Unit - I

Electrical Properties of Materials

Two mark questions

1. Give any two postulates of classical free electron theory

 - According to this theory, a metal consists of a very large number of free electrons. These free electrons move freely throughout the volume of the metal. They are fully responsible for the electrical conduction in the metal.

 - Drude assumed that the free electrons in a metal form of an electron gas. These free electrons move randomly in all possible directions just like the gas molecules move in a container.

2. Define mean free path

 The average distance travelled by a free electron between any two successive collisions in the presence of an applied field is known as mean free path.

$$\lambda = v_d \times \tau_c$$

3. Define relaxation time of an electron

 The average time taken by a free electron to reach its equilibrium state from its disturbed state due to application of an external electrical field is called relaxation time.

4. Define drift velocity of electron. How is it different from the thermal velocity of an electron?

 The average velocity acquired by a free electron in a particular direction after a steady state is reached on the application of an electrical field is called drift velocity. It is denoted as V_d and its value is very small.

The thermal velocity is random in nature and its value is very high.

5. Define mobility of electrons

The magnitude of the drift velocity acquired by the electrons per unit electric field is defined as the mobility of electrons (μ)

$$\mu = \frac{V_d}{E}$$

$V_d \rightarrow$ Drift velocity of electrons

$E \rightarrow$ Electrical field

6. Define electrical Conductivity. what is its unit

The amount of electrical charges (q) conducted per unit time (t) across unit area (A) of the Conductor for unit applied electrical field (E) is defined as electrical conductivity

$$\sigma = \frac{q}{tAE}$$

Its unit is $ohm^{-1} m^{-1}$ or $mho\, m^{-1}$

7. State Wiedemann - Franz law

It states that the ratio of thermal conductivity (K) to electrical Conductivity (σ) of a metal is directly Proportional to absolute temperature (T). This ratio is Constant for all metals at a given temperature

$$\frac{K}{\sigma} \propto T$$

$$\frac{K}{\sigma} = LT$$

where L is a constant and it is known as Lorentz number.

8. what is Lorentz number?

The ratio between thermal conductivity (K) of a metal to the product of electrical conductivity (σ) of a metal and absolute temperature (T) of the metal is a constant. It is called Lorentz number and it is given by

$$L = K/\sigma T$$

9. Define Fermi distribution function

The probability F(E) of an electron occupancy for a given energy level at temperature T is known as Fermi distribution function. It is given by

$$F(E) = \frac{1}{1 + e^{(E - E_f)/kT}}$$

E_f → Fermi level

K → Boltzmann's constant

T → Absolute temperature

E → Energy of the level

10. Define Fermi level and Fermi energy with its importance.

Fermi level : It is the energy level at finite temperature above 0K in which the probability of the electron occupation is 1/2 and it is also the level of maximum energy of the filled states at 0K.

Fermi energy : It is the energy of the state at which the Probability of the electron occupation is 1/2 at any temperature above 0K. It is also the maximum energy of filled states at 0K.

Importance :

Fermi level and Fermi energy determine the probability of an electron occupation for a given energy level at a given temperature

11 Define density of states. What is its use?

It is defined as the number of available electron states per unit volume in an energy interval E and E+dE. It is denoted by Z(E)

It is used to determine Fermi energy at any temperature

12 What is electron theory of solids?

The electrons in the outermost orbit of the atoms which constitute the solids determine its electrical properties. The electron theory of solids explains the structure and properties of solids through their electronic structure.

13 What is a periodic Potential?

When an electron moves through a solid its potential energy varies periodically with the periodicity equal to period of space lattice 'a'. This is called periodic potential.

Unit - II

Semiconductor physics

Two mark questions

1. What are elemental Semiconductors ? Give some important elemental semiconductors ?

Elemental semiconductors are made from single element of the fourth group elements of the periodic table.

Example : Germanium and silicon

2. What are the properties of semiconductors ?

- They are formed by covalent bond
- They have empty conduction band.
- They have almost filled valence band.
- These materials have comparatively narrow energy gap.

3. What are compound semiconductors ? Give some Important compound semiconductors ?

Semiconductors which are formed by combining third and fifth group elements or second and sixth group elements in the periodic table are called semiconductors.

III, IV - group → Gallium phosphide (GaP)
→ Gallium Arsenide

II, VI group → Magnesium oxide
Magnesium Silicon.

4. Mention any four advantages of Semiconducting materials.

- It behaves as insulator at 0K and as conductor at high temperatures.
- It has some properties of both conductor and insulator.
- On doping, n and p-type Semiconductors are produced with charge carriers of electrons and holes respectively.
- It has many applications in electronic field such as manufacturing of diodes, transistors, LED's, IC etc.

5. What is fermi level in a Semiconductor?

Fermi level in a Semi conductor is the energy level situated in the band gap of the semi conductor. It is exactly located at the middle of the band gap in the case of an intrinsic Semiconductor.

6. Define Hall effect and Hall voltage.

When a conductor carrying a current (I) is placed in a transverse magnetic field (B), a potential difference is produced inside the conductor in a direction normal to the directions of the current and magnetic field.

This phenomenon is known as Hall-effect and the generated voltage is called Hall voltage.

7. Mention the uses of Hall effect.

- It is used to find type of semiconductor
- It is used to measure carrier concentration
- It is used to find mobility of charge carrier.
- It is used to measure the magnetic flux density using a semiconductor sample of known Hall coefficient.

8. What is a semiconductor?

Semiconductor is a special class of material which behaves like an insulator at 0K and acts conductor at temperature other than 0K. Its resistivity lies in between a conductor and an insulator.

9. What is an intrinsic semiconductor?

Semiconductor is an extremely pure form (without impurities) is known as intrinsic semiconductor.

10. What is an extrinsic semiconductor?

A semiconducting material in which impurity atoms added (doped) to the material to modify its conductivity is known as extrinsic semiconductor or impurity semiconductor.

11. What is an n-type semiconductor?

When a small amount of pentavalent impurity is added to a pure semiconductor, it becomes extrinsic or impure Semiconductor and it is known as n-type Semiconductor.

12 What is a p-type Semiconductor?

When a small amount of trivalent impurity is added to a pure semiconductor, it becomes extrinsic semiconductor or impure Semiconductor and it is called P-type Semiconductor.

13 What is mean by doping and doping agent?

The technique of adding impurities to a pure Semiconductor is known as doping and the added impurity is called doping agent.

14. What is mean by donor energy level?

A pentavalent impurity when doped with an intrinsic Semiconductor donates one electron which produces an energy level called donor energy level.

15 What is mean by acceptor energy level?

A trivalent impurity when doped with an intrinsic semiconductor accepts one electron which produces an energy level called acceptor energy level.

16 Mention the uses of Compound Semiconduction

They are used as photovoltaic materials, Photo Conductive cell, laser materials and for making LED

17. Define drift velocity

when an electrical field is applied in a Semiconducting material, the free charge carriers such as free electrons and holes attain drift velocity V_d.

The drift velocity attained by the carriers is proportional to the electrical field strength E

$$V_d \propto E$$

$$V_d = \mu E$$

where μ - proportionality constant and it is known as the mobility of the charge carrier.

18. Define drift current.

The electric current produced due to the motion of charge carriers under the influence of an external electric field is known as drift current.

19. Define diffusion current.

The non-uniform distribution of charge carriers creates the regions of uneven concentrations in the semiconductor.

The charge carriers move from the regions of higher concentration to the regions of lower concentration. This process is known as diffusion. The current is known as diffusion current.

17. what is a Hall device?

The device which uses the hall effect for its application is known as Hall device.

18. what are different types of Hall devices?

Three types of Hall devices

a) Gauss meter

b) Electronic Multiplier

c) Electronic Watt meter

19. what is a schottky diode?

It is a junction formed between a metal and n-type semiconductor.

when the metal has a higher work function than that of n-type semiconductor then the junction formed is called schottky diode.

20. what is ohmic contact?

An ohmic contact is a type of a metal semiconductor junction. It is formed by a contact of a metal with a heavily doped semiconductor.

when the semiconductor has a higher work function than that of a metal, then the junction formed is called as ohmic junction.

Unit - III

Magnetic Properties of Materials

Two mark questions

1. On the basis of spin how the materials are classified as para, ferro, antifero and ferrimagnetic.

- Paramagnetic materials have few unpaired electron spins of equal magnitudes
- Ferro magnetic materials have many unpaired-electron spins with equal magnitudes.
- Antiferro magnetic materials have equal magnitude of spins but in antiparallel manner.
- Ferrimagnetic materials have spins in antiparallel manner but with unequal magnitudes.

2. What is curie constant ? or what is curie law ?

It is found that susceptibility (χ) is inversely proportional to the temperature (T)

$$\chi \propto 1/T$$

$$\chi = C/T$$

C - constant, known as curie constant. This relation is known as curie law.

3. State Curie - Weiss law and its importance.

Curie - Weiss law is given by

$$\chi_x = \frac{C}{T - \theta}$$

C → Curie constant

T → Absolute temperature

$\theta \rightarrow$ Curie temperature

Importance : It determines the susceptibility of the magnetic materials interms of temperatures.

If the temperature is greater than Curie temperature a ferromagnetic material becomes paramagnetic material.

4. What is ferromagnetism ?

Certain materials like Iron (Fe), Cobalt (Co), Nickel (Ni) and Certain alloys exhibit spontaneous magnetization. they have a small amount of magnetisation even in the absence of an external magnetic field. This phenomenon is known as ferromagnetism.

5. What are ferromagnetic materials ?

The materials which exhibit ferromagnetism are called as ferromagnetic materials.

6. What is domain theory of ferromagnetism ?

According to domain theory, a specimen of ferromagnetic material consists of a number of regions or domains which are spontaneously magnetized due to parallel alignment of all magnetic dipoles. The direction of spontaneous magnetisation varies from domain to domain.

7. Why ferrites are advantageous for use as transformer cores ?

Ferrites are used as transformer cores for frequencies upto microwaves. This is because the eddy current which prevents the penetration of magnetic flux into the material is very much less in ferrites than in iron.

8. What is Saturation magnetisation?

The maximum magnetisation in a ferromagnet when all the atomic magnetic moments are aligned is called saturation magnetization.

9. what are the required magnetic parameters for recording?

i) Electromagnetic induction should occur in materials.

ii) The material should easily acquire magnetism.

iii) It should posses magneto resistance.

iv) Soft magnets should be used for temporary storage and hard magnets should be used for permanent storage.

10. Mention application of GMR

The main application of GMR is magnetic field sensors, which are used to read data in hard disk drives, biosensors, micro electro mechanical systems and other devices. GMR multilayer structures are also used in magnetoresistive random access memory as cell that store one bit of information.

Unit - IV

Optical properties of Materials

Two mark questions

1. What are optical materials?

The materials which are sensitive to light are known as optical materials. These optical materials exhibit a variety of optical properties.

2. What are the type of optical materials?

   i) Transparent
   ii) Translucent
   iii) opaque

3. Define scattering of light

It is a process by which the intensity of the wave attenuates as it travels through a medium.

4. Define Carrier generation and recombination

The Carrier generation is the process where by electrons and holes are created. The recombination is the process where by electrons and holes are annihilated.

5. what are types of carrier generations?

   i) Photogeneration
   ii) Phonon generation
   iii) Impact ionization

6. What are types of recombination process?

a) Radiative Recombination

b) Shockley - Read - Hall Recombination

c) Auger Recombination

7. What is photo diode?

It is a reverse biased P-N junction diode which responds to light absorption

8. what is the basic Principle of Photo diode?

when light is incident on the depletion region of the reverse-biased pn junction, the Concentration of minority Carriers increases. Therefore reverse saturation current increases.

9. what is solar cell?

It is a P-N junction diode which converts Solar energy (light energy) into electrical energy

10. what is LED?

It is a P-N junction diode which emits light when it is forward biased.

11. What is the basic principle behold LED?

The injection of electrons into the p-region from n-region makes a direct transition from the conduction band to valence band. Then, the electrons recombine with holes and emits photons of energy Eg.

The forbidden gap energy is given by

$$E_g = h\nu$$

12. What is an organic light emitting diodes ?

Organic light emitting diodes are solid state devices made up of thin films of organic molecules that produces light with the application of electricity

13. What is a laser diode ?

It is a specially fabricated p-n junction diode. This diode emits laser light when it is forward biased.

14. What is the Principle of CD ?

The Principle of CD is that the data to be stored is first converted into binary from as 0s and 1s.

It is then stored in the form of reflecting and non-reflecting micro-points in spiral path on a disc.

During the read-out process, variation in the reflected intensity of laser is converted back to data.

15. What are advantages of optical disc ?

The optical discs have several advantages over semiconductor memories. Some of these include their larger data storage capacity, shorter access time size. Therefore they are used in ~~the~~ terminal equipment of computers as well as in audio visual equipment.

Unit : V

Nano Devices and Quantum Computing

Two mark questions

1. Define nano materials.

Nanophase materials are newly developed materials with grain size at the nanometre range (10^{-9} m) in the order of 1-100 nm. The particle size in a nano material is 1-100 nm.

2. what is a quantum confinement?

It is a process of reduction of the size of the solid such that the energy levels inside become discrete.

3. what is quantum structure?

when a bulk material is reduced in its size, atleast one of its dimension, in the order of few nanometres, then the structure is known as quantum structure.

4. what is quantum size - effect?

when the size of a nanocrystal becomes smaller than the debroglie wavelength, electrons and holes get spatially confined, electrical dipoles get generated, the discrete energy levels are formed.

As the size of the material decreases the energy seperation between adjacent levels increases. The density of states of nanocrystals is positioned in between discrete and continuous.

5. what is single electron phenomena?

Present day, transistors require 10,000 electrons. Rather than moving many electrons through transistors, it may very well be practical and necessary to move electrons one at a time. The phenomena in known as single electron phenomena.

6. Define Coulomb - Blockade effect.

The charging effect which blocks the injection or rejection of a single charge into or form a quantum dot is called Coulomb blockade effect.

7. what is single electro tunneling?

The quantization of charge can dominate and tunneling of single electrons across leaky capacitors carries the current. This is called single electron tunneling.

8. what is a Single Electron Transistor?

SET is three-terminal switching devices which can transfer electrons from source to drain one by one.

9. What is Quantum cellular Automata?

Quantum Cellular Automata is an emerging nanotechnology. CMOS (complementary Metal oxide Semiconductor) technology has a lot of limitations while scaling into a nano-level.

In order to improve the performance of a system, new nano-technology approach should be taken into account. The QCA technology is a perfect replacement of CMOS technology with out any limitations.

10. Define Hilbert Space.

Hilbert Space is defined as an infinite-dimensional vector space with an inner product and its associated norm

$$|\psi_a\rangle = \alpha_0|0\rangle + \alpha_1|1\rangle + \dots + \alpha_i|i\rangle + \dots + \alpha_{n-1}|n-1\rangle$$

11. Define classical Bits

Classical bits is an abstraction of a physical system, in anyone of two states either '0' or '1'. Hence it can take the value 0 or 1. The bit is a smaller and

and simpler physical system. It requires less energy to speedily process information and to store it. The physical system of bit is at atomic or subatomic level.

12 What is a qubit?

A qubit is a mathematical model of microscopic physical system such as the spin of electron or the polarization of a photon. It also exists in a continuum of intermediate states or superposition states.

13. Define Bloch Sphere

The Bloch sphere representation is useful in understanding the qubits. It provides a geometric picture of the qubit and of the transformations takes on the state of a qubit.

14. Define one qubit quantum gates.

A one-qubit gate transforms an input quite $|\psi\rangle = \alpha_0 |0\rangle + \alpha_1 |1\rangle$) into an output qubit

$$|\varphi\rangle = \alpha_0' |0\rangle + \alpha_1' |1\rangle$$

Mathematically, a gate G is represented by a 2 x 2 transfer matrix with complex entries

$$G = \begin{pmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{pmatrix}$$

15. What are the applications of single electron Transistor?

- It is used for mass data storage
- It is used in highly sensitive electrometer
- SET is a suitable measurement set-up for single electron spectroscopy.
- SET can be used as temperature probe, particularly in the range of very low temperatures.