**Physics for Information Science - PH3256**

**PART-A**

**Unit-I Electrical Properties of Materials**

1.What are the merits of classical free electron theory?

(i)It is used to verify Ohm’slaw.

(ii)It is used to explain electrical and thermal conductivities of metals.

(iv) It is used to derive Wiedemann –Franz law.

2.What are the drawbacks of classical free electron theory?

(i) Classical theory states that all free electrons will absorb the supplied

energy; on the contrary, quantum theory states that only a few electrons will

absorb the supplied energy.

(ii) Electrical conductivity of semiconductors and insulators (non –metal)

could not be explained by this theory.

(iii) The phenomena such as photo –electric effect, Compton effect and black

body radiation could not be explained on the basis of this theory because these

phenomena are based on quantum theory.

3. Define mean free path.

The average distance traveled by a free electron between any two

successive collisions in the presence of an applied field is known as mean free

path. It is the product of drift velocity of the electron (vd) and collision time (τ)

λ= vd ×τc

4. Define relaxation time of an electron.

The average time taken by a free electron to reach its equilibrium position

from its disturbed position due to application of an external electrical field is

called relaxation time.

5. 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 vd..

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

(10

5 m/s), but the drift velocity is unidirectional and its value is very small (50

cm/s).

6. Define mobility of electrons.

The magnitude of the drift velocity per unit electric field is defined asthe

mobility of electrons (μ)

i.e., μ= vd/E

Where vd→ drift velocity of electrons E→ lectricalE field.

7. Define electrical conductivity.

It is the amount of electrical charge (q) conducted per unit time (t) across

unit area (A) of the solid per unit applied electrical field (E).

σ= q/tAE

8. State Wiedemann –Franz law.

It states that the ratio of thermal conductivity (K) to electrical conductivity

(σ)ofa metal is directly proportional to absolute temperature (T) and this ratio is

constant for all metals at a given temperature.

K/ σ∞T i.e., K/ σ= LT

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

9. What is Lorentz number?

ratio between thermal conductivity (K) of a metal to the product of electrical

conductivity (σ)ofa metal and absolute temperature (T) of the metal is a constant. It is

called Lorentz number and it is given by

L =K/σT

10. Define Fermi distribution function.

The probability F (E) of an electron occupying a given energy level at temperature

T is known as Fermi distribution function. It is given by

E →Energy of the level whose occupancy is being considered.

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

Fermi level 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 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 occupying a given energy level at a given temperature.

12. 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.

UNIT II

SEMICONDUCTOR PHYSICS

1. What are elemental semiconductors? Give some important elemental

semiconductors.

Elemental semiconductors are made from single element of the forthgroup

elements of the periodic table.

It is also known as indirect band gap semiconductor.

Example: Important elemental semiconductors germanium and silicon.

2. What are the properties of semiconductors?

(i) They are formed by covalent bond.

(ii) They have empty conductionband.

(iii) They have almost filled valance band.

(iv) These materials have comparatively narrow energy gap.

3. Mention any four advantages of semiconducting materials.

(i) It can behave as insulators at 0K and as conductors at high temperature.

(ii) It possess some properties of both conductors and insulators.

(iii)On doping we can produce both N and P-type Semiconductors withcharge

carriers of electrons and holes respectively.

(iv) It possess many applications in electronic field such as manufacturingof

diodes, transistors, LED’s,IC etc.

4. What are compound semiconductors? Give some important

compound semiconductors.

Semiconductors which are formed by combining third and fifth elements

or second and sixth group elements in the periodic table are called compound

semiconductors.

6. What is Fermi level in a semiconductor?

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.

7. Define Hall-effect and Hall voltage.

When a conductor (metal or semiconductor) carrying a current (I) is placed

in a transverse magnetic field (B),a potential difference (electric field) is

produced inside the conductor in a direction normal to the directions of both the

current and magnetic field.

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

called Hall-voltage.

Hall field per unit current density per unit magnetic induction is called hall

coefficient.

8. Mention the applications of Hall Effect.

It is used to,

i. Find type of semiconductor.

ii. Measure carrier concentration.

iii. Find mobility of chargecarrier.

iv. Measure the magnetic flux density using a semiconductor sample of

known Hall coefficient.

10. What is an intrinsic semiconductor?

Semiconductor in an extremely pure form (without impurities) is known as

intrinsic semiconductor.

11. 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.

13. 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.

14. What is a p-type semiconductor?

When a small amount of trivalent impurity is added to a pure

semiconductor, it becomes extrinsic or impure semiconductor and it is called p-

type semiconductor.

15. What is meant 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.

16. What is meant 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.

17. What is meant 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.

**UNIT III**

**MAGNETIC PROPERTIES OF MATERIALS**

1. On the basic of spin how the materials are classified as para, ferro,

antiferro and ferrimagnetic.

(i)Paramagnetic materials have few unpaired electron spins of equal magnitudes.

(ii)Ferro magnetic materials have many unpaired electron spins with equal

magnitudes.

(iii) Anti ferro magnetic materials have equal magnitude of spins but in

antiparallel manner.

(iv)Ferrimagnetic materials have spins in antiparallel manner but with unequal

magnitues.

2. What is Bohr magneton?

The orbital magnetic moment and the spin magnetic moment of an electron

in an atom can be expressed in terms of atomic unit of magnetic moment

called Bohr magneton.

3 What is ferromagnetism?

Certain materials like iron (Fe), Cobalt (Co), Nickel (Ni) and certain

alloys exhibitSpontaneous magnetization ie., they have a small amount of

magnetization (atomic moments are aligned) even in the absence of an external

magnetic field.This phenomenon is known as ferromagnetism.

7. Mention the energies involved in origin of domains in ferromagnetic

material.

(i) Magnetostatic energy

(ii) Crystalline energy

(iii) Domain wall energy

(iv)Magnetostriction energy

8. What is antiferromagnetism?

In anti-ferromagnetism, electron spin of neighbouring atoms are aligned

antiparallel. Anti-ferromagnetic susceptibility is small and positive and it

depends greatly on temperature.

9. What are ferrites and mention its types.

Ferrites are modified structure of iron with no carbon and in which the adjacent

magnetic moments are of unequal magnitudes aligned in antiparallel direction.

Its general formula is given by X2+ Fe23+ O42-.

Types: normally there are two types of structure. 1. Regular spinel 2. Inverse

spinel.

5. What are the properties of ferromagnetic materials?

(i) All the dipoles are aligned parallel to each other due to the magnetic

interaction between any two dipoles.

(ii) They have permanent dipole moment. They attract the magnetic field

strongly.

(iii) They exhibit magnetisation even in the absence of magnetic field. This

property of ferromagnetic materials is called as spontaneous magnetization.

6. What is domain theory of ferromagnetism?

According to domain theory, a virgin specimen of ferromagnetic materials

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.

10. State the applications of ferrites.

(i)They are used in transformer cores for high frequencies upto

microwaves.

(ii) They are used in ratio receivers to increase the sensitivity and

selectivity of the receiver.

(iii) Ferrites are used in digital computers and data processing circuits as

magnetic storage elements.

(iv) They are used as an isolator, gyrator and circulator which are used

in microwave devices.

11. What is hysteresis in magnetic materials?

The lagging of magnetic induction (B) behind the applied field strength (H)

is called hysteresis.

12. What is meant by hysteresis loss?

When the specimen is taken through a cycle of magnetization, there is a loss of

energy in the form of heat. This is known as hysteresis loss

13. What are soft- magnetic materials?

Materials which are easy to magnetize and demagnetize are called soft

magnetic materials.

14. State the properties of soft magnetic materials.

(i)They have high permeability

(ii)They have low coercive force.

(iii) They have low hysteresis loss.

17. State the properties of hard magnetic materials.

They possess high value of B-H product

They have high retentivity

They have high coercivity

They have low permeability.

28. What are properties of paramagnetic materials?

(i) Paramagnetic materials attract the magnetic lines of force.

(ii)They possess permanent dipole moment.

(iii) The susceptibility is positive

**UNIT IV**

**OPTICAL PROPERTIES OF MATERIALS**

1. Give four applications of fiber optic sensors.

 Fiber optic sensors are used as optical displacement sensors, which

is used to find the displacement of a target along with its position.

 It is used as fluid level detector.

 It is used to sense the pressure, temperature at any environment.

 It is also used to measure the number of rotations of the fiber coilusing

the instrument called a gyroscope.

2. Explain the basic principle of fiber optic communication

Total internal reflection is the principle of fiber opticcommunication.

Principle:

When light travels from a denser to rarer medium, at a particular

angle of incidence called the critical angle, the ray emerges along the

surface of separation. When the angle of incidence exceeds the critical

angle, the incident ray is reflected in the same medium and this

phenomenon is called the total internal reflection.

3. Give the application of fiber optical system.

 It can be used for long distance communication in trunk lines.

 A large no of telephone signals nearly 15000 can be passed through

the optical fibers in a particular time without any interference.

 It is used in computer networks especially in LAN.

 It is also used as optical sensor.

4. Mention any four advantages of LED in electronic display.

 Very small in size.

 Different colours of display.

 Works under a wide range of temperature.

 It is a very wide range of operation.

5. Mention any four advantages of fiber optic sensors.

 It has no external interference

 It is used in remote sensing.

 Safety of data transfer.

 It is small in size.

6. Mention any two fiber optic sources.

 Light emitting diode (LED) in LED we have two types

1.planar 2.dome shaped LED.

 Laser diodes (LD). In laser diodes we have homojunctionlaser

heterojunction laser injection laser diode etc.

7. What is meant by injection luminescence? Give examples.

When the majority careers are injected from P to N and N to P

region, they become excess minority carriers. Then this excess minority

carrier diffuses away from the junction and recombines with the majority

carriers in P and N region and emits light. This phenomenon is known as

injection luminescence.

8. What is meant by LED? Give its principle.

An LED is the abbreviation of light emitting diode. It is a

semiconductor P N junction diode which converts electrical energy to light

energy under forward biasing.

9. What is the principle used in PIN photodiode?

This diode works in reverse bias. Under reverse bias when light is

made to fall on the neutral or intrinsic region electron hole pairs are

generated. These electrons and holes are accelerated by the external electric

field, which results in photo current. Thus light is converted into

electricalsignal.

10. Give any four examples of intrinsic sensor.

 Pressure sensor

 Liquid level sensor

 Phase and polarization sensor.

 Optical fiber flow sensor.

11. State the applications optical fibers in medical field.

 Fiber optics endoscopes are used in medical diagnosis

 It is used to visualize the inner organs of the body

 Fibers as endoscopes are used in various medical fields such as

cardioscopy, laparoscopy, cryoscopy etc.

12. What is meant by attenuation?

It is defined as the ratio of the optical power (Pout) from a fiber of length

‘L’ tothe power input (Pin).

13. Mention the advantages of optical fiber communication over radio wave

communication.

 Optical communication can be made even in the absence of

electricity

 The optical signals are not affected by any electrical signals or

lightening

 Optical fiber communication is free from electromagnetic

interference(EMI)

 This type of communication is suitable to any environmental

conditions

 Easy maintenance, longer life, economical and high quality signal

transmission are the additional features of optical fiber

communication.

14. What are the losses that occur during optical fiber communication?

1. During the transmission of light through the optical fiber,

threemajor losses will occur, viz., attenuation, distortion, and dispersion.

2. Attenuation is mainly caused due to absorption, scattering and

radiation of light inside the fibers.

3. Distortion and dispersion occurs due to spreading of light and

alsodue to manufacturing the defects.

15. What are the conditions of Total Internal reflection?

a) Light should travel from denser medium to rarer medium

b) The angle of incidence(Ф) on core should be greater than critical

angle (Фc) Ф> Фc

c) The refractive index of the core (n1) should be greater than the

refractive index of the cladding (n2).

n1 > n2

**UNIT V**

**NANO DEVICES**

1. What are metallic glasses?

Metallic glasses are the newly developed engineering materials which

shar es the properties of both metals and glasses. They are glasses having

metallic properties.

2. What are the types of metallic glasses and mention few metallic glasses.

There are two types of metallic glasses, they are

i. Metal –Metalloid metallic glasses

ii. Metal –Metal metallic glasses

Metal –Metalloid metallic glasses

(Fe, Co, Ni) Metal –(B, Si, C, P)

Metalloid Metal –Metal metallic glasses

Nickel –niobium (Ni –Nb)

3. State the structural properties of metallic glasses.

i. They do not have any crystal defects such as grain boundaries

dislocation etc

ii. Metallic glasses have tetrahedral close packing (TCP) in contrastto

hexagonal close packing(HCP) of the crystalline solid.

4. What are the mechanical properties of metallic glasses?

i. Extremely high strength due the absence of point defects,

dislocation and slip plane.

ii. They have high elasticity.

iii. They are highly ductile

5. What are the electrical properties of metallic glasses?

i. Electrical resistively of metallic glasses is high (> 100μcm)Ωandit

does not vary much with temperature.

ii. Due to high resistivity, the eddy current loss is very small.

6. What are the magnetic properties of metallic glasses?

i. Metallic glasses have both soft magnetic and hard magnetic properties.

ii. They exhibit high saturation magnetization.

iii. The core losses of metallic glasses are very less.

7. What are the chemical properties of metallic glasses?

i. They are highly resistant to corrosion due to the formationof

protective oxide film in chromium containing glasses.

ii. They are highly reactive and stable.

8. What are the applications of metallic glasses?

i. Metallic glasses possess high tensile strength. They are superior than

common steels. This makes them useful as reinforcing elements in concrete,

plastic or rubber.

ii. Due to their high strength, high ductility, rollability and good corrosion

resistance, they are used to make razor blades. This fact is also utilized to

make different kinds of springs.

9.What are the advantages of using metallic glasses as transformer core

material?

Metallic glasses are ferromagnetic. They possess low magnetic losses, high

permeability and saturation magnetization with low coactivity. They also have

extreme mechanical hardness and excellent initial permeability.

10. What are shape memory alloys?

The group of metallic alloys which demonstrate the ability to return to their

original shape or size (i.e., the alloy appears to have memory) when subjected to

the appropriate thermal procedure (heating/cooling) is called Shape Memory

Alloys (SMAs).

11. What is shape memory effect?

Certain metallic alloys like alloy of gold (Au) and Cadmium (Cd) exhibit

a plastic nature, when cooled to a lower temperature. The return to their original

dimensional configuration (metallic) during heating at high temperature. This

effect is called Shape Memory Effect (SME).

12. What are the properties of shape memory alloys?

i. They can exist in two different solid phases with distinct crystal

structures in SMA.

ii. If temperature is increased, material goes to austenite phase which

has cubic crystal structure and on cooling; the material comes back

to its original shape in the martensite phase.

iii. SMAs exhibit changes in electrical resistance, volume and length

during the transformation with temperature.

iv. They are extremely elastic or exhibit pseudo elasticity, i.e., strain

can be very large for a given stress in the martensite phase.

v. SMAs exhibit self-healing effect.

13. What are the applications of shape memory alloys?

i. Shape memory alloys can act as actuators and sensors.

ii. Fiber composite shape memory alloys are used to produce twist on the

helicopter blades.

iii. They are used in orthopaedic devicesfor pulling fractures together,

artificial hearts and shrink-wrap.

14. What is glass transition temperature?

The temperature at which the transition from liquid (metallic liquid) to solid

(glass) occurs is known as the glass transition temperature.

15. What are nano phase materials?

Nanophase materials or nanaomaterials are newly developed materials with

grain size at the nanometer range (10

-9

), i.e., in the order of 1 –100 nm. The

particle size in a nano materials is 1 nm.

16. Mention different forms of nanomaterials.

Nanodots, nanorods, Carbon nanotubes and Fullerenes.

17.What are two routes through which nano particles can be

synthesized?

(i)Top down approach: involving breaking down bulk materials to

nanosizes. Example:Mechanical alloying

(ii)Bottom up approach: where the nano particles are made by building

atom by atom.

Example: Inert gas condensation

18. Mention few techniques for synthesis of nano phase materials.

i) Mechanical

ii) Inert gas condensation alloying

iii) Sol-gel technique

iv) Electro-depostion

v) Laser synthesis

vi) Spraying

19. What are physical properties of nanomaterials?

Melting point reduces with decrease in cluster size.

Interparticle spacing decreases with decreases in grain size for metal clusters.

Ionization potential changes with cluster size of the nano grains.

Greater luminescence efficiency in nano semiconductor materials.

20. What are mechanical properties of nanomaterials?

Higher hardness and mechanical strength (2-7 times) when grain size reduces

from 1 μm to 10 nm.

Higher moduli of elasticity (30%-40%)

Very high ductility and super plastic behavior at low temperatures.

21. What are magnetic properties of nanomaterials?

Non-magnetic materials become magnetic when the cluster size reduces

to 80 atoms. Bulk magnetic moment increases with decreases in coordination

number Ferro magnetic materials exhibit superparamagnetism at nanograin sizes.

Paramagnetic materials exhibit ferromagnetism at nano grain size.

22. What is non-linear optics?

The field of optics dealing with the non-linear behavior of optical materials.

23. Name few non-linear optical phenomena.

The few of the nonlinear phenomena observed are

1. Second harmonic generation

2. Optical

3. mixing

4. Optical phase conjugation

5. Soliton