ASSIGNMENT – 1

(UNIT-1)

Multiple Choice Questions

1. Solution of Schrödinger equation Ψ is written in terms of

(a) Energy and momentum

(b) Position and momentum

(c) Velocity and position

(d) Amplitude and phase

2. In Drude's free electron theory, electrons are supposed to behave like

(a) Matter waves

(b) Solid particles

(c) Gas molecules

(d) Liquid molecules

3. The lowest energy band with significantly unoccupied energy states becomes

(a) Valence band

(b) Band gap

(c) Conduction band

(d) Forbidden band

4. Band structure of semiconductors can be obtained by E-k diagram in a reduced region of reciprocal space. This region is called

(a) K - space

(b) Brillioun zone

(c) Band region

(d) Forbidden region

5. Effective mass of electron depends on

(a) Temperature of material

(b) Number density of electrons

(c) Electric field applied on material

(d) Curvature of energy band

6. The physics of particles at subatomic/ very small scale is governed by

(a) Quantum Physics

(b) Classical Physics

(c) Quantum as well as Classical Physics

(d) None of the above

7. If n is number of states available per unit volume, then the density of states can be found using

(a) $\frac{dn}{dE}$

(b) $\frac{dE}{dn}$

(c) $\frac{dn}{dV}$

(d) $\frac{dE}{dV}$

8. Density of states does not depend on

(a) Type of material

(b) Temperature

(c) Energy range

(d) all of these

9. At zero Kelvin temperature, conduction band of pure semiconductor will be

(a) Completely occupied

(b) Completely unoccupied

(c) Partially occupied

(d) Almost occupied

10. The average Kinetic Energy of electron in the ground states in 1D is

(a) $\frac{1}{3}$ of fermi energy

(b) $\frac{1}{4}$ of fermi energy

(c) $\frac{1}{2}$ of fermi energy

(d) equal to that of fermi energy.

11. Free electron Fermi gas consist of

(a) Bound and Non-interacting electrons

(b) Free and Non-interacting electrons

(c) Bound and interacting electrons

(d) Free and interacting electrons

12. In Quantum Mechanical (i.e Sommerfield) model of electron

(a) The potential is taken constant inside the metal

(b) The potential is taken variable inside the metal

(c) The potential is taken infinite inside the metal

(d) The potential has no rule inside the metal

13. According to Kronning Penny model, in 1D lattice the energy discontinuities

(a) $\boldsymbol{k = \pm \frac{n\pi}{a}}$

(b) $\boldsymbol{k = \pm \frac{n\pi}{2a}}$

(c) $\boldsymbol{k = \pm n\pi}$

(d) $\boldsymbol{k = 0}$

14. To Kronning Penny model, which equation is used

(a) Plane wave equation only

(b) The time-dependent Schrödinger equation and Bloch equation

(c) The time-independent Schrödinger equation and Bloch equation

(d) Bloch equation only

15. The density of state varies with energy as

(a) linear

(b) exponential

(c) parabolic

(d) none of the above

Short and Long answer based questions

1. What are the assumptions in Drude's free electron theory?

2. Which phenomena Drude's free electron theory cannot explain?

3. What is difference between conductor, semiconductor and Insulator?

4. Why resistivity of conductor increases with temperature and that of Semiconductor decreases with temperature?

5. What is the reason for splitting of energy levels in solid materials? As Interatomic
distance decreases in the material, why higher energy levels split first?

6. What is energy band gap? Why is energy bandgap called as forbidden region?

7. What do you mean by wave function Ψ?

8. Define Fermi energy level. Write the formula for fermi energy in terms of number density of electrons.

9. What information does an E – k diagram give?

10. Write down the relation between energy E and wave vector k for free electron, for conduction band electron and for valence band electron.

11. What is the meaning of effective mass? Justify briefly why effective mass of electron is positive near the minima of band edge and negative near the Maxima of band edge.

12. Define density of states and write the formula for density of states in conductors.

13. Write the formula for density of states in conduction band and valence band.

14. Draw the graph of density of states for conductors and semiconductors.

15. Draw two E-K diagrams, one showing direct bandgap and the other showing indirect bandgap.

16. What is the difference between direct and indirect bandgap semiconductors?

17. Write the examples of direct and indirect bandgap semiconductors.

18. Why direct bandgap semiconductors are preferred for making LEDs?

19. Why can't we use Si or Ge for making LEDs?

20. Write the formula for Fermi function used to calculate occupation probability for a given energy state and mention all the terms in it.

21. For an energy state E, f (E) = 0.6 at 300 K temperature. What will be the probability that electron will not exist in energy state E at 300 K temperature?

22. Using Fermi function, show that at zero Kelvin temperature, occupation probability for any energy state below Fermi level is 1.

23. Using Fermi function, show that at zero Kelvin temperature, occupation probability for any energy state above Fermi level is 0.

24. Using Fermi function, show that at any temperature, occupation probability for Fermi energy level is 0.5.

25. Upon which factors, occupation probability depends?

26. Discuss the types of E-K Diagrams (with proper labelled diagrams).

27. In relation to band theory of solids explain significance of effective mass of electron. Derive an expression for it.

28. For a given SC the effective mass of electron is 1.25 times of the rest mass and energy is 0.3 eV. Determine the momentum of electron.

29. If electron propagation vector is $2\hat{\imath} + 3\hat{\jmath} + 2\sqrt{3}\hat{k}$ which moving within material. Find the momentum of electron.

30. Calculate the Energy if density of states is 10^{20} /m^3 and effective mass of electron is 0.5 times of the rest mass.