac{1}{3} cv\lambda,$ where symbols have their usual meaning.

4. Derive the London equation.

   Or

   Describe D. C. Josephson effect.

5. Derive the equation of motion of an electron in an energy band.

   Or

   Derive the expression for carrier concentration in intrinsic semiconductor.