EASWARI ENGINEERING COLLEGE **15.12.2018**
I YEAR BE/B. TECH (II SEM)
QUESTION BANK

PHYSICS FOR ELECTRONICS ENGINEERING (SUB CODE: PH8253)

(Common to ECE, EEE & EIE)

UNIT I – ELECTRICAL PROPERTIES OF MATERIALS
PART – A

1. What are the special features of free electron theory of metals? June 2009; May 2011

The classical free electron theory visualizes a metal as an array atoms (icons) premeated by a gas of free electrons. There is no mutual interaction among the free electrons or between ions & electrons. The free electrons can move freely in random directions under the constant potential provided by the fixed ions of the lattice.

2. What are failures of classical free electron theory?

i. It predicated that the value of electronic specific heat as 3/2 R. But experimentally it is about 0.01R only.
ii. The ratio between thermal conductivity and electrical conductivity is not constant at low temperatures.
iii. The theoretical value of paramagnetic susceptibility is greater than the experimental value.
iv. The electrical conductivity of semiconductors, ferromagnetism, the photoelectric effect and black body radiation cannot be explained.

3. What are the important applications of quantum free electron theory? Apr 2003

Here the wave aspect of electrons is taken into account. Particularly the fermi level electrons are responsible for electrical conductivity and thermal conductivity. Hence the correct values of electrical and thermal conductivities and electronic specific heat are obtained.

4. Give the meaning of wave function?

The wave function is defined as the probability amplitude of a particle to find its location in the atomic structure and measures the variations of matter waves associated with the particles. It is the complex displacement of the matter waves.

Further the probability density | Ψ*Ψ| is the real quantity and it tells us where the particle is likely to be not where it is. Thus it connects the particle and its associated wave statistically.

5. What is fermi energy? What is its importance? June 2010; May 2011; June 2012

Fermi energy is the maximum energy of the filled energy stables in a metal at 0 K. It depends on the free electron density. The properties of metals depend on the value of fermi energy since the effective electrons taking part in various physical phenomena or processes are only the fermi level electrons.

6. Define density of states. What is its use? May 2011; June 2010

Density of states is defined as the number of energy states per unit volume in an energy interval. It is used to calculate the number of charge carriers per unit volume of the solid.

7. Define band gap, valence band & conduction band?

Band gap is the energy difference between the minimum energy of conduction band and the maximum energy of valence band. Those energies lying in the band gap are not allowed to occupy by the electrons of that solid.

Valence band is the region of energy levels where the valence electrons occupy their positions.

Conduction band is the region of energy levels where the conduction electrons or free electrons occupy their positions.

8. What are holes?

Holes are the vacant sites in the valence band of a solid. These will behave like positive charge carriers having the mass of electron in the presence of applied electric field.

9. Define effective mass of electron. Nov 2003

Effective mass of electron. 'm*' is the mass of the electron when its moving through the periodic lattice.

For example, in copper m*> m where m is the rest mass of an electron.

10. State the relation between thermal conductivity and electrical conductivity. Does it hold good for all types of materials.

$K / \sigma = LT$ where L is a constant called **Lorentz number** and T is the temperature of metal in Kelvin. This relation is hold only for metals. At low temperatures this relation is not true even for metals.

11. Explain thermal conductivity.

Thermal conductivity of a material 'K' is equal to the amount of heat flowing power unit through the material having unit area of cross section and maintaining a unit temperature gradient. In general the total thermal conductivity of a solid is the sum of thermal conductivity due to free electrons and thermal conductivity due to photons (lattice vibrations)

i.e., $K_{total} = K_{electron} + K_{photon}$

In metals, $K_{electron} >> K_{photon}$

In non-metallic conductors, K_{photon} is a dominating one.

Example: Diamond at 30 K is a better thermal conductor than silver at 30 K.

But in insulators, $K_{total} = K_{photon}$.

The thermal conductivity of a metal increase exponentially from 0 K to 20 K and then decreases with increase of temperature.

12. What are the sources of electrical resistance in metals? **Nov 2003**

i) Lattice defects and ii) thermal vibrations of the lattice.

When the electron is moving through a perfect periodic lattice, there is no resistivity except temperature dependent resistivity. The impurities and residual defects produce so many scattering centers and reduce the mean free path of electrons. Similarly if the vibration amplitude increases with the increase of temperature, the mean free path of electron decreases. Hence the resistivity increases.

13. Give the microscopic form of ohm's law in a metallic conductor. Whether the ohm's law is true at all temperatures\ June 2009

J = σ E

Where **J** is the current density, σ is the electrical conductivity and E is the electric field intensity.

The ohm's law is not true at all temperatures in a conductor, since the resistance of a conductor varies with temperature in a complicated manner at different range of temperatures.

14. Define drift velocity\ How is it different from thermal velocity of an electron\ June 2009

The drift velocity is defined as the average velocity acquired by an electron in the presence of an electric field $V_d = J / ne$

The thermal velocity is random in nature and is very high (10^5 m/s). But the drift velocity i_d directional one and is very small (50 cm/s).

15. Define relaxation and collision time of free electrons in a metal. June 2009

Relaxation time is defined as the time taken by an electron to reach equilibrium position from its disturbed position in the presence of electric field. **The collision time** is defined as the average time taken by an electron between two successive collisions. For an isotropic collision, the relaxation time and collision time are equal.

16. Distinguish between conductor and semiconductor on the basis their electrical conductivity.

Conductor has electrical conductivity of 10^4 to 10^9 $ohm^{-1}m^{-1}$ and semiconductor has electrical conductivity of 10^3 to 10^4 $ohm^{-1}m^{-1}$. For conductors, the electrical conductivity is decreased with respect to addition impurities and increase of temperature due to decrease in mean free path. But in **semiconductors**, the electrical conductivity is increased with respect to addition of impurities and increase of temperature due to increase of charge density.

17. Aluminium has three valence electrons and copper has one valence electron. Why do we have large electrical conductivity for copper than Aluminium

Based on quantum electron theory, even though aluminium has three times as many conduction electrons as copper, the area of the fermi surface in aluminium is about the same in copper. But the number of uncompensated electrons in the fermi surface of copper is more than the number of uncompensated electrons in the fermi surface of aluminium.since the value of the electrical conductivity depends on the number of compensated electrons, copper has higher electrical conductivity than aluminium.

18. State Widemann – Franz law. June 2010; May 2011

The ratio between thermal conductivity and electrical conductivity of a metal is a constant at a given temperature.

i.e., $K / \sigma T = L$ (constant)

Where K and σ are thermal conductivity and electrical conductivity respectively.

19. Discuss the variation of resistivity of a metal with respect to variation of temperature.

At very low temperatures, the resistivity is almost constant and its value in very small. From the low temperature to the Debye temperature of the metal, the resistivity varies in a non-linear manner. i.e., $\rho \propto T^5$. Above Debye temperature $\rho \propto T$.

20. 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.

21. What is periodic potential?

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

22. State and explain Bloch Theorem.

The Schrodinger equation is

$$\frac{d^2\psi}{dx^2} + \frac{2m}{h^2}[E-V(x)]\,\psi = 0$$

With reference to the solution of this equation, there is an important theorem which states that these exist solutions of the form.

$$\Psi(x) = e^{\pm ikx}\, u_k(x) \text{ where } u_k(x) = u_k(x+\alpha)$$

Where α is the period,

Thus the solutions are plane waves modulated by the function $u_k(x)$,
which has the same periodicity as the lattice. This theorem is known as the Bloch Theorem.

23. What is an energy band?

A set of closely spaced energy levels is called an energy bond.

24. What is an effective mass of electron?

The mass acquired by an electron when it is accelerated in a periodic potential is called effective mass of an electron. It is denoted by m.

25. Distinguish between mean free path and collision time. (MAY 2018)

S.No.	Collision time	Mean free path
1.	**The collision time** is defined as the average time taken by an electron between two successive collisions. For an isotropic collision, the relaxation time and collision time are equal. $T_c=\lambda/c$	The average distance travelled between two successive collision is called as a mean free path it is denoted as λ $\lambda= T_c * c$

PART – B

1. State and prove the Widemann – Franz law. **June 2011**
2. Deduce a mathematical expression for electrical conductivity of a conducting material and hence obtain Widemann-Franz law.(**MAY2018**)
3. Derive an expression for electrical conductivity in a material in terms of mobility of electrons. How does the conductivity vary with temperature? **Nov 2013**.
4. What are the main sources of electrical resistance in metals? Discuss the effect of impurity and temperature on the electrical resistivity of metals.
5. (i) Derive an expression for density of states. **June 2011**
   (ii) State the merits and demerits of classical free electron theory.
6. Define Fermi energy. Obtain a general expression for the Fermi energy of electrons in solids at zero degree Kelvin. Show that at the same temperature the average energy of the electron is (3/5)th of the Fermi energy. **June 2010**

7. Explain the origin of band gap when the electron is moving in a periodic potential. Also explain the effective mass of electron in a periodic potential. **Apr 2002**
8. Discuss qualitatively how band theory of solids leads to the classification of solids in conductors, semiconductors and insulators.
9. (i) Define Fermi energy. **June 2012**
(ii) Explain Fermi Dirac distribution for electrons in a metal.
10. Derive an expression for the density of states and based on that calculate the carrier concentration in metals. **May 2011**
11. Write short notes on (i) Energy levels (ii) Energy bands (iii) Bound and free electrons (iv) Electronic work function.
12. State and explain Bloch Theorem.
13. Explain periodic potential and show that it reaches to energy band structures.
14. Describe the formation of energy band in a crystalline solid.
15. Explain the origin of energy band in a solid.
16. Describe tight binding approximation to explain the formation of energy band.
17. Derive an expression for the effective mass of an electron moving in energy bands of a solid. Show how it varies with the wave vector.
18. Explain the concept of hole.
19. Define valance band, conduction band, and forbidden energy gap in the energy band structure.
20. Distinguish between conductor, semiconductor and insulator.
21. Explain the band theory of solids in detail and classify solids into conductors , insulators and semiconductors with the neat diagram.(MAY 2018)

UNIT – II SEMICONDUCTOR PHYSICS
PART – A

1. What are the p-type and n-type semi conductors? (MAY 2018)

P-type semi conductor is the one having holes as the majority charge carriers and electrons as the minority charge carriers.
Example: Silicon or Germanium doped with trivalent impurities like Al, Ga and In.

N-type semi conductor is the one having electrons as the majority charge carriers and holes as the minority charge carriers.
Example: Silicon or Germanium doped with pentavalent impurities like P, As and Sb.

2. What are donors and acceptors? June 2011

The **donors** are the doped pentavalent impurity atoms like P, As and Sb in Silicon or Germanium donating an electron from its atom to Silicon or Germanium crystal. The **acceptors** are the doped trivalent impurity atoms like Al, Ga and In in Silicon or Germanium accepting an electron from each Silicon or Germanium atom.

3. Why do we prefer extrinsic semi conductors than intrinsic semi conductors?

Extrinsic semi conductors have high electrical conductivity which depends on the number of dopant (impurity) atoms and have high operating temperature. But in the **intrinsic semi conductors** the electrical conductivity is very small and is not a constant at different temperatures.

4. What is the meaning of bandgap of a semi conductor?

Bandgap (or) energy gap of a semi conductor is the region of energies, which are not allowed to occupy by the electron of that material. Its equal to the energy difference between the minimum energy of conduction band and the maximum energy of valence band of that material. But in a band gap the added impurity atoms can have their energy levels.

5. Distinguish between direct and indirect bandgap semiconductors. June 2010; May 2011

In **direct bandgap** semiconductors the electron from the conduction band can directly recombine with the hole in the valence band emitting a light photon and the charge carriers have smaller lifetime. Examples: GaAs, InP. But in **indirect bandgap** semiconductors, the electron from the conduction band can recombine with a hole in the valence band in an indirect manner through the traps. The lifetime of charge carriers is more. Examples: Si, Ge.

6. What is fermi level in a semiconductor? June 2009; May 2011

Fermi level in a semiconductor is the energy level situated in the band gap of the semiconductor. It is exactly located at the middle of the band gap in the case of intrinsic semiconductor. Thus it is a reference energy level from which the maximum energy the valence band and minimum energy of the conduction band are referred. In extrinsic semiconductors, the fermi level is situated in between the acceptor energy level and maximum energy of the valence band in the case of p-type semiconductor and is situated in between the donor energy level and minimum energy of the conduction band in the case of n-type semiconductor.

7. Discuss the variation of fermi level with temperature in the case of p-type semiconductor or n-type semiconductor.

The fermi level in extrinsic semiconductor shifts down in the n-type and shifts up in the p-type and reaches the middle of the band gap when the temperature is gradually increased up to 500 K.

8. Define the operating temperature of a semiconductor.

The operating temperature of a semiconductor is defined as the maximum temperature up to which extrinsic behavior or amplification is existed. For example, silicon has the operating temperature of 200°C so that the silicon transistors or diodes can be operated safely with effect of doped impurities up to 200°C.

9. Why do we prefer silicon for transistors and GaAs for laser diodes? June 2009

Silicon is an indirect bandgap semiconductor and so the lifetime of the charge carriers are more and hence amplifications are more.

GaAs is the direct bandgap semiconductor and the electrons can recombine directly with the holes in the valence band emitting a light photon.

10. What is Hall Effect? What is its use in the semiconductors? June 2009; June 2010

Hall Effect to the creation of a transverse e.m.f. across the semiconductor slab carrying current in the perpendicular magnetic field. Using this effect the concentration and the sign of charge can be determined. Further the mobility of charge carriers can also be determined.

11. What is the effect of doped impurities and increase of temperature in a semiconductor?

The doped impurities and increase of temperature create the charge carriers and thereby increasing the electrical conductivity of a semiconductor, eventhough there is an increase of scattering centers. Since the increase of conductivity due to doped impurities and increase of temperature is larger than the reduction of conductivity due to increase of scattering centers.

12. 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.

13. Write down the Einstein's relation.

The relation between the mobility (μ) and diffusion coefficient (D) of a semiconductor is known as Einstein's relation

$$\frac{D_n}{D_p} = \frac{\mu_n}{\mu_p}$$

Where D_n - Diffusion coefficient of electron.
D_p - Diffusion coefficient of holes.
μ_n -Mobility of electron.
μ_p - Mobility of holes.

14. What is a Hall device?

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

15. What are different types of Hall devices?

There are three types of Hall devices. They are

(a) Gauss Meter
(b) Electron Multiplier
(c) Electronic Wattmeter.

16. What is Breakdown voltage is pn junction?

The reverse voltage at which the PN junction breaks down with sudden rise in reverse current is called breakdown voltage.

17. What is zener breakdown?

In a heavily doped junction diode, breaking of covalent bonds occurs due to increase in reverse voltage which leads to junction breakdown. It is called zener breakdown.

18. What is avalanche breakdown?

In lightly doped junction diodes, at a relatively high reverse voltage breaking of covalent bond occurs due to collision of accelerated electrons with valence electrons.

The multiplication of collision leads avalanche effect. Thus the junction breakdown occurs. It is known avalanche breakdown.

19. What are the differences between Zener and avalanche breakdown?

S. No	**Zener breakdown**	**Avalanche breakdown**
1.	It occurs in a heavily doped junction.	It occurs in a lightly doped junction.
2.	It occurs with reverse bias voltage less than 6V.	It occurs in PN junction diode with reverse voltage greater than 6V.
3.	The reverse bias of VI characteristics is very sharp in breakdown region.	The reverse bias of VI characteristics is not sharp. (i.e., soft)
4.	It occurs by breaking covalent bonds due	It occurs by breaking covalent bonds due

	to very high electrical field developed by the reverse bias.	to collision of accelerated electrons as a chain reaction.
5.	The breakdown voltage decreases if the junction temperature increases.	The breakdown voltage increases if the junction temperature increases.

20. What is schottky diode?

It is 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.

21. What are advantages of schottky diodes?

- In schottky diode, stored charges or depletion region is negligible. So a schottky diode has a very low capacitance.
- In Schottky diode, the depleting region is negligible. So the schottky diode will immediately switch from ON to OFF state (fast recovery time).
- The depletion region is negligible in schottky diode. So applying a small voltage is enough to produce large current.
- IT has high efficiency.
- It operates at high frequencies.
- It produces less noise.

22. What are the applications of Schottky diode?

- Schottky diode can be used for rectification of singles of frequencies even exceeding 300 MHz.
- It is commonly used in switching device at frequencies of 20 GHz.
- It is used in radio frequency (RF) applications.
- It is widely used in power supplies.

23. What are the differences between Schottky diode and p-n diode?

S.No	Schottky Diode	P-N Diode
1.	Forward current due to thermionic emission (major carrier transport).	Forward current due to diffusion currents (majority carrier transport).
2.	Reverse current only due to majority carriers that overcome the barrier (less temperature dependent).	Reverse current due to minority carriers diffusing to the depletion layer and drifting to the other side (strong temperature dependence).
3.	Cut-in voltage is small (about 0.3 V).	Cut-in voltage is large (about 0.7 V).
4.	High switching speed, because of majority carries transport. No recombination time needed.	Switching speed limited by the recombination time of the injected minority carriers.

24. What is ohmic contact?

An ohmic contact is a type of 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 metal, then the junction formed is called the Ohmic junction.

25. What are the uses of ohmic contact?

The use of ohmic contacts is to connect one semiconductor device to another, an IC, or to connect an IC to its external terminals.

26. What are the differences between schottky diode and ohmic contacts?(MAY2018)

S. No.	Schottky Diode	Ohmic contact
1.	It acts as a rectifier	It acts as a resistor
2.	Very low forward resistance but very high reverse biased resistance	Resistance is same in both forward and reverse bias
3.	Work function of metal is greater than that of semiconductor $\phi_m > \phi_{semi}$	Work function of metal is smaller than that of semiconductor $\phi_m < \phi_{semi}$

27. What is a tunnel diode?

A tunnel diode is a simple p-n junction in which both p and n sides are very heavily doped with impurities.

It is a p-n junction which exhibits negative resistance between two values of forward voltage (i.e., between peak-point voltage and valley point voltage).

28. What are the advantages of tunnel diodes?

- Tunnel diode has low noise.
- It is easy to operate this diode.
- The switching speed is high.
- It consumes low power.

29. What are the disadvantages of tunnel diodes?

- Voltage range over which it can be operated is 1 V or less
- Being a two terminal device, there is no isolation between the input and output circuit

30. What are the applications of tunnel diodes?

- Tunnel diode is used as ultra –high speed switch with switching speed of the order of nano second (ns) or Pico second (ps)
- It is used in logic memory storage device.
- It is used in microwave oscillator
- It can be used in relaxation oscillator circuit

31. What are the differences between tunnel diode and P-N junction diode?

S.No	Tunnel Diode	P-N Junction Diode
1.	Doping levels at p and n sides are very high	Doping in both p and n sides is normal
2.	Majority carriers' current responds much faster to voltage changes-suitable to microwaves.	Majority carrier current does not respond so fast to voltage changes-suitable for low frequency applications only.
3.	Shows negative resistance characteristics – useful for oscillators.	Does not show negative resistance – used as detector and rectifiers.
4.	Preferred semiconductors are Ge and	Preferred semiconductors are Ge and Si.

	GaAs	
5.	It is a low noise device.	Moderate noise characteristics.

32. What is metal oxide semiconductor capacitor?

Metal Oxide semiconductors (MOS) are used as capacitors.

33. What are the applications of metal oxide semiconductor capacitor?

These types of capacitors are widely used as internal capacitors in Integrated circuits (IC's).

34. What are power transistors?

Transistors which handle high voltage and high current ratings are known as power transistors.

35. What are the advantages and disadvantages of power transistor?

Advantages

- The power loss is low
- The switching speed is high.
- The size of this transistor is large.
- It can handle high power with high efficiently.
- It thermal resistance is low.

Disadvantages

- It has little ability to withstand a reverse voltage.

36. What are the applications of power transistors?

- It is used in power switching devices.
- It is also used in power amplifiers.

PART – B

1. (i) What are the differences between elemental and compound semiconductors? **April 2010**
(ii) Discuss the effect of temperature on semiconducting materials.

2. (i) Get an expression for the carrier concentration of an intrinsic semiconductor. **May & June 2011**
(ii) Explain the variation of Fermi energy with temperature in an intrinsic semiconductor.
(iii) Describe a method of determining the band gap energy of a semiconductor?

3. Derive an expression for carrier concentration in n-type semiconductors and deduce an expression for Fermi energy at 0K.

4. Derive the expressions for Fermi energy at any temperature for an 'n' type and 'p' type semiconductors. **June 2009**

5. Derive an expression for the carrier concentration in a p – type semiconductor and explain the variation of the same with temperature. **June 2010**

6. With a neat sketch explain the variation of carrier concentration and the electrical conductivity with temperature. Write a note on hole concentration in an extrinsic semiconductor.

7. With a neat sketch explain the variation of Fermi level and carrier concentration with temperature in the case of p-type and n-type semiconductors for low and high doping levels.

8. (i) Assuming Fermi-Dirac statistics and Fermi function derive the expressions for electron and hole densities in an intrinsic semiconductor and hence obtain the expression for their electrical conductivity.

(ii) Deduce an expression for the energy band gap of an intrinsic semiconductor.

9. (i) What is meant by Hall Effect and Hall co-efficient? **Dec 2009**

(ii) Explain how the semiconducting material can be classified into p-type and n-type semiconductors, using Hall co-efficient.

10. (i) Describe an experiment for the measurement of the Hall coefficient. (ii) Write the applications of Hall Effect.(MAY 2018)

11. Write down expression for drift current and diffusion currents. Derive Einstein's relation.
12. Explain working of any two Hall devices.
13. Explain zener and avalanche breakdown in P-N junction. **April 2014**
14. Describe construction and working of schottky diode.
15. Write a note on ohmic contact.
16. Describe the construction and working of tunnel diode. **Nov 2013**
17. Explain principle and working metal oxide semiconductor capacitor.
18. Describe the construction and working of power transistor.
19. Write a note carrier transport in n-type and p-type semiconductors.(MAY 2018)

UNIT – III MAGNETIC AND DIELECTRIC PROPERTIES OF MATERIALS

PART – A

1. What are the essential differences between hard and soft magnetic materials?

Sl.No.	Hard magnetic material	Soft magnetic material
i.	It has large area hysteresis Loop.	It has smaller area hysteresis loop
ii.	It has high coercivity and high retentivity.	It has less coercivity and lesser retentivity.
iii.	It has irreversible domain wall movement.	It has reversible domain wall movement.
iv.	It has lesser permeability.	It has large permeability.
v.	It is used for making permanent magnets.	It is used for making electromagnets.

2. Explain the terms remenance and coercivity.

Remenance is the property of the magnetic material by which it retains some magnetization when the magnetizing field is reduced to zero. It is expressed in terms of weber/m^2. **Coercivity** is the property of the magnetic material by which it requires a demagnetizing force to destroy the residual magnetism in it. It is expressed in terms of ampere turn/m.

3. Name two uses of soft magnetic materials.

i. Since soft magnetic materials can be easily magnetized or demagnetized, these are used to make electromagnets used in cranes.

ii. Due to their low hysteresis loss, they are also used as transformer core materials.

4. What are the requirements of transformer core material?

Transformer core material should have high resistivity to reduce eddy current losses and magnetically soft to reduce hysteresis losses.

5. What are magnetostriction materials?

Magnetic materials whose length along the axis magnetization may charge when it is placed parallel to the magnetic field are called magnetostriction materials. These are used to produce ultrasonic waves and deign mechanical filters used in the single side band transmission of ratio waves.

6. Give the origin of magnetic moment in magnetic materials. June 2009

The magnetic moment originates from the orbital motion and spinning motion of electrons in atoms. Particularly ferromagnetism is mainly due to spin-spin interaction of unpaired electrons in the ferromagnetic atoms.

7. What is mean by energy product of a hard magnetic material?

The product of residual magnetic induction (B_r) and coercively (H_c) is called energy product. It is the important quantity to design powerful permanent magnets. For example Alnico magnets have high energy products and hence they are very powerful permanent magnets.

8. For making electromagnet what is nature of magnetic material.

For making electromagnets we require high initial permeability, low coercivity and low hysteresis loss magnetic materials.

Example: Permalloy

9. What are ESD magnets? What are they properties?

ESD magnets are elongated simple domain magnets. These have very fine particles with larger magnetization. These are stable towards their magnetic properties and have a single domain structure.

10. How do you get high-energy product in a hard magnetic material?

Making irreversible domain wall movement by introducing voids or internal stresses inside the magnetic material, one can make hard magnetic material used for making powerful permanent magnets.

11. What are domains?

Domains are the small regions in a ferromagnetic material, which are completely magnetized by favourable exchange spin-spin interaction. The domains are responsible for large magnetization of ferromagnetic materials with very weak magnetic fields.

12. What is meant by dielectric breakdown?

Dielectric breakdown is the failure of the material at which the dielectric loses its insulation resistance and permits large currents to pass through it.

13. What are dielectrics?

Dielectrics are the materials having permanent electric dipoles or having the ability to produce enormous induced dipoles in the presence of applied electric field.

14. What is meant by local field in a dielectric?

The local field in a dielectric is the space and time average of the electric field acting on a molecule or atom of the dielectric kept in an applied electric field. It is equal to

$E_i = E + P/3\varepsilon_0$ for simple elements dielectricals.

Here, E = applied field strength and
P = polarization field produced in the dielectric.

15. Define dielectric loss. May 2011

When a dielectric is subjected to the a.c. voltage, the electrical energy is absorbed by the material and is dissipated in the form of heat. This dissipation of energy is called dielectric loss. The dielectric loss is mainly due to imaginary term of the complex dielectric constant.

16. Define dielectric constant. May 2011

Dielectric constant is the measure of the polarization in a material. It is also called relative permitivity 'ε_r' of the material.

Thus, $\varepsilon_r = E_o / E_o - E_p$

Where E_o = applied electric field.
E_p = produced polarization field.

If there is more polarization in a medium then E_p is more and ε_r is higher for that medium.

17. Define electric polarization. May 2011

Electric polarization means production or inducement of electric dipoles by the applied electric field. It is due to shifting of the charges in the material by the applied electric field. It depends upon frequency of the applied field and temperature.

18. Define dielectric strength. June 2012

Dielectric strength is the minimum voltage required per unit thickness of the material to produce dielectric breakdown or dielectric failure. Unit: V / m

19. What is high-k dielectric?

The term high –k dielectric refers to a material with high dielectric constant k High dielectrics are used in semiconductor manufacturing where they are usually used to replace a silicon dioxide gate dielectric or another dielectric layer of a device.

20. What are the applications of high-k dielectric?

They have a wide range of the following applications

- Storage capacitor dielectrics.
- High aspect ratio diffusion barriers for Cu interconnect.
- Adhesion layers.
- Highly conformal coatings for micro fluidc and MEMS applications
- Coating of nano-porous structures.
- Fuel cells (e.g.) single metal coating for catalyst layers.
- Bio-MEMS.
- Electroluminescence

21. Define the term instensity of magnetization and flux density?(May 2018)

Intensity of Magnetization :

The term magnetization is the process of converting non magnetic material into magnetic material. It measures the magnetization of the magnetized specimen.

$M = M_\mu / V$ weber/m^2

Magnetic flux density:

It is defined as the number of magnetic lines of force passing normally through unit area of cross section A at that point.

$B=\phi_m/A$ Weber /m^2

22. Mention the energies involved in the origin of domains in ferro magnetic materials.(MAY2018)

1.Exchange energy

2.Anisotropy energy

3.Domain wall energy

4.magnetostrictive energy

PART- B

1. (i) What is Ferromagnetism? **April** 2002
(ii) Explain the reason for the formation of domain structure in a ferromagnetic material and how the hysteresis curve is explained on the basis of the domain theory?

2. (i) Classify the material on the basis of their spin.
(ii) What are ferromagnetic domains?
(iii) Discuss Weiss theory of ferromagnetism. **June 2009**
(iv) What are its merits and demerits?

3. (i) What are ferromagnetic domains.
(ii) Draw a B-H curve for a ferromagnetic material and identify retentivity and coercivity fields on the curve.
(iii)What is the energy loss/per cycle?

4. Discuss the domain structure in ferromagnetic materials. Show how the Hysteresis curve is explained on the basis of domain theory.

5. (i) Distinguish between Ferro, anti-Ferro and Ferrimagnetic materials. **June 2009**

6. (i) Explain the origin of ferromagnetism. **June 2010**
(ii) Discuss the Domain theory of ferromagnetism.

7. Distinguish between soft and hard magnetic materials.

8. (i) Describe the different types of polarization. **June2010**
(ii) Obtain an expression for electronic and ionic polarization in dielectrics.

9. Starting with the internal field expression, Derive Clausis-Mosotti equation. **June 2010**

10. (i) What is meant by internal field?
(ii) Obtain expression for internal field using Lorentz method. **May** 2011
(iii)The dielectric constant of water is 80. Is water a good dielectric? It is for energy storage in capacitors? Justify your answer.

11. (i) Give a detailed discussion on the various types of dielectric breakdown in dielectric materials. **June 2009**
(ii) What are the remedies to avoid breakdown mechanism?

12. What is high k-dielectric? Explain its principle.

13.describe the working of magnetic hard disc based on GMR Sensors.
Mention its advantages and disadvantages process.

UNIT-IV OPTICAL PROPERTIES OF MATERIALS

PART-A

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 types of optical materials?

Generally, optical materials are classified into three types based on the nature of propagation of light namely,

(i) Transparant
(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 whereby electrons and holes are created. The recombination is the process whereby electrons and holes are annihilated.

5. What are types of carrier generation?

(i) Photo generation
(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 exciton?

The combination of an electron in an excited state (below conduction band) and the associated hole in valence band (electron-hole pair) is known as an exciton.

8. What are the types of exciton?

Types of excitons
(i) Frenkel excitons -Strongly (tightly) bound excitons
(ii) Mott and Wannier excitons – Weakly bound excitons

9. Give the importance of excitons.

- The excitons play an important role in the luminescence of solids.
- Excitons are unstable and they will separate at high temperature.
- The exciton can move through the semiconductor and transport energy.
- The excitons does not transport any charge as it is electrically neutral.

10. What is photo diode?

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

11. 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.

12. What is solar cell?

It is a PN junction diode which converts solar energy (light energy) into electrical energy.

13. What is a photo detector?

It is a semiconductor device which is used to detect the presence of photons. This device is known as photo detector. It converts optical signals into electrical signals.

14. What are the types of photo detector?

There are three types of Photo-detectors
(i) Photo emissive
(ii) Photo conductive
(iii) Photo voltaic

15. What is a Photo conductor?

The simplest solid – state photo detector is a piece of photo conducting semiconductor. It is also called a photo resistive device.

It is based on the decrease in the resistance of certain semiconductors when they are exposed to light radiation (both infrared and visible). Such materials have a high dark resistance and low resistance on irradiation.

16. What is a photo-voltaic device?

Semiconductor junction photo diodes are called photo-voltaic devices.

17. What are types of photo-voltaic devices?

There are three Photo – voltaic devices.
1. PN Junction photo detector
2. PIN photo diode
3. Avalanche photo Diode (APD)

18. What is LED?

It is a p-n junction diode which emits light when it is forward biased.

19. 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 emit photons of energy Eg.

The forbidden gap energy is given by

$$E_g = h\nu$$

20. What are the advantages of LEDs?

- LEDs are smaller in size. A number of LEDs can be stacked together in a small space to form numerical display.
- LEDs can be turned ON and OFF in less than 1 nano second (10-9 second). So, they are known as fast devices.
- Varieties of LED's are available which emit light in different colors like red, green, yellow etc.
- Light modulation can be achieved with pulse supply.
- It has long life time.
- It has low drive voltage and low noise.
- It is easily interfaced to digital logic circuits.
- It can be operated over a wide range of temperatures.

21. What are the disadvantages of LEDs?(MAY 2018)

- They require high power.
- Their preparation cost is high when compared to LCD.

22. What are the applications uses of LEDs?

- Because of their miniature size, they are widely used in numeric and alphanumeric display devices.
- They are used as indicator lamps.
- They are used as light sources in fiber-optic communication system.
- Infrared LEDs are used in burglar alarms.
- They are used in image sensing circuits used for picture phone.

23. What is a laser diode?

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

24. What are the advantages of Laser diodes?

- This laser is very small in size and compact.
- It has high efficiency.
- The laser output can be easily increased by increasing the junction current.
- It is operated with less power than ruby and CO2 lasers.
- It requires very little additional equipment.
- It emits a continuous wave output or pulsed output.
- It emits a continuous wave output or pulsed output.

25. What are the applications of Laser diodes?

- Used in fiber optic communication.
- Used in various measuring devices such as range finders, bar-code readers.
- Used in printing industry both as light sources for scanning images and for resolution printing plate manufacturing.
- Infrared and red laser diodes are common in CD players, CD-ROM and DVD technology. Violet lasers are used in HE-DVD and Blue –ray technology.
- High power laser diodes are used in industrial applications such as heat treating, cladding seam welding and for pumping other lasers.
- Used in laser medicine especially, dentistry.

26. What are organic light emitting diodes?

Organic light emitting diodes (OLEDs) are solid state devices made up of thin films of organic molecules that produce light with the applications of electricity.

27. What are advantages of OLED?

- OLEDs are tough enough to use in portable devices such as cellular phones digital video cameras, DVD players, car audio equipment etc.,
- Can be viewed up to 160 degrees.
- High information applications including videos and graphics (Active matrix)
- OLEDs are paper-thin.
- Up to 20% to 50% cheaper than LCD processes.

- They hold the ability to handle streamlined video, which could revolutionize the display and cellular phone market.
- Takes less power.

28. What are drawbacks of OLED?

- The biggest technical problem for OLEDs is the limited lifetime of the organic materials.
- The intrusion of water into displays can damage or destroy the organic materials.
- Color- The reliability of the OLED is still not up to the mark. After a month of use the screen becomes non-uniform.

29. What are the applications of OLED?

- OLED technology is used in commercial applications such as small screens for mobile phones and portable digital audio players (MP3 players), car radios, digital cameras and high- resolution micro displays for head-mounted displays.
- They can be used in television screens, computer displays, advertising information and indication.
- OLEDs can also be used in light sources for general space illumination and large-area light-emitting elements.

30. State Quantum confined stark effect.

In quantum well structure, with the application of an electric field, the electron and hole wave functions are separated and pushed towards opposite sides of the well. The reduced overlap results in corresponding reduction in absorption.

This results in a shift of the absorption spectrum to longer wave-length (red shift). This shift is known as the quantum confined Stark effect.

31. What is a quantum dot?

Quantum dots are tiny particles or nano crystals of a semiconducting material with diameters in the range of 2-10 nanometers (10-50 atoms).

32. What are quantum dot lasers?

They are the new generation semiconductor lasers. They consist of several million nano-sized crystals called quantum dots in the active region and they act as light emitters.

33. What are the advantages of quantum dot laser?

- High gain as well as high differential gain due to high density of states in the discrete levels.
- Low threshold current density Jth and large output power at much lower power consumption.
- Higher modulation frequency for high speed operation with reduced wavelength shift.
- High temperature stability.

34. What are the drawbacks of QD lasers?

- Fabrication process is complicated leading to non-homogenous in size and shape of the QDs.
- High material gain but low optical confinement factor leads to low modal gain.
- There is a carrier leakage out of the QD due to finite barrier height.
- Strained wells might lead to shift in wavelength.

35.What is recombination process in Semiconductors.(MAY2018)

Recombination is simply the process of converting free electrons in to valence electrons. When an electron moves from the conduction band to the valance band an empty place or hole in the valence band is occupied. Here an electron travelled from the higher energy state to lower energy state some amount of energy is emitted as heat. So when ever free electrons come to fill up with hole the process is called as the recombination process.

PART-B

1. Explain scattering of light in solids.
2. Describe absorption and emission of light in metal, insulator and semiconductor.(MAY 2018)
3. Explain carrier generation and recombination in semiconductor.
4. Describe excitons with example.
5. Describe the construction and working of photodiode.
6. Explain the construction and working of a solar cell.
7. Describe the construction and working of photo detector.
8. Explain the construction and working of a LED with energy band diagram. **May 2003**
9. Describe the construction and working of laser diodes. What are the advantages of these diodes?
10. What is OLED? Explain the basic concept of OLED, types, advantages, disadvantages and application.(MAY2018)
11. Explain quantum-confined stark effect.
12. Explain quantum dot lasers. What are their applications and advantages?

UNIT – V NANOELECTRONIC DEVICES

PART – A

1. What is meant by bottom-up approach in constructing Nanomaterials?

In the "bottom up" approach, materials and devices are built from molecular components which assemble themselves chemically by principles of molecular recognition. These seek to arrange smaller components into more complex assemblies.

2. What is meant by top-down approach in constructing Nanomaterials?

In the "top-down" approach,nano-objects are constructed from larger entities without atomic-level control. These seek to create smaller devices by using larger ones to direct their assembly.

3. Define nano materials.

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

4. Define density of states. (May 2018)

Electron density is the number of electrons per unit volume in a material. It is determined by using density of states.

5. Define Fermi energy.

It is defined as the highest energy level occupied by the electron at 0K in metal.

6. What is quantum confinement?

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

7. What is quantum structure?

When a bulk material is reduced in its size, atleast one of its dimensions, in the order of few nanometers, then the structure is known as quantum structure.

8. Define Zener-Bloch oscillation.

It denotes the oscillation of a particle (e.g. an electron) confined in a periodic potential when a constant force is acting on it.

9. What is resonant tunneling?

The transmission probability of the double symmetric barrier is maximum and hence the tunneling current reaches peak value when energy of electron wave is equal to quantized energy state of the well.

This phenomenon is known as resonance tunneling.

10. What is a single electron phenomenon?

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.

11. Define Coulomb-Blockade effect.

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

12. What is the condition for Coulomb-Blockade effect?

If two or more charges near one another, they exert coulomb forces upon each other. If two charges are the same kind, the force is repulsive. Therefore, the condition for observing coulomb blockade effects is expressed as

$$W_c = e^2/2C >> Kt$$

Where C - capacitance of the quantum dot

T - Temperature of the system

Wc - Charging energy and this is the energy needed to add one negatively Charged Electron to the dot

13. What is single electron tunneling?

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

14. What is a Single Electron Transistor?

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

15. What are the advantages of single electron transistor?

- The fast information transfer velocity between cells (almost near optic velocity) is carried on via electrostatic interactions only.
- No wire is needed between arrays. The size of reach cell can be as small as 2.5 nm. This made them very suitable for high density memory.

- This can be used for the next generation quantum computer.

16. What are the limitations of single electron transistor?

- In order to operate SET circuit at room temperature, the size of the quantum dot should be smaller than 10 nm.
- It is very hard to fabricate by traditional optical lithography and semiconductor process.
- The methods must be developed for connecting the individual structures into logic circuits and these circuits must be arranged into larger 2D patterns.

17. What are the applications of single electron Transistor?

- A variety of digital logic function, including AND or NOR gates, is obtained based on SET operating at room temperature.
- It is used for mass data storage.
- IT is used in highly sensitive electrometer.
- SET can be used as a temperature probe, particularly in the range of very low temperatures.
- SET is a suitable measurement set-up for single electron spectroscopy.
- It is used for the fabrication of a homo-dye receiver operating at frequencies between 10 and 300 MHz.

18. What is mesoscopic structure?

The structures which have a size between the macroscopic world and the microscopic or atomic one are called mesoscopic structure.

19. What is conductance fluctuation?

Conductance (reciprocal of resistance) fluctuation in quantum physics is a phenomenon exhibited in electrical transport experiment in mesoscopic system.

20. What is quantum interference effect?

It states that much like waves in classical physics, any two (or more) quantum states can be added together ("superposed") and the result will be another valid quantum state.

21. What are the applications of quantum interference effect?

Quantum interference effect is being applied in a growing number of applications, such as the

- Superconducting Quantum Interference Device (SQUID).
- Quantum cryptography
- Quantum computing and quantum interference transistor.

22. What are magnetic semiconductors?

The semiconducting materials which exhibit both ferromagnetism and useful semiconductor properties are known as magnetic semiconductors.

23. Give the examples for dilute magnetic semiconductor.

Oxide semiconductors:

- Zinc oxide
- Manganese-doped zinc oxide
- n-type cobalt-doped zinc oxide

Magnesium oxide:

- p-type transparent MgO films with cation vacancies

Titanium dioxide:

- Cobalt-doped titanium dioxide
- Iron-doped titanium dioxide
- Chromium-doped titanium dioxide
- Copper-doped titanium dioxide
- Nickel-doped titanium dioxide

24. What is spintronics?(MAY 2018)

The 'Spin' of the electron can be used rather than its charge to create a remarkable new generation of 'spintronic' devices. These are smaller, more versatile and more robust than those currently making up silicon chips and circuit elements.

25. What is a carbon nano tube?

The carbon nano tubes are the wires of pure carbon like rolled sheets of graphite or like soda straws.

26. What are the types of carbon nano tube structure?

Three types of nano tube structures are considered by rolling a graphite sheet with different orientations about the axis.

They are (i) Armchair structure
(ii) Zig-zag structure
(iii) Chiral structure

27. How carbon nano tubes are classified.

Based on the number of layers, the carbon nano tubes are classified as
(i) Single-walled (SWNTs)
(ii) Multi-walled (MWNTs)
In multi walled nano tubes, more than one CNT are coaxially arranged.

28. Mention any two properties of carbon nano tubes.

- Carbon nano tubes are metallic or semiconducting depending on the diameter and chirality (i.e., how the tubes are rolled).
- The energy gap also varies along the tube axis and reaches a minimum value at the tube ends.
- The strength of the carbon-carbon bond is very high therefore any structures based on aligned carbon-carbon bonds will ultimately have high strength.
- One of the important properties of nano tubes is their ability to withstand extreme strain.
- Nano tubes have a high thermal conductivity and the value increased with decrease in diameter.

29. Write down any two applications of carbon nano tube.

- The unusual properties of carbon nano tubes have many applications such as battery electrodes, electronic devices and reinforcing fibers for stronger composites etc.
- Carbon nano tubes can be used to make a computer switching device.
- Carbon nano tubes have many applications in battery technology. Lithium which is a charge carrier in some batteries can be stored inside nano tube.
- Carbon nano tube can be used for storing the hydrogen which is used in the development of fuel cells.

- A plastic composite of carbon nano tubes provides light weight shielding material for electromagnetic radiation.
- Nano tunes act as catalysts for some chemical reactions.

30. Define the term Quantum well and Quantum wire. (MAY 2018)

Quantum well: An electrically isolated region, like a thin film, where electrons are constrained in one dimensional and exhibiting quantum behavior is called as a quatum well.

Quantum well: An electrically isolated region , like a nano tube and wire, where electrons are constrained in two dimensional and exhibiting quantum behavior is called as a quatum wire.

PART- B

1. Explain the electron density in bulk material and size dependence of Fermi energy.
2. Explain quantum confinement and quantum structures in Nano material.
3. Discuss density of states in quantum well, quantum wire and quantum dot structure.
4. Write note on Zener-Block oscillations resonant tunneling quantum interference effect.
5. Write note on mesoscopic structure, conductance fluctuations and coherent transport.
6. Explain coulomb blockade effect and single electron phenomena.
7. Describe construction and working of single electron transistor.
8. Write note on magnetic semiconductor.
9. Discuss on spintronics and also on spin based Field Effect Transistor.
10. Describe the carbon nano tubes with properties and applications.
11. Discuss in detail quantum confinement and quantum structures in nano materials.
12.Write a note on CNT.(MAY 2018)

Prepared by
Mrs.J.Sivasankari

Approved by

HOD/Physics