Chapter 1: Free Electron Theory of Solids

1. Objective Questions

1. What does the conductivity of metals depend upon?

a) The nature of the material

b) Number of free electrons

c) Resistance of the metal

d) Number of electrons

2. What happens to the free electrons when an electric field is applied?

a) They move randomly and collide with each other

b) They move in the direction of the field

c) They remain stable

d) They move in the direction opposite to that of the field

3. Which of the following theories cannot be explained by classical theory?

a) Electron theory

b) Lorentz theory

c) Photo-electric effect

d) Classical free electron theory

4. Which of the following theories can be adopted to rectify the drawbacks of classical theory?

a) Compton theory

b) Quantum theory

c) Band theory

d) Electron theory

5. What is the level that acts as a reference which separated the vacant and filled states at 0K?

a) Excited level

b) Ground level

c) Valance orbit

d) Fermi energy level

6. Hall voltage is zero when the semiconductor is

a) Extrinsic

b) Intrinsic

c) P type

d) None of the above

7. Hall effect can be used to measure

a) Magnetic field intensity

b) Electric field intensity

c) Carrier concentration

d) None of the above

8. In Hall Effect, the output voltage produced across the crystal is due to

a) Drop across the crystal is due to the current passed through it

b) Induced voltage by the applied magnetic field

c) Movement of charge carriers towards one end

d) All of the above

9. Hall effect can be used to measure

a) Magnetic field intensity

b) Carrier concentration

c) Both (a) and (b)

d) Electric field intensity

10. Fermi energy level

a) is the top most filled energy level at 0K temperature

b) is the top most filled energy level at 00C temperature

c) Separates valance band and conduction band

d) none of the above

11. Fermi-Dirac statistics explains

a) how electrons are distributed among different energy levels

b) the probability of an energy level to be occupied by electrons

c) the probability of an energy level to be occupied by quantum mechanical particles

d) how quantum mechanical particles are distributed in different energy level.

11. Fermi-Dirac (FD) statistics governs

a) fermions

b) free electrons

c) gas molecules

d) All the above

12. In free electron gas theory, electrons

a) can move anywhere inside the metal.

b) are considered as a gas.

c) pairs with holes and become neutral.

d) All the above.

13. Which of the following can be explained by using free electron theory

a) Copper

b) Gold

c) Silver

d) Sodium

2. Answer in one sentence

14. What is the main drawback of Sommerfeld theory?

15. What is the main feature of Sommerfeld theory?

16. Write the Fermi-Dirac distribution function.

17. What is Fermi level and Fermi energy?

18. What is mobility?

19. State Bloch theorem

20. What do you mean group velocity?

21. What do you mean by density of states?

22. Why semiconductors are insulators at 0^0K temperature?

23. What is Hall Effect?

3. Short notes

24. Write a short note on Hall Effect

25. Write a short note on classical free electron theory

26. Write a short note on Sommerfeld theory

27. Write a short note on density of states

28. Write a short note on Fermi Dirac distribution function

29. Write a short note on Bloch theorem

30. Write a short note on Wiedemann-Franz law

31. Write a short note on Schrödinger's equation for the electron in a one-dimensional potential box
32. Write a short note on group velocity
33. Write a short note on band theory

4. Short answer questions

34. What is the main assumption in classical free electron theory?
35. What are the drawbacks of classical free electron theory?
36. What is the main feature of Sommerfeld theory?
37. What is the main drawback of Sommerfeld theory?
38. Why Sommerfeld theory is unable to explain some solids are conductors, some are semiconductors and others are insulators?
39. Explain how Sommerfeld modified the classical free electron theory
40. Write the Fermi-Dirac distribution function. Plot it as a function of energy
41. What is Fermi level and Fermi energy?
42. What do you understand by Fermi level? Plot this function for various temperature including T= 00K
43. Write down the Schrödinger's equation for the electron in a one-dimensional potential box.
44. What are values of energy gap for metals, semiconductors and insulators?
45. What is mobility?
46. On which factor Hall coefficient depends?
47. How does Fermi energy change with temperature?
48. State Bloch theorem

5. Long answer questions

49. Explain the basis of band theory
50. Plot E versus K for nearly free electron model
51. What do you mean group velocity?
52. What do you mean by density of states?
53. Why the effective number of free electrons in completely filled band is zero?
54. Why semiconductors are insulators at 0^0K temperature?
55. Why conductivity of semiconductor increases with increase in temperature?
56. Why conductivity of metal decreases with increase in temperature
57. Explain classical free electron theory
58. Explain Wiedemann-Franz law

59. Explain Sommerfeld's free electron theory and give the drawbacks of this theory
60. Obtain an expression for energy levels and density of states in one dimension
61. Describe Hall Effect. Obtain an expression for Hall angle
62. On the basis of band theory, distinguish between insulators, semiconductor and metals
63. Explain Fermi energy and Fermi levels at 0^0K
64. Define Fermi energy. Using Fermi distribution function, explain how Fermi energy changes with temperature
65. Define Fermi energy. Show that E= 3/5 EF0
66. Define the term density of states. Obtain an expression for density of states in three dimensions
67. Discuss the motion of an electron in cubical box and obtain an expression for its energy levels
68. Explain the basis of band theory and describe the formation of energy bands in solid
69. State and explain Bloch theorem
70. Write a note on nearly free electron model
71. On the basis of the nearly free electron model, show that at the Brillouin zone boundary energy gap exist
72. Explain the origin of energy gap in a crystalline solid and calculate its magnitude
73. Distinguish between metals, semiconductors and insulators on the basis of band theory
74. Obtain an expression for total effective number of free electrons in the given energy band. Discuss various cases
75. What is Hall Effect? Show that Hall coefficient is equal to 1/ne

Chapter 2: Crystalline Solids

1. Objective Questions

1. X-ray diffractometer are not used to identify the physical properties of which of the following?

a) Metals

b) Liquids

c) Polymeric materials

d) Solids

2. X-ray diffractometer provide _____ information about the compounds present in a solid sample.

a) Quantitative

b) Qualitative

c) Quantitative and qualitative

d) Either quantitative or qualitative

3. Using the powder method of diffractometer, which of the following can be determined?

a) Percentage of K+

b) Percentage of Na+ and Cl-

c) Percentage of KBr and NaCl

d) Percentage of Br-

4. In powder method, the powder sample is contained in which of the following?

a) Thin walled glass capillary tubes

b) Thin walled test tube

c) Thin walled curvettes

d) Thin walled flask

5. Which of the following is the most common instrument for photographic recording of diffraction patterns?

a) Debye-Scherrer’s powder camera

b) Gamma camera

c) Geiger tube

d) Scintillation counter

6. With the help of which of the following equations is the distance calculated from a known wavelength of the source and measured angle?

a) Coolidge equation

b) Bragg's equation

c) Debye equation

d) Scherrer equation

7. In Diffractometer, the identification of a component of the sample from its powder diffraction pattern is based upon the _____ of lines and their relative _____

a) Number, length

b) Number, intensity

c) Position, length

d) Position, intensity

8. Diffractometer is similar to which of the following?

a) Optical grating spectrometer

b) Prism spectrometer

c) Photo multiplier

d) Photovoltaic cell

9. In Diffractometer, line intensities depend on _____ and kind of atomic reflection centers in each set of plates.

a) Number

b) Position

c) Length

d) Distance between lines

10. In powder diffractometer, the sharpness of the lines is greatly determined by which of the following?

a) Quality of the sample, size of the slit

b) Quality of the slit, size of the sample

c) Thickness of the slit, amount of the sample

d) Number of slits, composition of the sample

2. Answer in one sentence

11. Define the term space lattice
12. Define the term basis
13. Define the term unit cell
14. Define the term primitive cell
15. Define the term coordination number
16. Define the term packing fraction
17. Define the term fold number
18. Define the term primitive translational vectors
19. Define the term reciprocal lattice vector
20. Define the term symmetry operators
21. Explain crystal as a grating
22. What is X-ray?
23. State Bragg's condition for diffraction in direct lattice
24. State Bragg's condition for diffraction in reciprocal lattice
25. Define reciprocal lattice
26. Why ordinary optical grating cannot diffract X-ray?

3. Short notes

27. Write a short note on X-ray diffraction
28. Write a short note on NaCl structures
29. Write a short note on NaCl structures
30. Write a short note on diamond cubic structure
31. Write a short note on TGA
32. Write a short note on Powder method
33. Write a short note on SEM
34. Write a short note on UV Visible spectroscopy
35. Write a short note on symmetry operations

4. Short answer questions

36. Define the following terms used in crystal structure

i) space lattice

ii) basis

iii) unit cell

iv) primitive cell

iv) co-ordination number

v) packing fraction

vi) fold number

vii) primitive translational vectors

37. Show that for simple cubic system, r= a/2

38. Obtain number of atoms per unit cell for simple cubic crystal

39. Obtain number of atoms per unit cell for FCC crystal

40. Obtain number of atoms per unit cell for BCC crystal

41. Give co-ordination number for SC, FCC and BCC structure

42. Draw NaCl structures

43. Distinguish between crystalline solid and amorphous solid

44. What do you mean by primitive translational vectors and non-primitive translational vectors?

45. Define the term reciprocal lattice vector

46. Define the term symmetry operators

47. Explain crystal as a grating

48. What are X-ray?

49. State Bragg's condition for diffraction in direct lattice

50. State Bragg's condition for diffraction in reciprocal lattice

51. Define reciprocal lattice

52. Why ordinary optical grating cannot diffract X-ray?

53. If the angle between the diffraction of incident X-rays and diffracted one is 20^0. What is the angle of incidence?

54. Explain how crystal can be used as a diffraction grating for X-ray

54. State various spectroscopic techniques in analysis of crystal structure

55. What is the principle involved in gravimetric analysis?

56. What do you mean by quantitative analysis?

57. What do you mean by qualitative analysis?

58. Explain the term spectroscopy
59. What is the main difference between ultraviolet and visible spectroscopy?
60. Give the principle of photoelectron spectroscopy
61. What do you mean by STM? Give application of STM
62. What is the main difference between UPS and XPS?
63. What are the advantages of powder method?
64. What do you mean by SEM? Give application of SEM

5. Long answer questions

65. What do you understand by fold number? How it is calculated?
66. What is a Bravais lattice? What are different space lattices in the cubic system?
67. What do you mean by space lattice? Explain space lattice with two-dimensional square array of points.
68. Show that a five fold rotation axis does not exist in crystal lattice
69. What are Miller indices of the plane? How they are determined?
70. Obtain an expression for interplaner distance. Hence show that for simple cubic system Dhkl= a/$\sqrt{h2 + k2 + l2}$
71. What is crystal system? Describe briefly the seven of crystals with suitable diagrams
72. With proper diagrams explain BCC, FCC and HCP structure in detail
73. What are symmetry operations? Explain three principle types of symmetry operation
74. What is co-ordination number? Write co-ordination number for simple cubic, BCC and FCC structures
75. Explain the term packing fraction. Show that packing fraction for simple cubic, BCC and FCC structures are 0.52, 0.68 and 0.74 respectively
76. Discuss crystal structure of NaCl, CsCl, ZnS and hcp in detail
77. What is reciprocal lattice? Obtain an expression for reciprocal lattice vectors A,B and C
78. Show that reciprocal of the reciprocal lattice is direct lattice
79. What are (100), (110) and (111) planes? Explain and draw sketches
80. With suitable diagram, explain diamond cubic structure
81. For BCC structure, show that r= $\frac{\sqrt{3}}{4}a$
82. FCC structure has atomic radius of 1.75 A0. Find the spacing of 100 plane and 200 plane
83. Calculate lattice constant of NaCl crystal using weight of NaCl= 58.45, density of NaCl= 2170 kg/m^3. Avogadro's number= 6x 10^{23}

84. Explain Bragg's law associated with diffraction of X-ray by crystals
85. Derive the Bragg's condition for diffraction
86. Derive the Bragg diffraction condition in the reciprocal lattice

2K.G+G2=0

87. With the help of Ewald's construction show that the diffraction condition in reciprocal lattice is exactly equivalent to $2d\sin\theta = n\lambda$ in the direct lattice
88. Explain how X-rays are used for determination of crystal structure
89. Describe powder method for determination of crystal structure
90. Describe the X-ray power diffraction camera and explain how it is used to determine crystal structure
91. With suitable diagram explain scanning electron microscope
92. What do you mean by gravimetric analysis? With suitable example explain gravimetric analysis
93. What do you mean by TGA? By taking suitable example explain TGA
94. State characterization techniques and explain applications of each technique
95. Write a short note on UV-Visible absorption spectroscopy
96. Give the principle of photoelectron spectroscopy
97. With suitable diagram, explain UV photoelectron spectrometer
98. By taking suitable data, give analysis of cubic crystal by powder method
99. What is SEM? Explain principle and applications of SEM
100. Explain advantages of SEM over FESEM

Chapter 3: Semiconductor

1. Objective Questions

1. A semiconductor is formed by …… bonds.

a) Covalent

b) Electrovalent

c) Co-ordinate

d) None of the above

2. A semiconductor has …… temperature coefficient of resistance.

a) Positive

b) Zero

c) Negative

d) None of the above

3. The most commonly used semiconductor is ……..

a) Germanium

b) Silicon

c) Carbon

d) Sulphur

4. A semiconductor has generally …… valence electrons.

a) 2

b) 3

c) 6

d) 4

5. When a pure semiconductor is heated, its resistance ……..

a) Goes up

b) Goes down

c) Remains the same

d) Can't say

6. The strength of a semiconductor crystal comes from ……..

a) Forces between nuclei

b) Forces between protons

c) Electron-pair bonds

d) None of the above

7. When a pentavalent impurity is added to a pure semiconductor, it becomes ……

a) An insulator

b) An intrinsic semiconductor

c) p-type semiconductor

d) n-type semiconductor

8. Addition of pentavalent impurity to a semiconductor creates many ……..

a) Free electrons

b) Holes

c) Valence electrons

d) Bound electrons

9. The resistivity of a semiconductor _____ conductors and insulators

a) More than that of

b) Lies between that of

c) Less than that of

d) None of the above

10. The most commonly used semiconductor is _____

a) Germanium

b) Carbon

c) Sulfur

d) Silicon

11. The strength of a semiconductor crystal comes from_____

a) Forces between nuclei

b) Force between protons

c) Electrons-Pairs bonds

d) None of the above

2. Answer in one sentence

12. Define the term semiconductor
13. Define the term insulator
14. Define the term metal
15. Define the term Fermi energy level
16. Define the term band gap energy
17. Define the term intrinsic semiconductor
18. Define the term extrinsic semiconductor
19. Define the term indirect band gap energy
20. Define the term direct band gap energy
21. Define the term PN junction diode

3. Short notes

22. Write a short note on Fermi energy level
23. Write a short note on PN junction diode
24. Write a short note on band gap energy
25. Write a short note on Fermi Dirac distribution function
26. Write a short note on Maxwell Boltzmann distribution
27. Write a short note on Hall Effect
28. Write a short note on applications of Hall Effect

4. Short answer questions

29. Explain classification of solids into conductors, semiconductors and insulators on the basis of energy band theory
30. What is Fermi energy level?
31. Write down an expression for probability of occupying of a particular energy state of an electron in an intrinsic semiconductor
32. Write the formula for the Fermi Dirac probability distribution function
33. Using the Fermi-Dirac probability distribution function, derive an expression for the position of Fermi energy level in the intrinsic semiconductor
34. Plot the variation of Fermi level with the increase of temperature for n-type and p-type semiconductor

5. Long answer questions

35. Derive an expression for conductivity in an intrinsic and extrinsic semiconductor
36. Derive an expression for conductivity of semiconductors
37. Comparing with zero bias explain the working of PN junction diode in forward bias and reversed bias on the basis of energy level diagram
38. Give the energy band picture of a PN junction diode and explain the effect of biasing on the band picture
39. Explain the working of PN junction diode on the basis of Fermi energy level in forward biased mode
40. Explain the working of PN junction diode on the basis of Fermi energy level in forward biased mode
41. Explain Hall Effect in semiconductors. Derive the equations of Hall voltage and Hall coefficient
42. State applications of Hall Effect
43. Write the formula for the Fermi Dirac probability distribution function
44. Using the Fermi-Dirac probability distribution function, derive an expression for the position of Fermi energy level in the intrinsic semiconductor
45. Write down an expression for probability of occupying of a particular energy state of an electron in an intrinsic semiconductor

Chapter 4: Magnetism

1. Objective Questions

1. If a material is ferromagnetic, what shall be the value of χ?

a) Negative

b) Small and positive

c) Large and Positive

d) Insufficient information

2. Which of the following is a diamagnetic material?

a) Sodium

b) Calcium

c) Oxygen (at STP)

d) Nitrogen (at STP)

3. Curie's law is applicable at every point on a Paramagnetic Material.

a) True

b) False

4. The phenomenon of perfect diamagnetism is called _____

a) Superconductivity

b) Diamagnetic Effect

c) Zero Kelvin Effect

d) Meissner Effect

5. Materials in which magnetization persists even after the field has been removed are called _____

a) Diamagnetic

b) Paramagnetic

c) Soft Ferro magnets

d) Hard Ferro magnets

6. Superconductors are diamagnetic materials.

a) True

b) False

7. Which of the following is not a constituent of Alnico?

a) Iron

b) Aluminum

c) Magnesium

d) Copper

8. At high temperature a Ferro magnet becomes _____

a) Diamagnetic

b) Paramagnetic

c) Hard Ferro magnet

d) Soft Ferro Magnet

9. The value of B at H=0 in a Hysteresis curve is called _____

a) Remanence

b) Coercivity

c) Magnetization

d) Porosity

10. When a ferromagnetic rod is placed in a solenoid with current, what happens to the rod?

a) Retentively increases

b) Coercivity Increases

c) Permanently Magnetized

d) None of these

11. Which of the following conditions are desired in the core of an electromagnet?

a) High permeability and High retentively

b) Low permeability and High retentively

c) High permeability and Low retentively

d) Low permeability and Low retentively

2. Answer in one sentence

12. What are domains?

13. What is Curie constant?

14. Define Curie temperature

15. What is superconducting state?

16. What is critical temperature of superconductor?

17. What is Meissner effect?
18. What is critical magnetic field of superconductor?
19. What is Neel temperature?
20. What are ferrites?

3. Short notes

21. Write a short note on ferrites
22. Write a short note on superconductor
23. Write a short note on domains
24. Write a short note on Curie temperature
25. Write a short note on Meissner effect
26. Write a short note on Meissner effect
27. Write a short note on Neel temperature
28. Write a short note on diamagnetic material
29. Write a short note on paramagnetic material
30. Write a short note on ferromagnetic material

4. Short answer questions

31. What is magnetization vector M?
32. State Langevin formula for susceptibility of diamagnetic material
33. What are domains?
34. How antiferromagnetic materials become paramagnetic?
35. What is Curie constant?
36. Define Curie temperature
37. What is superconducting state?
38. What is critical temperature of superconductor?
39. What is Meissner effect?
40. What is critical magnetic field of superconductor?
41. What is Neel temperature?
42. What are ferrites?
43. Write a note on diamagnetic material

4. Long answer questions

44. Explain Langevin theory of diamagnetic material and show that susceptibility is negative
45. Obtain Langevin formula for paramagnetic susceptibility
46. What are superconductors? Mention the important property changes that occur in superconductors? Give some examples of practical uses
47. Describe Meissner effect
48. Describe Type-I and Type-II superconductors
49. Describe critical magnetic field of superconductor
50. Write a note on ferromagnetic materials. Give their examples
51. Write a note on antiferromagnetic materials
52. Write a note on ferromagnetic materials
53. Explain why it is desirable to use hard ferromagnetic materials to make permanent magnets
54. What is hysteresis? What information is obtained from hysteresis loop?
55. What are ferrites? Give their applications