TYPICAL QUESTIONS & ANSWERS

PART – I

OBJECTIVE TYPES QUESTIONS

Each Question carries 2 marks.

Choose correct or the best alternative in the following:

Q.1 Materials which can store electrical energy are called
- **(A)** magnetic materials.
- **(B)** semi conductors.
- **(C)** dielectric materials.
- **(D)** super conductors.

Ans: C

Q.2 ACSR (Aluminium Conductor Steel Reinforced) are used as
- **(A)** over head transmission lines.
- **(B)** super conductors.
- **(C)** fuse
- **(D)** underground cables.

Ans: A

Q.3 Brass is an alloy of
- **(A)** copper and zinc.
- **(B)** copper and iron.
- **(C)** copper and Aluminium.
- **(D)** copper and tin.

Ans: A

Q.4 Property of material which allows it to be drawn out into wires is
- **(A)** Ductility.
- **(B)** Solder ability.
- **(C)** Super conductivity.
- **(D)** Malleability.

Ans: A

Q.5 In n type semi conductor added impurity is
- **(A)** pentavalent.
- **(B)** divalent.
- **(C)** tetravalent.
- **(D)** trivalent.

Ans: **A**

Q.6 The covers of electrical machines are made of
- **(A)** soft magnetic materials.
- **(B)** hard magnetic materials.
- **(C)** super conductors.
- **(D)** semiconductors.

Ans: A

Q.7 The dielectric constant of air is practically taken as
- **(A)** more than unity.
- **(B)** unity.

(C) less than unity. (D) zero.

Ans: B

Q.8 n-type semiconductor is an example of

(A) extrinsic semiconductor. **(B)** intrinsic semiconductor.
(C) super conductor. **(D)** insulators..

Ans: A

Q.9 Atomic weight of an atom is

(A) sum of the number of protons and neutrons.
(B) sum of the number of protons and electrons.
(C) sum of the number of electrons and neutrons.
(D) sum of the number of electrons, protons and neutrons.

Ans: A

Q.10 Gold and silver are

(A) dielectric materials
(B) low resistivity conducting materials.
(C) magnetic materials.
(D) insulating materials.

Ans: B

Q.11 Phenol and Formaldehyde are polymerised to a resultant product known as

(A) PVC. **(B)** bakelite.
(C) polyester. **(D)** teflon.

Ans: B

Q.12 Dielectric materials are

(A) Insulating materials. **(B)** Semiconducting materials.
(C) Magnetic materials. **(D)** Ferroelectric materials.

Ans: A

Q.13 Thermocouples are used for the measurement of

(A) humidity. **(B)** pressure.
(C) temperature. **(D)** density.

Ans: C

Q.14 Large scale integration chips have between

(A) Less than 10 components. **(B)** 10 and 100 components.
(C) 100 and 1000 components. **(D)** More than 1000 components.

Ans: C

Q.15 All semiconductors in their last orbit have

(A) 8 electrons. **(B)** 2 electrons.
(C) 4 electrons. **(D)** 6 electrons.

Ans: C

Q.16 The material with lowest resistivity is

(A) constantan. **(B)** silver.
(C) manganin. **(D)** nichrome.

Ans: B

Q.17 The property due to which the resistance of some metal or compound vanishes under certain conditions is

(A) Semi conductivity. **(B)** Super conductivity.
(C) Curie point. **(D)** Magnetostriction.

Ans: B

Q.18 Bronze is an alloy of

(A) copper. **(B)** aluminium.
(C) silver. **(D)** carbon.

Ans: A

Q.19 Ceramics are good

(A) insulators. **(B)** conductors.
(C) superconductors. **(D)** semiconductors.

Ans: A

Q.20 The critical temperature above which the ferromagnetic materials loose their magnetic property is known as

(A) hysterisis. **(B)** Curie point.
(C) transition temperature. **(D)** standard temperature.

Ans: B

Q.21 Permanent magnets are made of

(A) soft magnetic materials. **(B)** hard magnetic materials.
(C) semi conductors. **(D)** super conductors.

Ans: B

Q.22 Holes are majority carriers in

(A) P-type semiconductors. **(B)** N-type semiconductors.
(C) Insulators. **(D)** Superconductors.

Ans: A

Q.23 Materials, which provide a path to the magnetic flux, are classified as

(A) insulating materials. **(B)** semi conducting materials.
(C) magnetic materials. **(D)** dielectric materials.

Ans: C

Q.24 Germanium possesses

(A) one valence electrons. **(B)** two valence electrons.
(C) three valence electrons. **(D)** four valence electrons.

Ans: D

Q.25 Dielectric constant of vacuum is

(A) infinity. **(B)** 100.
(C) one. **(D)** zero.

Ans: C

Q.26 Ferrites are

(A) ferromagnetic material. **(B)** ferrimagnetic materials.
(C) anti ferromagnetic material. **(D)** diamagnetic materials.

Ans: A

Q.27 The relative permeability of a paramagnetic substance is

(A) unity. **(B)** slightly more than unity.
(C) zero. **(D)** less than unity.

Ans: B

Q.28 Hall effect may be used for which of the following?

(A) determining whether the semiconductor is p or n type.
(B) determining the carrier concentration.
(C) calculating the mobility.
(D) All the above.

Ans: D Determining whether the semiconductor is p or n type, determining the carrier concentration, calculating the mobility.

Q.29 Manganin is an alloy of

(A) copper, manganese and nickel. **(B)** copper and manganese.
(C) manganese and nickel. **(D)** manganese, aluminium and nickel.

Ans: A

Q.30 Eddy current loss is proportional to the

(A) frequency. (B) square of the frequency.
(C) cube of the frequency. (D) square-root of the frequency.

Ans: B

Q.31 A pure semiconductor under ordinary conditions behaves like
(A) a conductor. (B) an insulator.
(C) a magnetic material. (D) a ferro-electric material.

Ans: B

Q.32 In p-type semiconductor the majority carriers are
(A) holes. (B) electrons.
(C) positive ions. (D) negative ions.

Ans: A

Q.33 Copper is completely miscible with
(A) nickel. (B) gold.
(C) hydrogen. (D) lead.

Ans: B

Q.34 For germanium the forbidden gap is
(A) 0.15ev. (B) 0.25ev.
(C) 0.5ev. (D) 0.7ev.

Ans: D

Q.35 The dielectric strength of transformer oil should be
(A) 100 V. (B) 5 KV.
(C) 30 KV. (D) 132 KV.

Ans: C

Q.36 Resistivity of conductors is most affected by
(A) composition. (B) temperature.
(C) pressure. (D) current.

Ans: B

Q.37 Copper constantan is used for measuring temperature upto
(A) $1400^\circ C$. (B) $1100^\circ C$.
(C) $800^\circ C$. (D) $400^\circ C$.

Ans: D

Q.38 Mica is a

(A) Dielectric material. (B) Insulating material.
(C) Magnetic material. (D) Both insulating and dielectric material.

Ans: D

Q.39 The conductivity of copper is less than that of silver by
(A) 5 – 10 %. (B) 50 – 60 %.
(C) 80 – 90 %. (D) 20 – 30 %.

Ans: A

Q.40 A ferrite core has less eddy current loss than an iron core because ferrites have
(A) High resistance. (B) Low resistance.
(C) Low permeability. (D) High hysteresis.

Ans: A

Q.41 Transformer cores are laminated with
(A) Low carbon steel. (B) Silicon sheet steel.
(C) Nickel alloy steel. (D) Chromium sheet steel.

Ans: B

Q.42 For silicon the forbidden gap is
(A) 1.1ev. (B) 0.25ev.
(C) 0.5ev. (D) 0.7ev.

Ans: A

Q.43 Plastics are
(A) Good conductors of heat. (B) Good conductors of electricity.
(C) Bad conductors of electricity. (D) High density.

Ans: C

Q.44 In order to obtain p-type germanium it should be doped with a
(A) Trivalent impurity. (B) Tetravalent impurity.
(C) Pentavalent impurity. (D) Any of the above will do.

Ans: A

Q.45 Barrier potential in a P-N junction is caused by
(A) Thermally generated electrons and holes.
(B) Diffusion of majority carriers across the junction.
(C) Migration of minority carriers across the junction.
(D) Flow of drift current.

Ans: B

Q.46 The heating elements of electric irons are made of
(A) Copper. **(B)** Nichrome.
(C) Constantan. **(D)** Aluminium.

Ans: B

Q.47 The most malleable, ductile low resistivity material is
(A) Copper. **(B)** Aluminium.
(C) Silver. **(D)** Iron.

Ans: C

Q.48 The percentage of carbon in mild steel is
(A) 0.08 to 0.3 % **(B)** 0.5 to 1.4 %
(D) 2.35 % **(D)** 0.5 %

Ans: A

Q.49 Aluminium is
(A) Silvery white in colour. **(B)** Yellow in colour.
(C) Reddish in colour. **(D)** Pale yellow in colour.

Ans: A

Q.50 Hard ferrites are used for making
(A) Transformer cores. **(B)** Electrical machinery.
(C) High frequency equipment. **(D)** Light weight permanent magnets.

Ans: D

Q.51 The main constituents of glass is
(A) SiO_2 **(B)** B_2O_3
(C) Al_2O_3 **(D)** Cr_2O_3

Ans: A

Q.52 Micanite is a form of
(A) Built up mica.
(B) Hydrated potassium aluminium silicate.
(C) Magnesium mica.
(D) Calcium mica.

Ans: A

Q.53 What is the type of bonding in silicon?
(A) Ionic. **(B)** Covalent.
(C) Metallic. **(D)** Ionic + Metallic

Ans: B

Q.54 P-N junction is
(A) a rectifier. **(B)** an amplifier.
(C) an Oscillator. **(D)** a Coupler.

Ans: A

Q.55 The conductivity of an extrinsic semiconductor
(A) decreases with temperature.
(B) increases with temperature.
(C) remains constant with temperature.
(D) decreases and then increases with temperature.

Ans: B

Q.56 When a semiconductor is doped with a P-type impurity, each impurity atom will
(A) acquire negative charge. **(B)** acquire positive charge.
(C) remain electrically neutral. **(D)** give away one electron.

Ans: A

Q.57 Number of Terminals in a MOSFET are
(A) Two **(B)** Three
(C) Four **(D)** Five

Ans: B

Q.58 Which of the following material has the highest melting point
(A) Copper. **(B)** Aluminium.
(C) Tungsten. **(D)** Gold.

Ans: C

Q.59 Bronze is an alloy of
(A) Copper and Tin. **(B)** Copper and Steel.
(C) Copper and Mercury. **(D)** Copper and Aluminium.

Ans: A

Q.60 A transistor has
(A) One p-n junction. **(B)** Two p-n junction.
(C) Four p-n junction. **(D)** Five p-n junction.

Ans: B

Q.61 Example of high resistivity material is
(A) Nichrome **(B)** Silver
(C) Gold **(D)** Copper

Ans: A

Q.62 Hard magnetic materials are used for making

(A) Permanent magnets. **(B)** Temporary magnets.
(C) Conductors. **(D)** Insulator.

Ans: A

Q.63 Hall effect is associated with

(A) Conductors. **(B)** Semiconductors.
(C) Thermistors. **(D)** Solders.

Ans: B

Q.64 Addition of trivalent impurity to a semiconductor creates many

(A) holes. **(B)** free electrons.
(C) valance electrons. **(D)** bound electrons.

Ans: B

Q.65 Magnetic materials

(A) provide path to magnetic flux. **(B)** are good insulators.
(C) are semiconductors. **(D)** None.

Ans: A

Q.66 In a ferromagnetic material the state of flux density is as follows when external magnetic field is applied to it.

(A) Increased **(B)** Decreased
(C) Remains unchanged **(D)** Becomes zero

Ans: C

Q.67 Paper is hygroscopic and absorbent.

(A) True **(B)** False

Ans: A

Q.68 Insulators have

(A) A full valence band. **(B)** An empty conduction band.
(C) A large energy gap. **(D)** All the above.

Ans: C

Q.69 Hysteresis loss least depends on

(A) Frequency. **(B)** Magnetic field intensity.
(C) Volume of the material. **(D)** Grain orientation of material.

Ans: D

Q.70 Atoms with four valence electrons are good conductors.

(A) True **(B)** False

Ans: B

Q.71 Semi-conductors have ________ temperature coefficient of resistance.
(A) Negative **(B)** Positive
(C) Both positive and negative **(D)** None of the above

Ans: A

Q.72 Tick off the material, which is different from the group
(A) Constantan. **(B)** Manganin.
(C) Nichrome. **(D)** Brass.

Ans: D

Q.73 Tick of the property, which is different from the group
(A) Ductility. **(B)** Resistivity.
(C) Tensile strength. **(D)** Hardness.

Ans: B

Q.74 Ferroelectric materials are characterised by
(A) Very high degree of polarisation.
(B) A sharp dependence of polarisation on temperature.
(C) Non-linear dependence of the charge Q on the applied voltage.
(D) All the above.

Ans: D

PART – II

DESCRIPTIVES

Q.1 Classify plastic materials into two categories, describe their important properties and give two examples of each. **(10)**

Ans:
Plastic materials can be classified into thermoplastic and thermosetting plastics.
Thermoplastic materials:- The properties of these plastic materials do not change considerably if they are melted and then cooled and solidify. They can be repeatedly melted or dissolved in various solvents. They are more elastic, less brittle and do not lose elasticity when subjected to prolonged heating. They are less apt to age thermally. They can be remoulded again and again in any shape after heating. Many of them possess extraordinary high insulating properties and are water repellent. They are polymers of linear structure, i.e. their molecules are elongated and are thread like. This, type of structure is fusible, soluble, highly plastic, capable of forming thin flexible threads and films. Examples are Polytetra Flouroethylene (P.T.F.E. or Teflon), Polyvinyl Chloride (P.V.C.).
Thermosetting Plastic Materials:- They undergo great changes when subjected to high temperatures for quite sometimes. They are said to be baked and no longer can melt or be dissolved. They are less elastic, more brittle and lose their elasticity when subjected to prolonged heating. So they cannot be remoulded in different shapes once they are set and hardened. They are used, when an insulation is to withstand high temperatures without melting or losing its shape and mechanical strength. Thermosetting plastic substances are space-polymers and the molecules branch off in various directions during polymerisation. This structure makes them very rigid, poorly soluble, fusible and incapable of forming elastic threads and films. Examples are Phenol formaldehyde (Bakelite), Epoxy resins.

Q.2 Give four examples of natural insulating materials. **(4)**

Ans:
Examples of the natural insulating materials are cotton, rubber, wood, mica.

Q.3 State the functions of a fuse. Mention the desirable properties of fuse materials. **(8)**

Ans:
Fuse is a protective device, which consists of a thin wire or strip. This wire or strip is placed with the circuit it has to protect, so that the circuit-current flows through it. When this current is too large, and heat produced due to I^2Rt exceeds the melting point of the fuse, consequently fuse wire or strip melts thus breaking the circuit and interrupting the power supply.
A fuse material should possess the following properties;-
Low resistivity – This means, thin wires can be used, which will give less metal vapour after melting of the wire. Less metal vapour in the arc gives lower conductivity and thus makes quenching of arc easier.
Low conductivity of the metal vapours itself.

Low melting point- This means that the temperature of the fuse material for norm[al current] stays at a low value. Previously lead was used as fuse material because of its low [melting] point but thick wires of lead are required due to higher resistivity. For rewireable fuses a[lloys] of tin and lead or tinned copper wires are commonly used. In caridge fuses silver and silv[er] alloys are used of lower ratings. Copper alloys are used in fuses of higher ratings.

Q.4 Differentiate between n and p type semiconductors. **(6)**

Ans:

n – type semiconductor:-	p - type semiconductor:-
(i) When small amount of pentavalent impurity is added to a pure semiconductor providing a large number of free electrons in it, the extrinsic semiconductor thus formed is known as n- type semiconductor. The addition of pentavalent impurities such as arsenic and antimony provide a large number of free electrons in the semiconductor crystal. Such impurities, which produce n- type semiconductors, are known as donor impurities because each atom of them donates one free electron to the semiconductor crystal.	(i) When small amount of trivalent impurity is added to a pure semiconductor providing a large number of holes in it, the extrinsic semiconductor thus formed is known as p- type semiconductor. The addition of trivalent impurities such as gallium and indium provide a large number of holes in the semiconductor crystal. Such impurities, which produce p- type semiconductors, are known as acceptor impurities because each atom of them creates one hole, which can accept one electron.
(ii) The majority and minority carriers are electrons and holes respectively.	(ii) The majority and minority charge carriers are holes and electrons respectively.
(iii) The impurity level is just below the bottom of conduction band.	(iii) The impurity level is just above the valence band.

Q.5 Explain how materials can be classified into three groups on the basis of atomic structure. **(8)**

Ans:

An atom consists of a positively charged nucleus surrounded by a group of negatively charged electrons. The nucleus is at the centre of the atom and electrons are established in definite states, orbits, energy- levels. The electrons in the outermost orbit of an atom are called valence electrons. It is these electrons that are responsible for determining the physical, chemical and electrical properties of the material.

On the basis of atomic structure the materials are classified as

1) When the No. of valence electrons of an atom is less than 4 i.e. half of maximum permissible 8 electrons, the material is a metal or conductor. Example Cu, Mg and Al have 1, 2 and 3 valence electrons respectively.

2) When the No. of valence electrons of an atom is more than 4 , the ma... insulator. Example As, Se and Bromine have 5,6 and 7 valence electrons respe...

3) When the No. of valence electrons of an atom is 4 i.e. exactly half of maxi... permissible 8 electrons, the material is a semiconductor. Example Carbon, Silicon a... Germanium have 4 valence electrons each.

Q.6 Discuss briefly:
(i) Lithography (ii) Superconductivity **(3+3)**

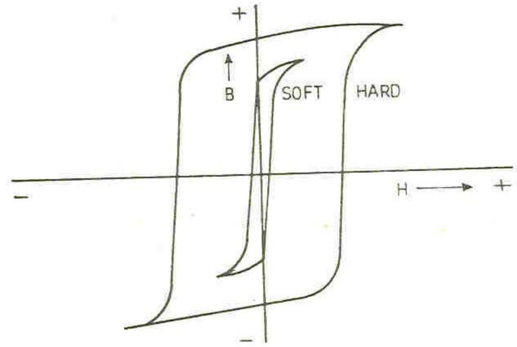
Ans:
i) **Lithography-** It is one of the processes which is carried out during manufacture of integrated circuits. SiO_2 layer is thermally grown on the wafer surface. The pattern is transferred from mask to the oxide layer as follows - A photo resist liquid is uniformly applied over the oxide layer and dried. Photo resist is a material, which changes its solubility in certain organic solvents, when exposed to ultra violet light. Non-polymerised parts are then dissolved using organic solvents. The oxide layer below these parts is now etched using net chemical etchant. By, this process, the pattern is transferred from the mask to the oxide. During next diffusion, the layer of SiO_2 serves as a mask.

ii) **Superconductivity-** The resistivity of most metals increases with increase in temperature and vice-versa. There are some metals and chemical compounds whose resistivity becomes zero when their temperature is brought near 0^0 Kelvin (-273^0C). At this stage such metals or compounds are said to have attained superconductivity. Example – mercury becomes superconducting at approximately 4.5 Kelvin (-268.5^0C). Superconductivity, was discovered by Heike Kamerlingh Onnes. The transition from normal conductivity to superconductivity takes place almost suddenly; it occurs over a very narrow range of temperature about 0.05^0K. The temperature at which the transition takes place from the state of normal conductivity to that of superconductivity is called transition temperature. Zero resistivity and Diamegnatic are two essential and independent properties of super conducting materials. The super conducting properties can be destroyed by applying magnetic field.

Q.7 Describe the physical properties and uses of the following:
(i) Soft and hard magnetic materials. **(10)**
(ii) Brasses

Ans:
i) Soft magnetic materials –They have small enclosed area of hysteresis loop, high permeability, high saturation value, low eddy current losses which is achieved by using laminated cores, less residual magnetism. Soft magnetic materials retain their magnetism as long as they are energised by an external magnetic field; Example: Alpha iron, super permalloy (Ni-Fe-Mo), silicon ferrite. Soft magnetic materials are used for the construction of cores for electrical machines, transformers, electromagnets reactors and cores of audio frequency couplings and matching transformers in telecommunication.
Hard Magnetic materials-have a gradually rising magnetization curve with large hysteresis loop area and hence large energy losses. They have high value of retentivity and high value of coercivity and low permeability. To saturate the hard magnetic materials, a high magnetizing force is required. Hard magnetic materials have the property of retaining their magnetism even after the magnetising field is removed. Example: Alnico (Al-Ni-Co), Cobalt

steel and retaining the same for a long time. Due to this property they are u[illegible] manufacture of permanent magnets.



B-H curves for soft and hard magnetic materials

(ii) Brass- Is an alloy of copper and zinc with 60% copper and 40% zinc. Its properties are-

1. Its electrical resistivity is 7.0X 10^{-8} ohm-m, which is higher than the copper resistivity.
2. It is ductile and can be drawn into different shapes.
3. It melts at 890^0C.
4. Its specific gravity is 3.3.
5. It has got an excellent corrosion resistance.
6. It has got good mechanical properties.

Uses:- Brass is used as a structural and current carrying material in power switches, plugs, sockets, lamp holders, fuse holders, knife switches, sliding contacts for starters and rheostats, wave guide components.

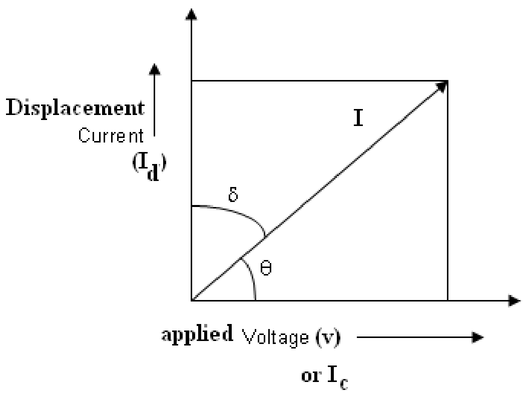
Q.8 Discuss electrical properties of insulating materials. **(14)**

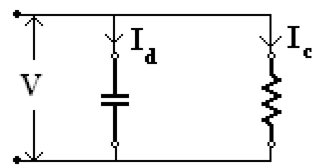
Ans:
Electrical properties of an insulating material are:
Insulation resistance-is the property, by the virtue of which, a material resists flow of electrical current. It should be high as possible. Insulation resistance is of two types:
(i) Volume resistance; (ii) Surface resistance.
The resistance offered to the current, which flows through the material is called **volume resistance.** The resistance offered to the current, which flows over the surface of the insulating material is called **surface resistance**. Factors that affect the insulation resistance are-temperature variations, exposure to moisture, voltage applied, aging.
Dielectric Strength- is therefore the minimum voltage which when applied to an insulating material will result in the destruction of its insulating properties. It can also be defined as the maximum potential gradient that the material can withstand without rupture, or without loosing dielectric properties. This value is expressed in volts or kilovolts per unit thickness of the insulating material. This value is greatly affected by the conditions under which the material is operated. Factors affecting the dielectric strength are temperature and humidity.
Dielectric Constant- Every insulating material has got the basic property of storing charge (Q), when a voltage (V) is applied across it. The charge is proportional to the voltage applied i.e. $Q \alpha V$, or $Q = CV$. Where C is called the capacity or capacitance of the material across which the voltage is applied. Every insulating material behaves as a capacitor. Capacitance is different for different insulating material. The property of insulating materials that causes the difference in the value of capacitance, with the physical dimensions remaining the same is

called dielectric constant or permittivity ($\in$) and $\in = C/C_o$, where C is capacity in presence of Dielectric and C_o is the capacity in air or vacuum or in the absence of dielectric.

Dielectric loss and Loss angle: When a perfect insulation is subjected to alternating voltage it is like applying alternate voltage to a perfect capacitor. In a perfect capacitor the charging current would lead the applied voltage by 90^0 exactly. This means that there is no power loss in the insulation. In most insulating materials this is not the case. There is a definite amount of dissipation of energy when an insulator is subjected to alternating voltage. This dissipation of energy is called dielectric loss. Factors affecting dielectric loss are – Frequency of applied voltage, humidity, temperature rise and voltage.

The dielectric phase angle is θ and $\delta = 90^0 - \theta$ is the dielectric loss angle as shown in the fig. below.





Also I is the phasor sum of I_d and I_c , where Ic is the conduction current which is in phase with the applied voltage and Id is the displacement current which is in quadrature phase with applied voltage.

Q.9 Discuss important properties and uses of

(i)	Rubber.	(ii) Mica and Mica products.	
(iii)	Glass and glass products.	(iv) Ceramics	**(3.5 x 4)**

Ans:

(i) Rubber: Rubber is polymeric material with high elastic yield strain. The different types of rubber materials are- Natural rubber, Hard rubber and Synthetic rubber.

Natural Rubber – Natural rubber is extracted from milky sap collected from special trees. Water is then evaporated. Additives like sulphur, oxidation inhibitors like aromatic amino compounds, softeners like vegetable oil and fillers like carbon black and zinc oxide are added to it. It is vulcanized by adding sulphur and heating it. Vulcanization improves heat and frost resistance of rubber, making it mechanically stronger. The permittivity and power factor varies depending on the sulphur content and temperature change.

Properties – This rubber is moisture repellent and has good insulating properties. It has good abrasion resistance.

Applications – It is used for the manufacturing of protective clothing such gloves, boots. It is used as an insulation covering for wires and cables.

Hard Rubber – Hard rubber is obtained by addition of more sulphur and by extended vulcanization.

Properties – It has good electrical properties. Water absorption is less. permissible operating temperature is 60^0 C. It can not be continuously exposed to S is harmful. It has high tensile strength.

Applications – Hard rubber is used for construction of storage battery housing, pa boards, bushings of various types. It is also used as jacketing material for cables.

Synthetic Rubber – The different types of synthetic rubber are

(a) Butadiene rubber – its properties are greater resistance to ageing and oxidation, lower tensile and tear strength, lower water absorption, higher heat conductivity.

(b) Butyl rubber – its properties are excellent resistance to vegetable oils and alcoholic solvents, but it is easily attacked by petroleum oils and greases. It has high resistance to ozone, high thermal and oxidation stability but poor tensile strength. It is used as insulation for wires and cables.

(c) Chloroprene Rubber (Neoprene Rubber) – It has better resistance to thermal ageing, oxidation, sunlight and gas diffusion. These rubbers have better thermal conductivity and more flame resistance. They exhibit better adhesion to metals. They possess better resistance to attack by solvents like mineral and vegetable oils but poor resistance to aromatic hydrocarbon liquids. They are inferior in mechanical properties like tear and tensile strength and abrasion resistance. Neoprene rubber is used as insulating material for wires and cables. It is also used as jacketing material for cables.

(d) Chlorosulphonated Polyethylene (Hypalon) – It has better electrical properties, high resistance to degradation when exposed to high temperature and oxidation. It can be operated at temperatures as high as 150^0 C. It has poor solvent resistance to hydrocarbons. It is mechanically less tough. It is used as insulating material for wires and cables and also as jacketing material for cables.

(e) Silicon Rubber – It has high thermal conductivity. Its tensile strength is low, has good flexibility at low temperatures and resistant to ozone, oxidation and severe atmospheric conditions. It can be used over a wide range of temperatures from -100^0 to 150^0 C. Silicon rubber is used as insulating material for wires and cables, in the manufacture of moulded parts, as an insulating tape and coating material.

(ii) Mica and Mica Products – Mica is an inorganic material. It is one of the best insulating materials available. From the electrical point of view, mica is of two types – Muscovite mica and Phologopite mica.

Muscovite mica – Chemical composition is $KH_2Al_3(SiO_4)_3$. The properties are

i) Strong, tough and less flexible
ii) Colourless, yellow, silver or green in colour
iii) Insulating properties are very good
iv) Abrasion resistance is high
v) Alkalies do not affect it

Uses – Muscovite mica is used where electrical requirements are severe. Because of high dielectric strength, it is used in capacitors. It is also used in commutators due to high abrasion resistance.

Phologopite mica – Chemical composition is $KH(MgF)_8MgAl(SiO_4)_3$. The properties are

i) Amber, yellow, green or grey in colour
ii) Greater structural stability, being tougher and harder than muscovite mica, less rigid
iii) Resistant to alkalies, but less to acids
iv) Greater thermal stability than that of muscovite mica

Uses – It is used when there is greater need of thermal stability as in domestic appliances like irons, hotplates, toasters.

Mica products

(i) Glass bonded mica – Ground mica flakes and powdered glass when moulded glass bonded mica. This material is impervious to water and chemically stable. This is in high humidity and high ambient temperatures.

(ii) Mica paper and Mica sheet– Mica is broken into small particles in aqueous solution. Out of this sheets of mica paper are produced which are used as insulation for armature and field coils of rotating machines. Also used as washers, spacers, sleeves, tubes etc.

(iii) Manufactured mica – Mica flakes held together with adhesives is called manufactured mica. It is used in commutators, electrical heating devices, motor slot insulation, transformers, etc.

(iii) Glass and glass products – Glass is an inorganic material made by the fusion of different metallic oxides. The properties of glass are –

i) It is transparent, brittle and hard
ii) Glass is insoluble in water and usual organic solvents
iii) It has low dielectric loss, slow ageing and good mechanical strength
iv) It is susceptible to destruction when sudden and high temperature cycles are applied

Uses – Glass is used in moulded insulating devices such as electrical bushings, fuse bodies, insulators. Glass is used as a dielectric in capacitors. Radio and television tubes, electrical laminated boards also make use of glass

Glass Products

a) Silica glass or fused quartz – Silica when heated to a temperature of fusion and then cooled is known as silica glass. This material has good electrical properties, low coefficient of expansion and high resistivity.

b) Borosilicate glass or Pyrex – This glass requires 28 per cent of boron oxide along with other oxides. They resist the effect of chemicals and moisture better than other glasses.

c) Fibre glass insulation – This is capable of withstanding high temperature. For most applications fibre glass is impregnated with materials like synthetic resins or with mineral oil. They possess good electrical and mechanical properties and sufficient flexibility to be moulded into required shapes.

d) Epoxy glass – It is made by joining glass fibre layer with a thermosetting compound. It is immune to alkalies and acids and is used in PCB making, terminal holders and instrument cases.

(iv) Ceramics – Ceramics are materials made by high temperature firing treatment of natural clay and certain inorganic matters. The properties of ceramics are –

i) Ceramics are hard, strong and dense.
ii) Ceramics are not affected by chemical action except by strong acids and alkalies.
iii) Stronger in compression than in tension.
iv) Excellent dielectric properties.
v) Stable at high temperatures.

Uses – The capacity to withstand high temperature, immunity to moisture, good electrical properties make ceramics valuable for the use in different types of insulators, transformer bushing pins, fuse holders, plugs and sockets.

Main ceramic materials are

(a) Porcelain – It is used in low frequency applications due to high dielectric loss factor. It has low electrical resistivity.

(b) Steatite – These are low dielectric loss porcelains, used for variable capacitors, switches, resistor shafts and bushings. It is also used for low voltage and high frequency applications.
(c) Alumina – It has high mechanical and dielectric strength. It also has high electrical resistivity and low dielectric losses. It is chemically stable and retains its properties over a wide range of temperature and frequencies. It is used for circuit breakers, spark plugs, resistor cores, integrated circuits and power transistors.
(d) Zirconia – It has poor thermal conductivity and shock resistance. It is available with calcium or yttrium. It is used for high temperature heating elements.

Q.10 State the advantages and disadvantages of alloying steel with silicon for use as magnetic materials in transformer and electric machines. **(10)**

Ans:
Extensive use, is made of iron-silicon alloy called silicon steel for relatively strong alternating magnetic fields generally used in transformers, electrical rotating machines, reactors, electromagnets and relays. Silicon sharply increases the electrical resistivity of iron thus decreasing the iron losses due to eddy currents. It increases the permeability at low and moderate flux densities but decreases it at high densities. Addition of silicon to iron reduces the hysteresis loss. The magnetostriction effect is also reduced. A, steel with more than 5% silicon may be too hard and brittle to be easily workable. The introduction of silicon in steel was an important development. In the past, iron was used as the core material in the form of sheets, the material gradually deteriorated due to repeated heating and cooling. This difficult overcome by using silicon sheet steel as core material. High silicon sheet steel with silicon of about 4% is used in magnetic circuits of power transformers, which operate at flux densities of about 1 Wb/m^2. The cores of rotating electrical machines are slotted with the teeth having small cross sectional areas. The flux density in the teeth is much higher, of the order of $1Wb/m^2$. To obtain high flux density in the case of high silicon steel, the magnetising current necessary is very large. Also punching slots in high silicon steel would be difficult because it is harder and more brittle.

Q.11 Describe soldering materials and their uses. **(4)**

Ans:
The process of joining two or more metals is known as soldering. An alloy of two or more metals of low melting point used for joining two or more base metals is known as soldering material or called solder. The most common solder is composed of 50% tin. Its melting point is about 185^0C. Many commercial solders, contain larger percentage of lead and some antimony with less tin, as the electrical conductivity of lead is only about half that of tin. For soldering flux is to be used. Solders are of two types- Soft solders and Hard solders. Soft solders are composed of lead and tin in various proportions. Hard solders may be any solder with a melting point above that of lead-tin solders. Soft solders are used in electronic devices and hard solders in power apparatus for making permanent connections. Examples: Tin – lead solders, Tin-Antimony- lead solders, Tin-Zinc solders, Lead-silver solders, Cadmium-silver solders etc.

Q.12 Write short notes on
(i) Soft ferrites and their applications. **(7)**
(ii) PVC and its applications. **(7)**

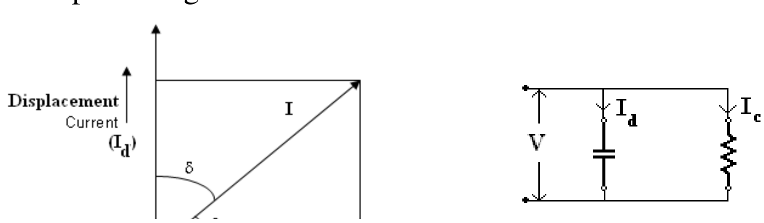
Ans:
(i) **Soft ferrites and their applications**: These are non- metallic compounds consisting of ferric oxide and one or two bivalent metal oxides such as Nickel oxide, Manganese oxide or Zinc oxide. These have resistivity of the order of 10^9 ohm-cm, which reduces eddy current losses at high frequency. The magnets made out of it have high coercive force and square hysteresis loop. Magnetic permeability of these materials is as high as 10,000 to 30,000. These materials are fabricated into shape such as E, U, I, beads and self shielding pot cores.
Applications – High frequency power transformers operating at 10 to 100 kHz, pulse transformers up to 100' MHz, adjustable air gap inductors, recording heads make use of cores made of soft ferrites.
(ii) **PVC and its applications –** This is obtained from polymerisation of vinyl chloride in the presence of a catalyst like peroxides at about 50^0 C. The properties like mechanical strength, porosity, flexibility, moisture absorption and electrical properties can be changed by adding certain materials. PVC has good mechanical and electrical properties. It is hard and brittle. It resists flame, most solvents and sunlight. It is non-hygroscopic. PVC is widely used as insulation and jacketing material for wires, cables. PVC films, tapes and sheets are used as insulation for dry batteries and conduit pipes.

Q.13 What are the desirable properties of an insulation material? **(8)**

Ans:
The desirable properties of an insulation material are:
1. Very good dielectric strength as that of mica (upto 80 kV/mm at 25^0C).
2. Volume and surface resistivity equal to that of sulphur.
3. Good mechanical strength like that of steel.
4. Very high crushing resistance (as that of granite).
5. Easy of machining.
6. Good fire proofing qualities (as that of silica).
7. It should have very high chemical inertness.
8. It should have good water proofing qualities similar to that of paraffin wax.

Q.14 Explain dielectric loss and loss angle. **(6)**

Ans:
Dielectric loss and Loss angle: When a perfect insulation is subjected to alternating voltage, it is like applying alternate voltage to a perfect capacitor. In a perfect capacitor the charging current would lead the applied voltage by 90^0 exactly. This means that there is no power loss in the insulation. In most insulating materials this is not the case. There is a definite amount of dissipation of energy when an insulator is subjected to alternating voltage. This dissipation of energy is called dielectric loss. Factors affecting dielectric loss are – Frequency of applied voltage, humidity, temperature rise and voltage.
The dielectric phase angle is θ and $\delta = 90^0 - \theta$ is the dielectric loss angle as shown in the fig. below.



Also I is the phasor sum of I_d and I_c , where Ic is the conduction current which i[s in phase] with the applied voltage and Id is the displacement current which is in quadrature pha[se with the] applied voltage.

Q.15 Explain the following:

(i) Permeability. (ii) Dielectric constant.

(iii) Corrosion. (iv) Contact resistance. **(3.5 x 4)**

Ans:

(i) **Permeability:** It is defined as the capability of the material to conduct flux. It is defined as the ratio of magnetic flux 'B' in a medium to the magnetic flux intensity 'H' at the same location in the medium, i.e. $\mu = B/H$, where B is plotted against H, a curve is obtained, called magnetization curve or B-H curve. The permeability of any material is not a constant. The permeability at low value of H is called initial permeability. The common core materials such as low carbon steel, silicon steel have low initial permeability.

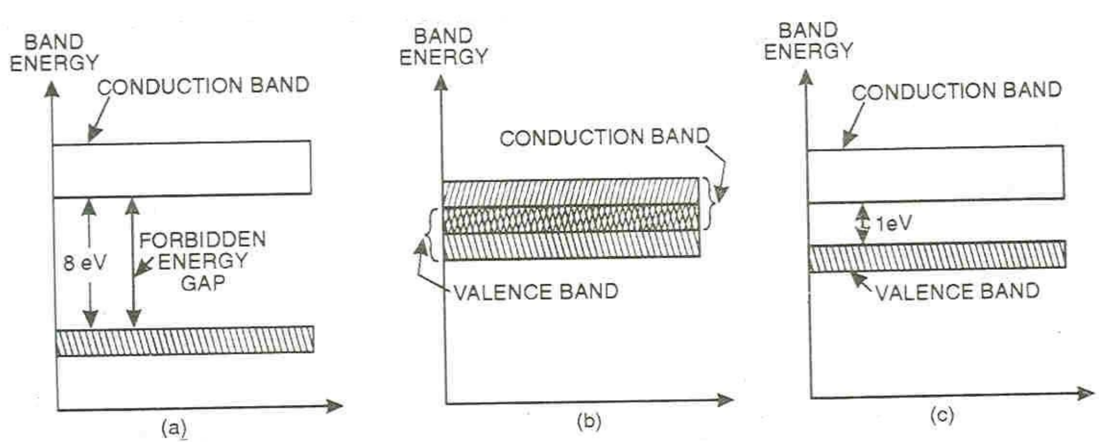
(ii) **Dielectric constant:** It is also known as 'Permittivity'. Every insulating material possesses an electrical capacitance. The capacitance of such unit depends upon dimensions and kind of dielectric placed between the capacitor plates. The capacitance of a parallel plate capacitor may be calculated from the formula $C = \in A/t$ where $\in$ is the permittivity of the material in F/m, A = Area of the plates and t = thickness of dielectric. Thus permittivity $\in$ of a material is a measurement of its ability to form an electrical capacitance of the insulating material, the dimensions of the capacitor being taken equal. Dielectric constant or permittivity is not a constant but varies with temperature and frequency and $\in = C/C_o$, where C is capacity in presence of Dielectric and C_o is the capacity in air or vacuum or in the absence of dielectric.

(iii) **Corrosion:** The process of constant eating (destruction) up of metals (from the surface) by the surrounding is called as corrosion. The metals are corroded when exposed to the atmosphere. The metals are generally converted into their oxides. This oxide covers the surface of the metal, which results in the destruction of the metal. Rusting of iron is the most common example of corrosion in which iron makes iron oxide with reaction with the oxygen of the atmosphere. The iron oxide covers the surface in the form of brownish powder. Therefore the conducting material should be corrosion resistant.

(iv) **Contact resistance:** This is measured as the voltage drop from tail to tail of the mated contacts with specified current flowing through the contact and is specified in milliohms. The total resistance offered by a contact depends upon the bulk resistivity of the contact material, actual surface area and mechanical wear of the contacts and environmental effects. To obtain low contact resistance it is necessary that the contact must be a good conductor of electricity. The contacts should have good mechanical resistance against wear due number of mechanical operations. The contacts are made using alloys, which have combination of mechanical properties, very good electrical and thermal conductivity and resistance to corrosion. Commonly used alloys are Beryllium copper, phosphor bronze, spring brass and low leaded brass. Plating of the contact metal is done to prevent deterioration of contacts mechanically and chemically and to obtain good surface conductivity. Commonly used plating materials are silver, gold, copper, nickel and tin.

Q.16 With the help of energy bands explain how conduction takes place in conductors, semiconductors and insulators.

Ans:
On the basis of energy band materials are classified as insulators, conductors, and semiconductors.
Insulators: Substance like wood, glass, which do not allow the passage of current through them are known as insulators. The valence band of these substances is full whereas the conduction band is completely empty. The forbidden energy gap between valence band and conduction band is very large (8ev) as shown in the fig (a). Therefore a large amount of energy, i.e. a very high electric field is required to push the valence electrons to the conduction band. This is the reason, why such materials under ordinary conditions do not conduct at all and are designated as insulators.
Conductors: Substances like copper, aluminium, silver which allow the passage of current through them are conductors. The valence band of these substances overlaps the conduction band as shown in fig (b). Due to this overlapping, a large number of free electrons are available for conduction. This is the reason, why a slight potential difference applied across them causes a heavy flow of current through them.
Semiconductors: Substances like carbon, silicon, germanium whose electrical conductivity lies in between the conductors and insulators are known as semiconductors. The valence band of these substances is almost filled, but the conduction band is almost empty. The forbidden energy gap between valence and conduction band is very small (1ev) as shown in fig (c). Therefore comparatively a smaller electric field is required to push the valence electrons to the conduction band. This is the reason, why such materials under ordinary conditions do not conduct current and behaves as an insulator. Even at room temperature, when some heat energy is imparted to the valence electrons, a few of them cross over to the conduction band imparting minor conductivity to the semiconductors. As the temperature is increased, more valence electrons cross over to the conduction band and the conductivity of the material increases. Thus these materials have negative temperature co-efficient of resistance.



Energy Band Diagrams

Q.17 Write a note on superconductors. **(5)**

Ans:

Superconductors - The resistivity of most metals increases with increase in tempera vice-versa. There are some metals and chemical compounds whose resistivity becomes when their temperature is brought near 0^0Kelvin (-273^0C). At this stage such metals compounds are said to have attained superconductivity. Example – mercury becomes superconducting at approximately 4.5 Kelvin (-268.5^0C). Superconductivity was discovered by Heike Kamerlingh Onnes. The transition from normal conductivity to superconductivity takes place almost suddenly; it occurs over a very narrow range of temperature about 0.05^0K. The temperature at which the transition takes place from the state of normal conductivity to that of superconductivity is called transition temperature. Superconductors are used for producing very magnetic fields of about 50 Tesla. Magnetic energy can be stored in large superconductors and drawn as required to counter the voltage fluctuations during peak loading. Superconductors can be used to perform logic and storage functions in computers. As there is no, I^2R losses in a superconductor, so power can be transmitted through the superconducting cables without any losses. Superconducting property can be destroyed by applying external magnetic field as in fig (b). In fig (b) H_C is the critical magnetic field and T_C critical temperature.

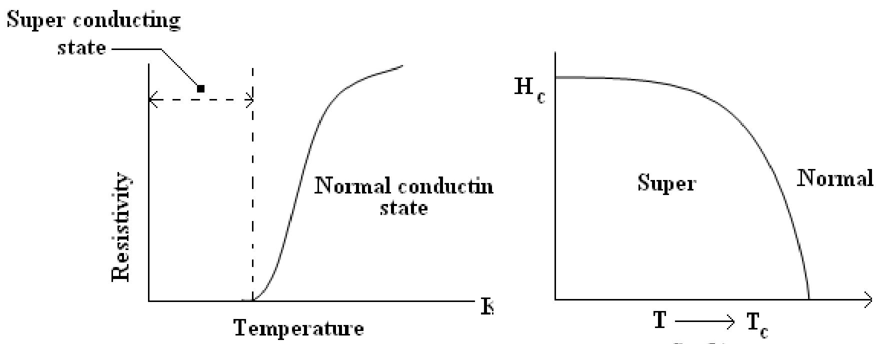


fig (a) fig (b)

Q.18 Classify the conducting materials. Describe their properties. **(10)**

Ans:

Conducting materials are classified as low resistivity materials and high resistivity materials.

Low resistivity materials: The conducting materials having resistivity between 10^{-8} to 10^{-6} ohm-m come under this category and are used in transmission and distribution lines, transformers and motor windings.

Properties:

a) **Low temperature coefficient:** For minimum variations in voltage drop and power loss with the change in temperature, these materials should have low temperature coefficient.
b) **Sufficient mechanical strength:** These materials must withstand the mechanical stresses developed during its use for particular applications.
c) **Ductility:** The material to be used for conductors must be ductile so that it can be drawn and moulded into different sizes and shapes.
d) **Solderability:** The conducting materials are required to be joined and the joint must have minimum contact resistance. These materials must have a good solderability.
e) **Resistance to corrosion:** The material should have a high resistance to corrosion so that it should not be corroded when used in different environmental conditions.

High resistivity materials: The conducting materials having resistivity between 1 ohm-m come under this category and are used for making resistance elements for devices, precision instruments, rheostats etc. Properties:

a) **Low temperature coefficient:** For minimum variations in voltage drop and power lo with the change in temperature, these materials should have low temperature coefficient.
b) **High melting point:** These materials, which are used as heating elements should have high melting point.
c) **Ductility:** The material to be used for conductors must be ductile so that it can be drawn and moulded into different sizes and shapes.
d) **Oxidation resistance:** The material should have a high oxidation resistance so that it should get oxidised when used in different environmental conditions.
e) **High mechanical strength:** These materials must withstand the mechanical stresses developed during its use for particular applications.

Q.19 Classify the different types of insulating materials with reference to their limiting safe temperatures for use. **(8)**

Ans:

Classification of insulating materials on the basis of their limiting safe temperatures for use

Class	Maximum working temperature	Materials or Combination of materials
Y	90^0C	Cotton, silk, paper, press board, wood, PVC with or without plasticiser, vulcanised natural rubber etc.
A	105^0C	Cotton, silk and paper when impregnated or immersed in a liquid dielectric such as oil.
E	120^0C	Materials possessing a degree of thermal stability allowing them to be operated at temperature 15^0C higher than class A materials.
B	130^0C	Mica, glass fibre, asbestos, etc. with suitable bonding substances.
F	155^0C	Mica, glass fibre, asbestos, etc. with suitable bonding substances as well as other materials, not necessarily

		inorganic, which by experien[illegible] accepted test can be shown to be capable of operation at 155^{0}C.
H	180^{0}C	Materials such as silicon elastomer and combinations of materials, such as mica, glass fibre, asbestos etc, with suitable bonding substances such as appropriate silicon resins.
C	above 180^{0}C	Mica, porcelain, glass and quartz with or without an inorganic binder.

Q.20 Explain the chemical properties of insulating materials. **(6)**

Ans:

Chemical properties-

Chemical resistance: Presence of gases, water, acids, alkalies and salts affects different insulators differently. Chemically a material is a better insulator if it resists chemical action.

Hygroscopicity: Many insulators come in contact with the atmosphere during manufacture or operation or both. Moisture affects the electrical properties of the insulator.

Effect of contact with other materials: Insulation remains in contact with different types of materials like air, gases, moisture, conducting materials and structural materials. This can adversely affect the insulating properties.

Ageing: Ageing is the long time effect of heat, chemical action, and voltage application. These factors decide the natural life of an insulator.

Q.21 What are plastics? Give their classification and also the differences between them. **(2+2+4)**

Ans:

Plastics are materials (having carbon as common element) which, consists of organic substances of high molecular weight and are capable of being formed into desired shape during or after their manufacture. The organic substances are called resins polymers and are derived from natural gas, petroleum etc. The polymers are mixed with other materials to modify their properties. There are two types of plastics: thermoplastics, thermosettings.

Thermoplastic materials:-	**Thermosetting Plastic Materials:-**
The properties of these plastic materials do not change considerably if they are melted and then cooled and solidify. They are deformable at higher temperature.	They are either originally soft or soften upon heating but harden permanently on further heating and they cannot be resoftened once they have set and hardened. They undergo

Thermoplastics are weaker, softer, less brittle and can be resoftened again on heating. They can be repeatedly melted or dissolved in various solvents. They are more elastic, less brittle and do not lose elasticity when subjected to prolonged heating. They are less apt to age thermally. Many of them possess extraordinary high insulating properties and are water repellent. They are polymers of linear structure, i.e. their molecules are elongated and are thread like. This, type of structure is fusible, soluble, highly plastic, capable of forming thin flexible threads and films. Examples are Polytetra Flouroethylene (P.T.F.E. or Teflon), Polyvinyl Chloride (P.V.C.), Nylon, Polyesters (saturated)	great changes when subjecte[illegible] temperatures for quite sometim[illegible] They are said to be baked and no longer can melt or be dissolved. They are less elastic, more brittle and lose their elasticity when subjected to prolonged heating. They are used, when an insulation is to withstand high temperatures without melting or losing its shape and mechanical strength. Thermosetting plastic substances are space-polymers and the molecules branch off in various directions during polymerisation. This structure makes them very rigid, poorly soluble, fusible and incapable of forming elastic threads and films. Examples are Phenol formaldehyde (Bakelite), Epoxy resins, Rubbers, polyesters(unsaturated)

Q.22 Give the properties and applications of
(i) Teflon
(ii) Bakelite **(3+3)**

Ans:
(i) **Teflon:** It is obtained by the polymerisation of tetrafloourethylene.
Properties:
1.It has good electrical, mechanical and thermal properties.
2.It can tolerate very, high temperature, without damage.
3.Dielectric constant does not change with time, frequency and temperature.
4.Its insulation resistance is very high.
5.It is highly resistant to water absorption.
6.It melts at 327^0C.
7.Its maximum useable temperature is 300^0C.
Applications: Teflon is used as dielectric material in capacitors. It is used as covering for conductors and cables, which are required to operate at high temperature. It is used as a base material for PCB’s.

(ii) **Bakelite**: It is most common type of phenol formaldehyde. It is hard, thermoset coloured material.

Its main properties are:

1. Its dielectric constant is 4.1.
2. Its dissipation factor is 0.001.
3. Its dielectric strength is 400 V/mil.
4. Volume resistivity is 10^{13} ohm-cm.
5. Maximum useable temperature is 300^0F.
6. Its water absorption is 0.13%in 24 hours.

Applications: It is widely used for moulded parts such as lamp holders, terminal blocks, instrument cases and small panels and also used as electrical parts or appliances eg. plug holders, sockets etc.

Q.23 Distinguish between ferromagnetic, paramagnetic and diamagnetic materials, mentioning at least one example of each. **(9)**

Ans:

Ferromagnetic Materials:- These are materials in which magnetic dipoles interact in such a manner that they tend to line up in parallel. A ferromagnetic substance consists of a number of regions or domains, which are spontaneously magnetized. The direction of magnetization varies from domain to domain. The resultant magnetization is zero or nearly zero. The relative permeability is very high. In presence of external magnetic field, the ferromagnetic materials get strongly magnetised and exhibit hysterisis loop. The susceptibility of these is given by $\chi = C / T - T_C$, where C is curie constant, T_C is the curie temperature above which the ferromagnetic material exhibits paramagnetic behaviour. The ferromagnetic materials are widely used in industries. Ex. Iron, nickel, cobalt.

Paramagnetic Materials:- The atoms of these materials contain permanent magnetic dipoles. Individual dipoles are oriented in random fashion such that resultant magnetic field is zero or negligible. For these materials relative permeability is slightly greater than unity and it is independent of magnetizing force. In presence of external magnetic field, paramagnetic materials get weakly magnetised in the field direction and the susceptibility is given by $\chi = C / T$, where C is a curie constant and T is the temperature. Ex. Chromium chloride, chromium oxide, manganese sulphate, air.

Diamagnetic Materials:- These are the materials whose atoms do not carry permanent magnetic dipoles. If an external magnetic field is applied to a diamagnetic material, it induces a magnetization in the direction opposite to the applied field intensity. For these materials the relative permeability is negative. These are hardly used as magnetic material in electrical/ electronic engineering applications. Ex. Aluminium oxide, copper, gold, barium chloride.

Q.24 What are hard magnetic materials? Name the various magnetically hard alloys. **(5)**

Ans:

Hard Magnetic materials-have a gradually rising magnetization curve with large hysteresis loop area and hence large energy losses. They have high value of retentivity and high value of coercivity and low permeability. To saturate the hard magnetic materials, a high magnetizing force is required. Hard magnetic materials have the property of storing a considerable amount of magnetic energy after magnetization and retaining the same for a long time. Due to this property they are used in the manufacture of permanent magnets.

Some of the magnetically hard materials are rare earth cobalt, carbon steel, tung cobalt steel, alnico and hard ferrites.

Q.25 Give the properties and application of brass and bronze, asbestos and glass. **(14)**

Ans:

Brass- Is an alloy of copper and zinc with 60% copper and 40% zinc. Its properties are-

1. Its electrical resistivity is 7.0X 10^{-8} ohm-m, which is higher than the copper resistivity.
2. It is ductile and can be drawn into different shapes.
3. It melts at 890^0C.
4. Its specific gravity is 3.3.
5. It has got an excellent corrosion resistance.
6. It has got good mechanical properties.

Applications: Brass is used as a structural and current carrying material in power switches, plugs, sockets, lamp holders, fuse holders, knife switches, sliding contacts for starters and rheostats, wave- guide components, brazing purpose, jewellery and utencils etc.

Bronze: alloy of copper and tin.

1. This alloy is very hard and brittle.
2. Its corrosion resistance is better than brass.
3. It is ductile and can be drawn into different shapes.
4. In bronzes, which are used as electrical conductor, the content of tin and other metal is usually low as compared to the bronzes, which are used for mechanical applications.

Applications: It is used for making structural elements for equipments. It is also used for making current carrying springs, sliding contacts, knife switches, bearings, marine work, turbine blading etc.

Glass – Glass is an inorganic material made by the fusion of different metallic oxides. The properties of glass are –

i) It is transparent, brittle and hard
ii) Glass is insoluble in water and usual organic solvents
iii) It has low dielectric loss, slow ageing and good mechanical strength
iv) It is susceptible to destruction when sudden and high temperature cycles are applied

Uses – Glass is used in moulded insulating devices such as electrical bushings, fuse bodies, insulators. Glass is used as a dielectric in capacitors. Radio and television tubes, electrical laminated boards also make use of glass

Glass Products

a) Silica glass or fused quartz – Silica when heated to a temperature of fusion and then cooled is known as silica glass. This material has good electrical properties, low coefficient of expansion and high resistivity.

b) Borosilicate glass or Pyrex – This glass requires 28 per cent of boron oxide along with other oxides. They resist the effect of chemicals and moisture better than other glasses.

c) Fibre glass insulation – This is capable of withstanding high temperature. For most applications fibre- glass is impregnated with materials like synthetic resins or with mineral oil. They possess good electrical and mechanical properties and sufficient flexibility to be moulded into required shapes.

d) Epoxy glass – It is made by joining glass fibre layer with a the[...] compound. It is immune to alkalies and acids and is used in PCB making, [...] holders and instrument cases.

Asbestos: It is inorganic fibrous material. Two types of asbestos are available.

Chrysotile asbestos: It is hydrated silicate of magnesium.

1. Its specific gravity varies between 2-2.8.
2. It is highly hygroscopic.
3. It has high dielectric losses and dielectric strength.
4. The melting temperature is 1525^0C.

Amphibole asbestos:

It is found in Africa and Alaska.

1. Its fibres cannot be woven easily as the fibres are too soft or too hard and brittle.
2. It possesses good tensile strength.
3. It is highly hygroscopic.
4. Its electrical properties are poorer.

Uses: Asbestos is used in low voltage work as insulation in the form of rope, tape, cloth and board. It is impregnated with liquid or solid resin in all such applications to improve its mechanical and electrical properties. It is used as insulator in wires and cables under high temperature conditions, as conductor insulator and layer insulator in transformer, as arcing barrier in switches and circuit breakers.

Q.26 What is the effect of temperature on conductivity of semiconductor? **(6)**

Ans:

Electrical conductivity of semiconductor changes appreciably with temperature variations. At absolute zero, it behaves as an insulator. At room temperature, because of thermal energy, some of covalent bonds of the semiconductor break. The breaking of bonds sets those electrons free, which are engaged in the formation of these bonds. This results in few free electrons. These electrons constitute a small current if potential is applied across the semiconductor crystal. This shows the conductivity for intrinsic semiconductor increases with increase in temperature as given by $\eta = A_{\exp}(-E_g / 2kt)$ where η is the carrier concentration, Eg is the band gap, T is the temperature and A is constant. In case of extrinsic semiconductors, addition of small amount of impurities produces a large number of charge carriers. This number is so large that the conductivity of an extrinsic semiconductor is many times more than that of an intrinsic semiconductor at room temperature. In n - type semiconductor all the donors have donated their free electrons, at room temperature. The additional thermal energy only serves to increase the thermally generated carriers. This increases the minority carrier concentration. A temperature is reached when number of covalent bonds that are broken is large, so that number of holes is approximately equal to number of electrons. The extrinsic semiconductor then behaves like intrinsic semiconductor.

Q.27 Name the materials used in the following cases. Give reasons in each case.

(i) Fuses.
(ii) Solder.
(iii) Bimetals. **(3+3+3)**

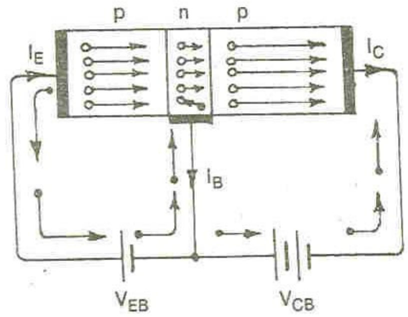
Ans:
(i) Fuses: For rewirable fuses, lead-tin and copper-tin alloy is used. For cartridge and HRC fuses silver is used because of their low melting point and low resistivity.
(ii) Solder: For soft solders tin, lead (in fifty fifty ratio) alloy and for hard solders silver and copper- zinc alloy (in various proportions) are used because of their low melting points, good electrical conductivity. eg. (i) Soft solders: 40% Pbt 60% Sn (ii) Tinman's solders: 38% Pbt + 62% Sn (iii) Plumber solders : 60% Pbt 37.5% Sn + 2.5% Antimony Similarly lead silver cadmium silver, tin-zinc solders etc.
(iii) Bimetals: Alloy of iron and nickel with low value of coefficient of thermal expansion are used as one element and metals like nickel, iron, constantan, brass etc., which, have high value of coefficient of thermal expansions are used as the other element.

Q.28 Explain the principle of a thermocouple. Give two examples of some common thermocouples. **(5)**

Ans:
Thermocouples: Are used for the measurement of temperature. When two wires of different metals are joined together an emf exits across the the junction which dependent on the types of metals or alloys used and also directly proportional to the temperature of the junction. Depending on the range of temperature to be measured, proper materials are to be chosen for a thermocouple. If one junction called the cold junction is held at a known constant temperature, the emf produced becomes measure of the temperature of the other junction. The emf produced by a thermocouple is very small but it can be measured with reasonable accuracy by a sensitive moving coil millivoltmeter, which can be calibrated in terms of temperature. Some of the materials used for thermocouples are copper/constantan, iron/constantan.

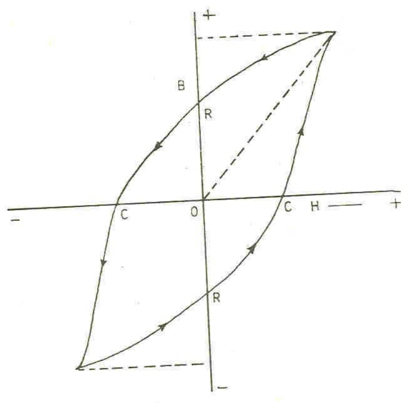
Q.29 Write notes on any **TWO**
(i) pnp transistors.
(ii) Hysteresis loop.
(iii) Factors affecting the resistivity of conducting materials.
(iv) Applications and properties of aluminium and copper. **(7+7)**

Ans:
(i) **pnp transistor**: A transistor has three terminals. In a pnp transistor has two blocks of p- type semiconductors which are separated by a thin layer of n-type semiconductor. A pnp transistor circuit is shown in the fig below. The emitter base junction is forward biased while the collector base junction is reverse biased. The forward biased voltage is V_{EB} is quite small, whereas the reverse biased voltage V_{CB} is considerably high. As the emitter base junction is forward biased a large number of holes (majority carriers) in the emitter (p- type) are pushed towards the base. This constitutes the emitter current I_E. When these holes enter p- type material (base), they tend to combine with electrons. Since the base is lightly doped and very thin, only a few electrons (less than 5%) combine with electrons to constitute the base current I_B. The remaining holes (more than 95%) diffuse across the thin base region and reach the collector space charge layer. These holes then come under the influence of the negatively biased p- region and are attracted or collected by the collector. This constitutes collector current I_C. Thus, it is seen that almost the entire emitter current flows into the collector circuit. The emitter current is the sum of collector current and base current i.e. $I_E = I_C + I_B$.



pnp transistor circuit

(ii) **Hysteresis loop**: In a ferromagnetic material, the flux density B increases when external applied magnetic field H to it is increased. When the saturation arrives, the increase in flux ceases even though H may be increased. This has be shown by OS in the fig. If the external field is gradually reduced, the original curve OS is not retraced but follows curve SR. The external field H is reduced to zero but B does not reduce to zero i.e. the material remains magnetised. The value of R flux density is called remanent flux density or residual magnetism. In order to demagnetise the material completely, external magnetic field must be reversed and when it reaches the value OC in reverse direction, it is seen that B is zero. This applied reverse magnetising force, which causes B to become zero is called coercive force. Further increase of H in reverse direction will now increase in B in reverse direction and again at the point S saturation occurs. The residual magnetism in reverse direction is represented by OR and to neutralise it H must be increased in positive direction to the value OC. Further increase in H will again magnetise the material and saturation will occur at S. The above property is characteristic of magnetic behaviour of the ferromagnetic material. When the material is taken through one complete cycle of magnetisation, it traces a loop called hysteresis loop. When a material is subjected to cyclic changes of magnetisation, the domains change the direction of their orientation in accordance with H. Work is done in changing the direction of domains, which leads to production of heat within the material. The energy required to take the material through one complete cycle of magnetisation is proportional to the area enclosed by the loop.



Hysteresis loop

(iii) Factors, which change the resistivity of conducting materials: -

Temperature- The electrical resistance of most metals increases with increase of temperature while those of semiconductors and electrolytes decreases with increase of temperature.

Alloying- Alloying is another factor, which affects the resistivity of a materi addition of some impurity to a metal, its resistivity can be changed. Alloys have resistivity than that of pure metal.

Mechanical stressing-When a material undergoes a mechanical treatment, its resistivity changes due to mechanical distortion of the crystal structure. eg. annealing decreases the resistivity.

Age Hardening- Age hardening increases the resistivity of an alloy.

(iv) Aluminium:

Properties

1) Pure aluminium is silver white in color.
2) It is a ductile metal and can be put to a shape by rolling, drawing and forging.
3) It melts at 655^0C.
4) It is resistant to corrosion.
5) Its tensile strength is $60MN/m^2$.
6) It can be alloyed with other elements.
7) Annealing can soften it.
8) It has a higher thermal conductivity.

Applications: Aluminium is widely used as conductor for power transmission and distribution. It is used in overhead transmission lines, busbars, ACSR conductors etc.

Copper:

Properties

1) It is reddish brown in color.
2) It is malleable and ductile and can be cast, forged, rolled, drawn and machined.
3) It melts at 1083^0C.
4) It easily alloys with other metals.
5) Electrical resistivity of copper is 1.7×10^{-8} Ω-m.
6) Tensile strength for copper is 210 MN/m^2.
7) It is highly resistant to corrosion.
8) It is a non-magnetic material.

Applications: - Copper is used in conductor wires, coil windings of generators and transformers, cables, bus bars etc.

Q.30 Differentiate between conductors, semiconductors and insulators. Give two examples of each. **(10)**

Ans:
Materials, which are commonly used in electrical and electronics engineering, can be classified as conductors, insulators, semiconductors.

Conductors: These are the material, which allow the current to pass through them. These have very low electrical resistance and are available in a large variety having different properties. Also the number of valence electrons is less than four. The, valence- band and the conduction- band overlap each other. Examples are copper, brass, aluminium, silver, gold, bronze, etc.

Semiconductors: These are the materials, which possess the electrical resistivity that of conductors and insulators. They are used for the manufacture of diod transistors. Also the number of valence electrons is equal to four. There is a small forbi energy gap of about 1eV between the conduction and the valence band. Example germanium, silicon, selenium, etc.

Insulators: These are the materials, which do not allow the current to pass through them without any appreciable loss. They have very high electrical resistance and are also available in a large variety to cover different applications. Some of the specific insulating materials are used for the purpose of storing of an electrical energy and are called dielectric materials such as mica, ceramic, paper etc. These materials are used as a dielectric in capacitors. Also the number of valence electrons is more than four. The energy gap between valence and conduction band is very large (more than 5-6 eV). Examples: Mica, rubber, ceramics, glass, diamond etc.

Q.31 Discuss the advantages and disadvantages of aluminium as compared to copper as a conductor of electricity. **(4)**

Ans:

Advantages of aluminium as compared copper as a conductor of electricity: The electrical conductivity of aluminium is next to that of copper. Its resistivity is $2.8X10^{-8}$ ohm-m, i.e. about 1.6 times higher than copper. Its density is 2.68 which means that aluminium is much lighter than copper. Its melting point is 655^0C. Like copper, it can be easily drawn into thin wires. Aluminium is soft metal but when alloyed with some other materials like magnesium, silicon or iron, it acquires higher mechanical strength and can be used for overhead transmission lines. Like copper, aluminium also forms an oxide layer over its surface when exposed to atmosphere and that layer prevents the material from further oxidation and acts as a resistance layer to corrosion.

Disadvantages: As aluminium is a soft material, there is always a possibility of loose contacts. Due, to the insulating property of aluminium oxide formed on the surface, it is difficult to solder aluminium wires. However for applications like winding of electrical machines and transformers, it is difficult to substitute aluminium for copper. This is because aluminium wires have lower tensile strength than that of copper.

Q.32 Explain

(i) Superconductivity. (ii) Resistivity. **(6)**

Ans:

(i) Superconductivity- The resistivity of most metals increases with increase in temperature and vice-versa. There are some metals and chemical compounds whose resistivity becomes zero when their temperature is brought near 0^0Kelvin (-273^0C). At this stage such metals or compounds are said to have attained superconductivity. Example – mercury becomes superconducting at approximately 4.5 Kelvin (-268.5^0C). Superconductivity was discovered by Heike Kamerlingh Onnes. The transition from normal conductivity to superconductivity takes place almost suddenly; it occurs over a very narrow range of temperature about 0.05^0K. The temperature at which the transition takes place from the state of normal conductivity to that of superconductivity is called transition temperature.

(ii) Resistivity: The resistance R of a wire having cross-sectional area A and len the relationship, - R α L and R α 1/A ; resulting Rα L/A or R = ρ L / A ; Where constant of proportionality and is called **resistivity** of a material and is defined as resistance between the two opposite faces of a meter cube of that material. The unit resistivity is ohm-m. Factors affecting resistivity are temperature, alloying, mechanical stressing, ageing.

Q.33 What is the effect of overheating on the life of an electric insulator? **(4)**

Ans:
An insulator is designed to withstand certain amount of heat. But when an insulator is overheated, dielectric losses will increase. Also overheating will affect the various important properties as electrical properties, mechanical strength, hardness, viscosity, solubility etc.

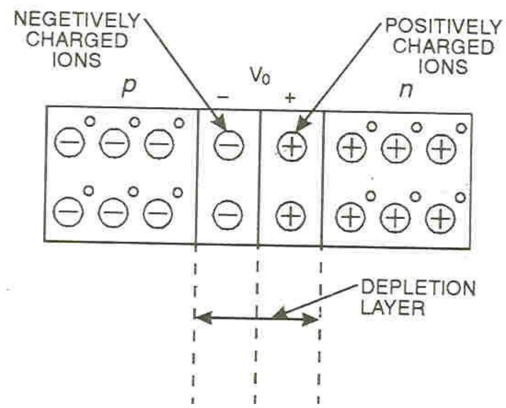
Q.34 Write notes on
(i) Brass and Bronze. (ii) Thermocouples.
(iii) P-N junction. (iv) Fuse materials. **(3.5 x 4 = 14)**

Ans:
(i)**Brass** - Is an alloy of copper and zinc with 60% copper and 40% zinc. Its electrical resistivity is 7.0X 10^{-8} ohm-m, which is higher than the copper resistivity. It is ductile and can be drawn into different shapes. It melts at 890^0C.Its specific gravity is 3.3.It has got an excellent corrosion resistance. It has got good mechanical properties. Brass is used as a structural and current carrying material in power switches, plugs, sockets, lamp holders, fuse holders, knife switches, sliding contacts for starters and reheostats, wave- guide components.

Bronze - Alloy of copper and tin. This alloy is very hard and brittle. Its corrosion resistance is better than brass. It is ductile and can be drawn into different shapes. In bronzes, which are used as electrical conductor, the content of tin and other metal is usually low as compared to the bronzes, which are used for mechanical applications. It is used for making structural elements for equipments. It is also used for making current carrying springs, sliding contacts, knife switches.

(ii) **Thermocouples:** Are used for the measurement of temperature. Depending on the range of temperature to be measured, proper materials are to be chosen for a thermocouple. If one junction called the cold junction is held at a known constant temperature, the emf produced becomes measure of the temperature of the other junction. The emf produced by a thermocouple is very small but it can be measured with reasonable accuracy by a sensitive moving coil millivoltmeter, which can be calibrated in terms of temperature. Some of the materials used for thermocouples are copper/constantan, iron/constantan, nickel/ nickelchromium.

(iii) **P – N junction**: When a p- type semiconductor is suitably joined to an n-type semiconductor the contact surface so formed is called p-n junction. All the semiconductor devices contain one or more p-n junction. P-N junction is fabricated by special techniques namely growing, alloying and diffusion methods. The p-type semiconductor is having negative acceptor ions and positively charged electrons. The n-type semiconductor is having positive donor ions and negatively charged electrons. When the two pieces are joined together and suitably treated they form a p-n junction. The moment they form a p- some of the conduction electrons from n-type material diffuse over to the p- type and undergo electron – hole recombination with the holes available in the valence Simultaneously holes from p-type material diffuse over to n- type material and undergo ho electron combination with the electrons available in the conduction band. This process is called diffusion. When a p-n junction is connected across an electric supply, the junction is said to be under biasing. The potential difference across the p- n junction can be applied in two ways, namely- forward biasing and reverse biasing. When the positive terminal of a dc source is connected to p-type, and negative terminal is connected n-type semiconductor of a p-n junction, the junction is said to be in forward biasing. When the positive terminal of a dc source is connected to n-type, and negative terminal is connected p-type semiconductor of a p-n junction, the junction is said to be in reverse biasing. With forward bias, a low resistance path is set up in the p-n junction, and hence current flows through the circuit. With reverse bias, a high resistance path is set up and no current flows through the circuit. This property is best suited for rectification of ac into dc.



p-n Junction

(iv) **Fuse materials:** Fuse is a protective device, which consists of a thin wire or strip. This wire or strip is placed with the circuit it has to protect, so that the circuit-current flows through it. When this current is too large, the temperature of the wire or strip will increase till the wire or strip melts thus breaking the circuit and interrupting the supply.

A fuse material should possess the following properties;-

Low resistivity – This means, thin wires can be used, which will give less metal vapour after melting of the wire. Less metal vapour in the arc gives lower conductivity and thus makes quenching of arc easier.

Low conductivity of the metal vapour itself.

Low melting point- This means that the temperature of the fuse material for normal currents stays at a low value. Originally lead was used as fuse material because of its low melting point. But as the resistivity of lead is high, thick wires are required. For rewirable fuses alloys of tin and lead or tinned copper wires are commonly used. In cartridge fuses silver and silver alloys are used in fuses of lower ratings and copper alloys are used in fuses of higher ratings.

Q.35 Discuss classification of insulating materials on the basis of physical and chemical structure.

Ans:

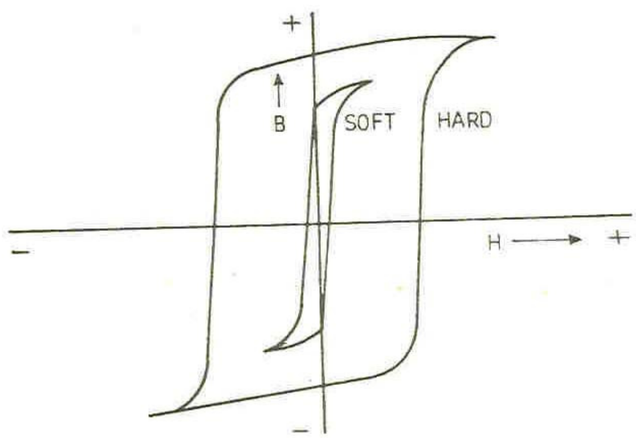
Insulating materials, on the basis of their physical and chemical structure may be classified into various categories as follows:

1. **Fibrous materials:** They are derived from animal origin or from cellulose, which is the major solid constituent of vegetable plants. The majority of materials are from cellulose. This includes paper, wood, card- board, cotton, jute and silk.
2. **Impregnated fibrous material:** The fibrous materials are impregnated with suitable impregnated oil, varnish, and epoxy - resin to improve its thermal, chemical and hygroscopic properties.
3. **Non-resinous materials:** Solid or semisolid insulations which are directly available in nature and are organic based come under this class. These materials are mineral waxes, asphalts, bitumen and chlorinated naphthalene.
4. **Insulating liquids:** Apart from working as insulation, they fulfil other important requirements like they offer good heat dissipation media, they used for extinguishing arcs in certain applications like circuit breakers. They include vegetable oils, fluorinated liquids, mineral insulating oils and synthetic liquids.
5. **Ceramics:** They are materials made by high temperature firing treatment of natural clay and certain inorganic matters. They are used as dielectric in capacitors, as insulators etc.
6. **Mica and mica products:** It is an inorganic mineral and one of the best natural insulating materials available. Mica is used as a dielectric in capacitors, as insulator. Some of the mica products are glass- bonded mica, synthetic mica, mica paper, manufactured mica.
7. **Asbestos and asbestos products:** These are strong and flexible fibres. It finds extensive use in electrical equipment as insulation because of its ability to withstand very high temperatures. Some of the asbestos products are: asbestos roving, asbestos paper, asbestos tapes and asbestos cement.
8. **Glass:** Glass is an inorganic material made by the fusion of different metallic oxides. It is normally transparent, brittle and hard. Glass finds its use in electrical industry because of its low dielectric loss, slow ageing and good mechanical strength. Glass is used in electrical-bushings, fuse bodies, insulators, radio and television tubes.
9. **Natural and synthetic rubber:** Natural rubber is obtained from the milky sap of rubber trees. It finds limited applications because it is rigid when solid, sticky when warm and gets oxidised, when exposed to atmosphere. Synthetic rubber are of various types such as butadiene rubber, butyl rubber, chloroprene and silicon rubber which are obtained by the polymerisation. Synthetic rubber, are used as insulating material for wires and cables. It is also used as jacketing material for cables.
10. **Insulating resins and their products:** Plastic or resins are of two types – one derived from plant and animals the other synthetic obtained from chemical reactions. Natural resins are used as binder material. It is used as thickening agent for manufacture of mineral insulating oils. Synthetic resins are used as insulation, manufacture of switches and instrument mountings, electrical bushings, radio and television cabinets etc.
11. **Laminates, adhesives, enamels and varnishes:** Laminates are multiple, thin layers or sheets of insulating materials like that of mica, paper, cloth, glass etc, bonded together. Adhesives, is a class of material compositions required to carry out bonding between two or more solid surfaces. Adhesives are used in the manufacture of laminated boards, coil winding cylinders, rods, tubes and special shaped insulators. Enamel is a fusible insulated coating of some organic base material, which is generally applied on conducting surface. Enamel finds extensive use in coating wires used for the windings of low rated motors, transformers, various types of instruments, etc. Varnish is a liquid, which when applied to a surface dries

resulting in hard shining coating which is resistant to air and water. Lacquer protecting wood and metal surface from external weather conditions.

Q.36 Draw the hysteresis loop for a soft magnetic material and compare it with the hysteresis lo of hard magnetic material. Give two examples of each. **(10)**

Ans:
Soft and Hard magnetic materials: All ferromagnetic materials are divided into two broad groups soft and hard magnetic materials.
Materials, which have, a steeply rising magnetization curve, relatively small and narrow hysteresis loop and consequently small energy losses during cyclic magnetization are called soft magnetic materials. Soft magnetic materials are therefore employed in building cores for use in alternating magnetic fields. Examples are nickel-iron alloy and soft ferrites. Fig below shows a typical narrow hysteresis loop for soft magnetic materials.
Magnetic materials, which have a gradually rising magnetisation curve, large hysteresis loop area and large energy losses for each cycle of magnetisation, are called hard magnetic materials. Such materials are used for making permanent magnets. Examples are carbon steel, tungsten steel alnico. Fig below shows a broad hysteresis loop for hard magnetic materials.



Hysteresis curves for soft and hard magnetic

Q.37 Write a note on
(i) Corrosion. (ii) Bimetals. **(4)**

Ans:
(i) **Corrosion :** The process of constant eating (destruction) up of metals (from the surface) by the surrounding is called as corrosion. The metals are corroded when exposed to the atmosphere. The metals are generally converted into their oxides. This oxide covers the surface of the metal, which results in the destruction of the metal. Rusting of iron is the most common example of corrosion in which iron makes iron oxide with reaction with the oxygen of the atmosphere. The iron oxide covers the surface in the form of brownish powder. Therefore the conducting material should be corrosion resistant.
(ii) **Bimetals:** A bimetal is made of two metallic strips of unlike metal alloys with different coefficients of thermal expansion. At a certain temperature the strip will bend and actuate a

switch or a lever of a switch. The bimetal can be heatedly directly or indirectly. W... the element bends so that the metal with the greater coefficient of expansion is on the ... of the arc formed while that with smaller coefficient is on the inside. When coole... element bends in the other direction. Alloys of iron and nickel with low coefficients ... thermal expansion are used as one element of the bimetallic strip. The other element consists of materials having high values of thermal expansion. Examples are iron, nickel, constantan, brass etc. Bimetallic strips are used in electrical apparatus and in devices such as relays and regulators.

Q.38 Give a short description of soft ferrites. **(5)**

Ans:
Soft ferrites and their applications: These are non- metallic compounds consisting of ferric oxide and one or two bivalent metal oxides such as Nickel oxide, Manganese oxide or Zinc oxide. They have the resistivity of about, 10^9 ohm-cm, which reduces eddy current losses at high frequency. The magnets made out of it have high coercive force and square hysteresis loop. Magnetic permeability of these materials is as high as 10,000 to 30,000. These materials are fabricated into shape such as- E, U, I, beads and self - shielding pot cores.
Applications – High frequency power transformers operating at 10 to 100 kHz, pulse transformers up to 1000 MHz, adjustable air gap inductors, recording heads make use of cores made of soft ferrites.

Q.39 Explain
(i) Eddy currents. (ii) Magnetostriction.
(iii) Permeability. **(3 x 3)**

Ans:
(i) Eddy currents: Magnetic materials placed in alternating magnetic fields also have eddy currents induced in them. This is because the material is subjected to rate of change of flux linkages and in accordance with Faraday's Law of electromagnetic induction, emfs are induced in the material causing currents, called eddy currents, to flow in the material. These currents cause loss of energy. This results in the heating up of the material. Eddy current loss is proportional to the square of the frequency and the square of the thickness of the material and inversely proportional to the resistivity of the material. In order to reduce this eddy currents loss thin sheets called laminations are used instead of solid core.

(ii) Magnetostriction: When ferromagnetic materials are magnetized a small change of dimensions of the material takes place. There is a small extension with corresponding reduction of cross-section of the crystals of which the material is made. When subject to rapidly alternating magnetic fields there is a rapid and continuous extension and contraction of the material. This is called magnetostriction. Magnetostriction is the major cause of hum in transformers and chokes.

(iii) Permeability – It is defined as the capability of the material to conduct flux. It is defined as the ratio of magnetic flux 'B' in a medium to the magnetic flux intensity 'H' at the same location in the medium, i.e. $\mu = B/H$, where B is plotted against H, a curve is obtained, called magnetization curve or B-H curve. Also $\mu = \mu_0\mu_r$ where μ_0 = absolute permeability of air and μ_r = relative permeability for air, μ_r =1.The permeability of any material is not a constant. The permeability at low value of H is called initial permeability. The common core materials such as low carbon steel, silicon steel have low initial permeability.

Q.40 Discuss the properties and uses of
(i) Cold rolled grain oriented steel.
(ii) ALNICO.

Ans:
(i) **Cold rolled grain oriented steel**: The grain orientation of silicon steel is obtained by a special technique called cold rolling. Sheet steel obtained in this process is called Cold Rolled Grain Oriented Steel. CRGO silicon steel is widely used for making transformer cores. The magnetising current required by transformers using CRGO steel is low. If CRGO sheet steel is used as core material for rotating machines, the core will be assembled from a large number of sections but this still will not result in grain orientations completely parallel with the flux path because of the circular nature of cores of rotating machines. Also assembling the core from sections of sheet steel will make the construction difficult and expensive.

(ii) **Alnico**: is an alloy of iron, cobalt, nickel and small amount of aluminium and copper. Properties are -
1. Saturation flux density is 1.2 Wb/m2.
2. More expensive than Alni, but magnetic properties are better than Alni.
3. Available in different grades, each having some different properties.
4. Hard and brittle, so it cannot be machined but has to be cast to shape and finished by grinding.
5. Magnets made with this alloy are smaller in size and lighter in weight than that made with tungsten steel.
6. The hysteresis loop is more rectangular.
7. Thermal and mechanical process, modify the crystal size and shape and thereby alter the shape of the hysteresis curve.

Uses: Alnico magnets find applications in loudspeakers, microwave devices, motors, generators, separators, vending machines and communication devices.

Q.41 Explain the factors which change the resistivity of a conducting material **(8)**

Ans:
Factors, which change the resistivity of conducting materials: -
Temperature- The electrical resistance of most metals increases with increase of temperature while those of semiconductors and electrolytes decreases with increase of temperature.

Alloying- Alloying is another factor, which affects the resistivity of a material. By the addition of some impurity to a metal, its resistivity can be changed. Alloys have higher resistivity than that of pure metal.

Mechanical stressing-When a material undergoes a mechanical treatment, its resistivity changes due to mechanical distortion of the crystal structure.

Age Hardening- Age hardening increases the resistivity of an alloy.

Q.42 Explain superconductivity and explain the effect of magnetic field on superconductors.

Ans:

A large number of metals become superconducting below a temperature, which is the characteristic of the particular metal. They have zero resistivity and the temperature at which this change takes place is called superconducting transition temperature. Metals, which are good conductors at room temperature like gold, silver, tin, do not exhibit superconducting properties. Whereas metals and compounds which have superconducting properties at certain temperatures are insulators at room temperature.

It is possible to destroy superconductivity by the application of a strong magnetic field. When, the magnetic field exceeds a certain critical value, the superconducting state disappears, the magnetic field penetrates the material and electrical resistance is restored.

Q.43 Give the properties and application of copper and aluminium. **(8)**

Ans:

Copper:

Properties

1) It is reddish brown in colour.
2) It is malleable and ductile and can be cast, forged, rolled, drawn and machined.
3) It melts at 1083^0C.
4) It easily alloys with other metals.
5) Electrical resistivity of copper is 1.7×10^{-8} Ω-m.
6) Tensile strength for copper is 210 MN/m^2.
7) It is highly resistant to corrosion.
8) It is a non-magnetic material.

Applications: - Copper is used in conductor wires, coil windings of generators and transformers, cables, busbars etc. Alloys of copper (like Brass, Bronze, Constantan, Manganin etc) are very useful for different purposes.

Aluminium:

Properties

1) Pure aluminium is silver white in colour.
2) It is a ductile metal and can be put to a shape by rolling, drawing and forging.
3) It melts at 655^0C.
4) It is resistant to corrosion.
5) Its tensile strength is 60MN/m^2.
6) It can be alloyed with other elements.
7) Annealing can soften it.
8) It has a higher thermal conductivity.

Applications: - Aluminium is widely used as conductor for power transmission and distribution. It is used in overhead transmission lines, busbars, ACSR conductors etc.

Q.44 What is polarisation? Explain. **(6)**

Ans:
When a dielectric material is subjected to an electric field the dipoles of the material oriented into a particular direction under the effect of the electric field. The material is said to be polarized and the phenomenon as polarization. In case of non polar material the atoms or molecules get polarized and induce dipole moments at atomic level. The individual dipoles get oriented towards field direction. The dipole moment (p) per unit volume is called polarization (P). The dipole moment is proportional to local electric field and the constant of proportionality is called polarisability. There are there types of polarization/polarisability

(i) Electronic or atomic polarization
(ii) Oriental or dipole polarization
(iii) Ionic polarization

Q.45 Give the properties and application of glass and cotton. **(8)**

Ans:
Glass: - It is an amorphous substance. It consists of silicates and in some cases borates and phosphates. Glass is an inorganic material made by the fusion of different metallic oxides. The properties of glass are –
i) It is transparent, brittle and hard
ii) Glass is insoluble in water and usual organic solvents
iii) It has low dielectric loss, slow ageing and good mechanical strength
iv) It is susceptible to destruction when sudden and high temperature cycles are applied
Uses – Glass is used in moulded insulating devices such as electrical bushings, fuse bodies, insulators. Glass is used as a dielectric in capacitors. Radio and television tubes, electrical laminated boards also make use of glass
Glass Products
a) Silica glass or fused quartz – Silica when heated to a temperature of fusion and then cooled is known as silica glass. This material has good electrical properties, low coefficient of expansion and high resistivity.
b) Borosilicate glass or Pyrex – This glass requires 28 per cent of boron oxide along with other oxides. They resist the effect of chemicals and moisture better than other glasses.
c) Fibre glass insulation – This is capable of withstanding high temperature. For most applications fibre glass is impregnated with materials like synthetic resins or with mineral oil. They possess good electrical and mechanical properties and sufficient flexibility to be moulded into required shapes.
d) Epoxy glass – It is made by joining glass fibre layer with a thermosetting compound. It is immune to alkalies and acids and is used in PCB making, terminal holders and instrument cases.
Properties
1) It has high resistivity & dielectric strength at ambient temperature.
2) Temperature coefficient is –ve and very large.
3) Tensile strength is low.
4) Coefficient of thermal expansion considerably varies with composition.
5) It is susceptible to destruction when used in high and low temperature cycle.
6) Surface resistivity falls considerably when exposed to moisture.

Applications:- Moulded glass is used in electrical bushings, fuse bodies, insulators. It is used as dielectric in capacitors. It is used in the manufacture of radio and television tubes, electrical lamps, and laminated boards. It is used to make optical fibers used [in] communications.

Cotton:- This is base material for insulating fibres. Properties of cotton can be improved [by] impregnating with varnish.

Properties

1) It is hygroscopic. Moisture absorption is 70%.
2) It has low dielectric strength.
3) Its resistivity changes with moisture content.
4) It can be used up to 110^0C.
5) Its density is 1.54gm/cm^3.

Applications:- It is used as insulating material for armature winding of small and medium sized machines, small transformers, coils and chokes. Cotton covered wires are used for winding of small magnet coils.

Q.46 Give the names of four alloys along with their composition, which are used for making heater and thermocouple elements. **(6)**

Ans:

Constantan or Eureka { (55-60%) Cu, (45-40%)Ni}
German Silver (an alloy of CU, Zn, Ni)
Manganin (86% Cu, 2% Ni, 12% Mn)
Nichrome (61% Ni, 15% Cr, 24% Fe)

Q.47 Explain ferroelectricity and piezoelectricity. **(8)**

Ans:

Ferroelectricity: - Ferroelectric materials have a high dielectric constant, which is non-linear i.e., it depends to a considerable extent on the intensity of the electric field. Such materials exhibit hysterisis loops, i.e. the polarization is not a linear function of applied electric field. If the center of gravity of the positive and negative charges in a body does not coincide in the absence of an applied electric field, the substance has an electric dipole moment. So material is said to be spontaneously polarized and called ferroelectric material. Such a substance is called ferroelectric. It contains small regions called ferroelectric domains and all dipoles are parallely oriented in domain but different domains are randomly oriented in the absence of an external electric field. When the temperature exceeds a certain value called the Curie point, the substance loses its ferroelectric properties. Ex. Rochelle salt, Potassium dihydrogen phosphate, Barium titanate.

Piezoelectricity:- Piezoelectricity provides us a means of converting electrical energy to mechanical energy and vice versa.

When an electric field is applied to a substance it becomes polarized, the electrons and nuclei assume new geometric positions and the mechanical dimensions of the substance are altered. This phenomenon is called electrostriction. The reverse effect i.e. production of polarization by the application of mechanical stresses can take place only if the lattice has no centre of symmetry, this phenomenon is known as piezoelectricity. Ex. Rochelle salt, Quartz, Barium titanate.

Applications: Piezo electric materials serve as a source of ultrasonic waves. At sea they may be used.

Q.48 Explain the electrical contact materials with examples.

Ans:

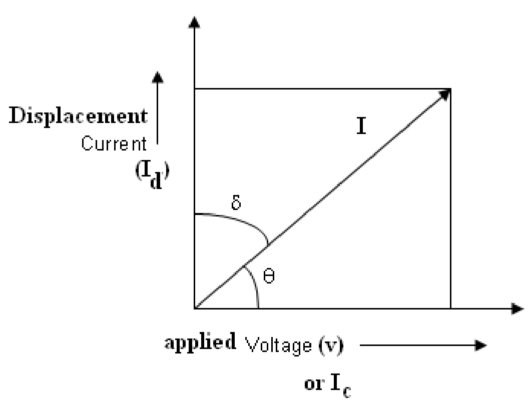
Electrical contact materials: - A number of elements in their pure form such as copper, molybdenum, nickel, palladium, platinum, silver and tungsten are mostly acceptable make and break contact materials. Alloys of the above mentioned elements are also used for electrical contacts. Silver is an important contact material. Copper added to silver reduces the cost of the contact material. Whereas a combination of tungsten and silver results in a contact material having the advantages of the individual metals. A silver tungsten contact material will have high thermal and electrical conductivity. Copper contacts are used in control relays, motor starter switches and tap changers. Copper contacts may be used for currents (a.c or d.c) upto 500A and voltages (a.c or d.c) upto 600V. Contacts made of silver and silver alloys are widely used. Silver has better resistance to oxidation compared to copper and can be used for voltages (a.c or d.c) upto 600V and direct currents upto 50A and alternating currents upto 200A. Such contacts are used in all types of industrial applications, relays, generator cut outs, thermal overload devices and thermostatic control.

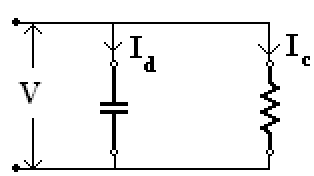
Q.49 Explain the terms dielectric constant and dielectric loss. **(7)**

Ans:

Dielectric Constant or Permittivity: - Every insulating material possesses an electrical capacitance. The capacitance of such unit depends upon dimensions and kind of dielectric placed between the capacitor plates. The capacitance of a parallel plate capacitor may be calculated from the formula $C = \in A/t$ where $\in$ is the permittivity of the material in F/m, A = Area of the plates and t = thickness of dielectric. Also $\varepsilon = C / C_0$, where C is the capacity in presence of dielectric and C_o is the capacity in air or vacuum or in absence of dielectric.Thus permittivity $\in$ of a material is a measurement of its ability to form an electrical capacitance of the insulating material, the dimensions of the capacitor being taken equal. Dielectric constant or permittivity is not a constant but varies with temperature and frequency.

Dielectric loss angle: - when an insulating material is subjected to alternating voltage, some of the electric energy is absorbed by the insulation and is dissipated as heat. Energy absorbed by the material in unit time is called dielectric loss. A perfect dielectric has a current, which leads the voltage by 90^0, but the practical dielectric material has a current, which leads the voltage by less than 90^0. The dielectric phase angle is θ and $\delta = 90^0 - \theta$ is the dielectric loss angle.





Also I is the phasor sum of I_d and I_c , where Ic is the conduction current which is in phase with the applied voltage and Id is the displacement current which is in quadrature phase with applied voltage.

Q.50 Explain n-type and p-type semiconductors. **(6)**

Ans:

n – type semiconductor:- When small amount of pentavalent impurity (group V elements) is added to a pure semiconductor providing a large number of free electrons in it, the extrinsic semiconductor thus formed is known as n- type semiconductor. The addition of pentavalent impurities such as arsenic and antimony provide a large number of free electrons in the semiconductor crystal. Such impurities, which produce n- type semiconductors, are known as donor impurities because each atom of them donates one free electron to conduction band in the semiconductor crystal.

p - type semiconductor:- When small amount of trivalent impurity group III elements is added to a pure semiconductor providing a large number of holes in it, the extrinsic semiconductor thus formed is known as p- type semiconductor. The addition of trivalent impurities such as gallium and indium provide a large number of holes in the semiconductor crystal. Such impurities, which produce p- type semiconductors, are known as acceptor impurities because each atom of them creates one hole, in valence band, which can accept one electron.

Q.51 Give the properties and uses of silicon iron alloy and nickel iron alloy. **(6)**

Ans:

Silicon Iron alloy:- Pure iron has low resistivity, which results in higher eddy current losses. These losses can be minimized by increasing the resistivity of the material, which is achieved by adding 1 to 4 % of silicon to iron. Silicon increases the electrical resistivity of iron. It reduces hysteresis loss. The magnetostriction effect is also reduced. Silicon also improves resistance to corrosion and oxidation and increases hardenability.

Silicon Iron alloy is used in the form of thin sheets called laminations. These laminations are used in transformers, small machines and large turbo- generators.

Nickel Iron alloy:- A group of iron alloys containing between 40 to 90 % nickel have much higher permeabilities at low flux densities and lower losses than ordinary iron. The important alloys are permalloy and mumetal. Mumetal has lower permeability but higher resistivity. Addition of small amounts of other elements to nickel iron alloys improves their magnetic properties. Nickel improves strength, toughness and resistance to fatigue. It also lowers the critical cooling rate and hence increases hardenability.

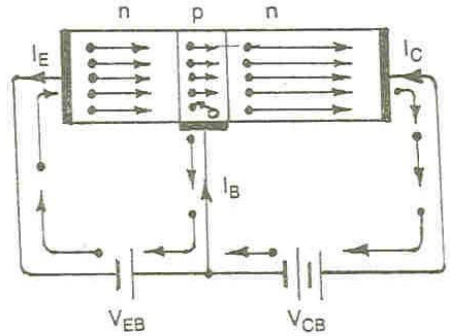
Nickel Iron alloy is widely used in transformer cores and loading coils for telephone circuits, instrument transformers, for magnetic circuits of instruments, for magnetic screens of electronic equipments.

Q.52 Explain the working of an npn transistor. **(8)**

Ans:

Working of npn transistor:- An npn transistor is shown in the fig. The emitter base junction is forward biased while the collector base junction is reversed biased. The forward biased voltage V_{EB} is quite small, whereas the reverse biased voltage V_{CB} is considerably large.

As the emitter base junction is forward biased, a large number of electrons (majo in the emitter (n-type region) are pushed towards the base. This constitutes the current I_E. When these electrons enter the p-type material (base), they tend to combine holes. Since the base is lightly doped and very thin, only a few electrons (less than 5 combine with the holes to constitute base current I_B. The remaining electrons (more than 95%) diffuse across the thin base region and reach the collector space charge layer. These electrons then come under the influence of positively biased n- region and are attracted or collected by the collector. This constitutes the collector current I_C. Thus, it is seen that almost the entire emitter current flows into the collector circuit. The emitter current is the sum of the collector, and base current. $I_E = I_C + I_B$.



npn Transistor Circuit

Q.53 What is meant by doping? How does it affect a semiconductor? **(6)**

Ans:

Doping: - The process by which an impurity is added to semiconductor is known as doping. A semiconductor to which an impurity at controlled rate is added to make it conductive is known as an extrinsic semiconductor. The purpose of adding impurity in the semiconductor crystal is to increase the number of free electrons or holes to make it conductive. If pentavalent impurity is added to a pure semiconductor a large number of electrons will exist in it. If a trivalent impurity is added a large number of holes will exist in the semiconductor.

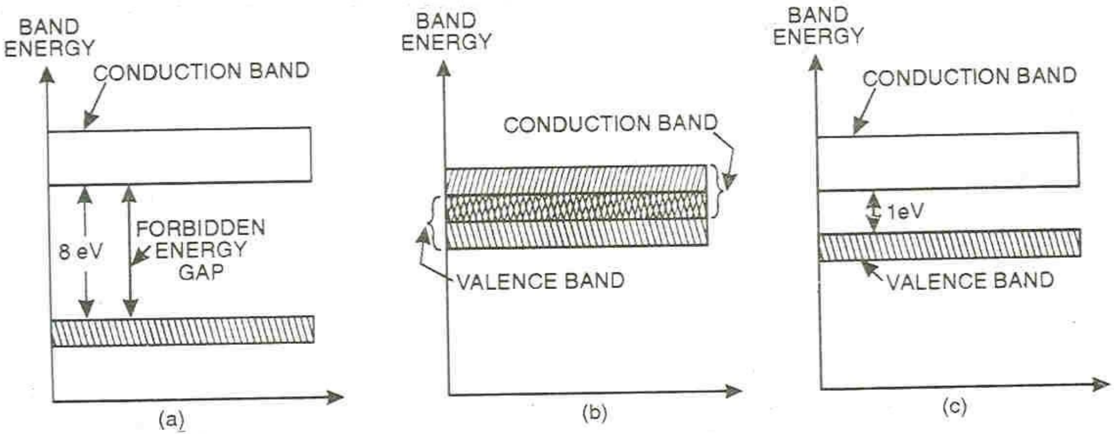
Q.54 Explain the factors affecting permeability and hysterisis loss. **(8)**

Ans:

Factors affecting permeability and hysterisis loss: - If the initial permeability is high, the hysterisis loss is low and vice versa. The permeability and the hysterisis loss depend upon the physical condition and chemical purity of the sample. The crystals of a ferromagnetic material when cold worked experience deformation as a result of which the material has very poor magnetic properties. Due to the internal strains on the domains, greater magnetic field is required to give a definite magnetization. Therefore the permeability decreases and the hysterisis loss is increased. A material, which has suffered magnetic damage due to cold work, may be heated to a sufficiently high temperature when the magnetic properties will be restored. The highest magnetic permeability and the lowest hysterisis loss that can be obtained are limited by the impurity content of the materials. Impurities affect the regular geometric pattern of the crystal and are harmful to the magnetic properties. The main impurities in the magnetic materials used for transformer cores and electrical machinery are carbon, sulphur, oxygen and nitrogen. Carbon is most detrimental and the amount is kept to a low value of 0.01% in commercial materials.

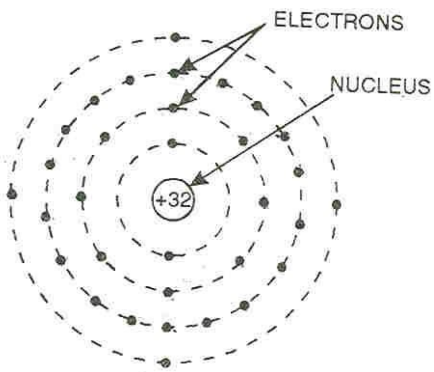
Q.55 Write notes on
(i) Classification of materials on the basis of energy band. **(7)**
(ii) Germanium and silicon. **(7)**

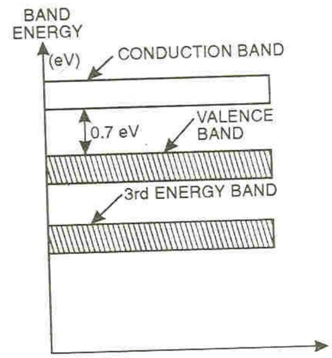
Ans:
(i) Classification of materials:- On the basis of energy band materials are classified as insulators, conductors, semiconductors.
Insulators:- Substance like wood, glass, which do not allow the passage of current through them are known as insulators. The valence band of these substances is full whereas the conduction band is completely empty. The forbidden energy gap between valence band and conduction band is very large (8ev) as shown in fig. (a). Therefore a large amount of energy, i.e. a very high electric field is required to push the valence electrons to the conduction band. This is the reason, why such materials under ordinary conditions do not conduct at all and are designated as insulators.
Conductors:- Substances like copper, aluminium, silver which allow the passage of current through them are conductors. The valence band of these substances overlaps the conduction band as shown in fig. (b). Due to this overlapping, a large number of free electrons are available for conduction. This is the reason, why a slight potential difference applied across them causes a heavy flow of current through them.
Semiconductors:- Substances like carbon, silicon , germanium whose electrical conductivity lies in between the conductors and insulators are known as semiconductors. The valence band of these substances is almost filled, but the conduction band is almost empty. The forbidden energy gap between valence and conduction band is very small (1ev) as shown in fig. (c). Therefore comparatively a smaller electric field is required to push the valence electrons to the conduction band. This is the reason, why such materials under ordinary conditions do not conduct current and behaves as an insulator. Even at room temperature, when some heat energy is imparted to the valence electrons, a few of them cross over to the conduction band imparting minor conductivity to the semiconductors. As the temperature is increased, more valence electrons cross over to the conduction band and the conductivity of the material increases. Thus these materials have negative temperature co-efficient of resistance.



Energy Band Diagrams

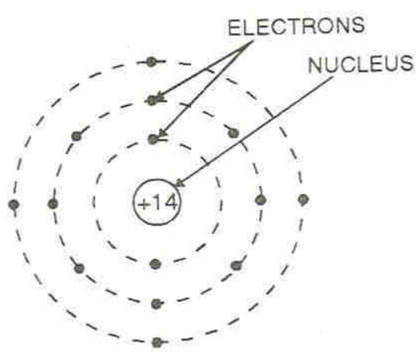
(ii) Germanium:- It is one of the most common semiconductor material used for application in electronics. The atomic number is 32. The number of electrons in the first, second, third and fourth orbit are 2, 8, 18and 4. It is clear that germanium atom has four valence electrons in the outermost orbit. It is known as tetravalent element. The germanium atoms are held together through covalent bonds. The forbidden gap in this material is very small 0.7ev. So small energy is sufficient to lift the electrons from valence to conduction band.

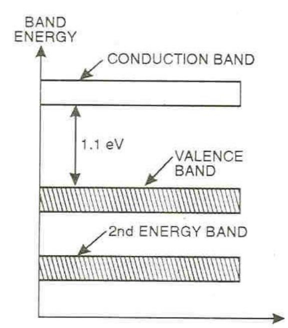




Atomic structure of Germanium **Energy Band Diagram of Germanium**

Silicon:- Silicon is another most commonly used semiconductor. Its atomic number is 14. The number of electrons in first, second and third orbit are 2, 8 and 4. The silicon atoms are also having four valence electrons and are known as tetravalent element. The various silicon atoms are held together through covalent bonds. The atoms of silicon are arranged in orderly pattern and form a crystalline structure. The forbidden energy gap in this material is quite small i.e. 1.1ev. It also needs small amount of energy to lift the electrons from valence to conduction band.





Atomic structure of Silicon **Energy Band Diagram of Silicon**

Q.56 What is resistivity? Explain the effect of temperature on the resistivity of conducting materials and define temperature coefficient of resistance. **(8)**

Ans:
Resistivity of a material may be defined as the resistance of the material having unit length and unit cross sectional area. Unit is ohm-m.

The resistance of most metals increases with increase of temperature whil semiconductors and electrolytes decreases with increase of temperature. Many meta vanishing resistivity at absolute zero of temperature. The phenomenon is know superconductivity. The resistance of a conductor changes with temperature according the law $R_t = R_O (1 + \alpha t)$. Where R_t and R_O are the resistances at "t" and zero degrees centigrade and α the temperature coefficient of resistance.

Temperature coefficient of resistance is defined as the change in resistance of a material per ohm per degree change in temperature. It is represented by α.

Q.57 Explain the effect of temperature on electrical conductivity of metals. **(6)**

Ans:
As the temperature is increased, there is a greater thermal motion of atoms which decreases the regularity in the atom spacing with a consequent decrease in the mobility of the electrons. The resistivity of most metals therefore increases with an increase in the temperature. Since the number and the energy of the electrons at top of the Fermi distribution curve vary insignificantly with temperature, the change in temperature must be associated with a change in the mean free path. In a perfectly regular lattice, each electron will exist in a particular energy state and will have a fixed velocity. Practical metals do not have a perfect lattice because of impurities and because of deviation of atoms about their mean position due lattice oscillations. Since the lattice oscillations decrease at low temperature the scattering of electron waves falls and the conductivity therefore increases rapidly. As the temperature, approaches absolute zero. There is a limiting value beyond which the conductivity will not increase. In general purer the specimen higher is the limiting conductivity. The conductivity of many metals decreases linearly as the temperature is increased above the room temperature but below this temperature the conductivity increases markedly.

Q.58 Give the applications of carbon and steel. **(8)**

Ans:
Carbon: - Carbon materials used in the field of electrical engineering are manufactured from graphite and other forms carbon like coal etc. It has very high value of resistivity. It has negative temperature coefficient of resistance. It is pressure sensitive and has low surface friction.
Applications: - Carbon is used in applications like brushes for electrical machines and apparatus, electrodes for electric- arc furnaces, in automatic voltage regulators for making the pressure sensitive pile resistors, components for telecommunication equipment, battery cell element, arc lamps etc.
Steel: - Steel contains iron with a small percentage of carbon added to it. Iron itself is not very strong but when carbon is added it assumes very good properties. Mild steel contains 0.25% of carbon; medium steel contains 0.45% of carbon and high carbon steel about 0.70% of carbon and above. The resistivity of steel is 8 to 9 times higher than that of copper.
Applications: - Galvanised steel is used in overhead telephone wires and earth-wires. Steel alloyed with chromium and aluminium is used for making starter rheostats in which lightness combined robustness and good heat dissipation are important.

Q.59 Explain the phenomenon of breakdown in dielectric materials. **(6)**

Ans:
Breakdown in dielectric materials: - The electric strength at breakdown is defined as minimum electric stress usually expressed in kV/cm which cause rupture or breakdown of the material under specified conditions of temperature, duration, waveform, frequency and type of electrodes. The electric strength of a material depends on its composition, thickness, temperature, and moisture content and to some extent on the time of application of the applied voltage. The shape of the waveform and steepness of the wave front of the applied voltage also affect it There is no definite relationship between these variables, but in general for sheet materials, the electric strength is an inverse function of the thickness and time and decreases with increasing temperature and moisture content. At breakdown the high electric stress is assumed to cause an inter-atomic displacement of the orbital electrons, which alters the atomic structure causing heating and a conducting path in the material. The breakdown mechanisms of gaseous, liquid and solid dielectrics are different in nature.

Q.60 Give the properties and applications of mica and PVC. **(8)**

Ans:
Mica– Mica is an inorganic material. It is one of the best insulating materials available. From the electrical point of view, mica is of two types – Muscovite mica and Phologopite mica.
Muscovite mica – Chemical composition is $KH_2\,Al_3\,(SiO_4)_3$. The properties are
i) Strong, tough and less flexible
ii) Colourless, yellow, silver or green in colour
iii) Insulating properties are very good
iv) Abrasion resistance is high
v) Alkalies do not affect it
Uses – Muscovite mica is used where electrical requirements are severe. Due to high dielectric strength, it is used in capacitors. It is also used in commutators due to high abrasion resistance.
Phologopite mica – Chemical composition is $KH\,(Mg\,F)_8\,Mg\,Al\,(Si\,O_4)_3$. The properties are
i) Amber, yellow, green or grey in colour
ii) Greater structural stability, being tougher and harder than muscovite mica, less rigid
iii) Resistant to alkalies, but less to acids
iv) Greater thermal stability than that of muscovite mica
Uses – It is used when there is greater need of thermal stability as in domestic appliances like irons, hotplates, and toasters.
Mica products
(i) Glass bonded mica – Ground mica flakes and powdered glass when moulded makes glass bonded mica. This material is impervious to water and chemically stable. This is used in high humidity and high ambient temperatures.
(ii) Mica paper – Mica is broken into small particles in aqueous solution. Out of this sheets of mica paper are produced which are used as insulation for armature and field coils of rotating machines.
(iii) Manufactured mica – Mica flakes held together with adhesives is called manufactured mica. It is used in commutators, electrical heating devices, motor slot insulation, transformers, etc.
PVC– This is obtained from polymerisation of hydrogen chloride and acetylene in the presence of a catalyst like peroxides at about 50^0 C.
Properties: - 1. It is a white powder.

2. This resin is hard, very little flexible and insoluble in many solvents.
3. Properties like mechanical strength; porosity, flexibility, moisture absorption and el[...] properties can be changed by adding certain materials (fillers).
4. PVC has good mechanical and electrical properties.
5. It resists flame, most solvents and sunlight.
6. It is non-hygroscopic.

PVC is widely used as insulation and jacketing material for wires, cables.
PVC films, tapes and sheets are used as insulation for dry batteries and conduit pipes.

Q.61 Give some applications of constantan, German silver, manganin, and nichrome. **(1½ x 4)**

Ans:
Applications: -
Constantan: - It is an alloy of copper and nickel and is used in precision resistors and thermocouples, motor starters.
German silver: - It is an alloy of copper, nickel and zinc. It is used in electrical measuring instruments.
Manganin: - Alloy of manganese, copper and nickel. It is used for making precision resistances and shunts in measuring instruments and for making their coils.
Nichrome: - It is an alloy of nickel, chromium, iron and manganese. It is used for making heating elements for electric iron and other heating appliances.

Q.62 Explain ionic and oriental polarisation. **(8)**

Ans:
Ionic Polarisation: The ionic polarisation takes account of the fact that when some of the atoms in a molecule have an excess positive or negative charge (resulting from the ionic character of the bonds), an electric field will tend to shift positive ions relative to negative ions. This leads to an induced moment of different origin from that induced by electron clouds shifting relative to nuclei. The ionic polarisability measures the shift of the ions relative to each other just as the electronic polarisability measures the shift of the electrons relative to the nucleus.
Orientational Polarisation: If two different atoms form a chemical bond, one of the two is more likely to part with one or more of its valence electrons than the other. When Z_{Ae} and Z_{Be} represents the nuclear charges of the two atoms where Z represents the atomic numbers nd if A atom has a tendency to give valence electrons to the atom B, there are more than Z_B electrons around the nucleus of atom B and fewer than Z_A electrons around that of atom A. So atom A is more electropositive than atom B. Consequently, the bond between A and B may be said to be of an ionic kind and therefore it is clear that the molecule AB carries an electric dipole moment even in the absence of an electric field. For molecule consisting of more than two atoms, several bonds may carry a permanent dipole moment and the resulting permanent dipole moment as a whole is obtained by vector addition of the moments associated with the various bonds. When an external field 'E' is applied to a molecule carrying a permanent dipole moment, the former will tend to align the permanent dipole along the direction of E. The contribution of this process of orientation of permanent dipoles to the polarisation P is called **Orientational or Dipolar Polarisation.**

Q.63 What are superconductors? Give some applications of superconductors. **(6)**

Ans:

Superconductors - The resistivity of most metals increases with increase in temperature and vice-versa. There are some metals and chemical compounds whose resistivity becomes zero when their temperature is brought near 0^0Kelvin (-273^0C). At this stage such metals or compounds are said to have attained superconductivity. Example – mercury becomes superconducting at approximately 4.5 Kelvin (-268.5^0C). Heike Kamerlingh Onnes discovered superconductivity. The transition from normal conductivity to superconductivity takes place almost suddenly; it occurs over a very narrow range of temperature about 0.05^0K. The temperature at which the transition takes place from the state of normal conductivity to that of superconductivity is called transition temperature.

Superconductors are used for producing magnetic fields of about 50 Tesla. Magnetic energy can be stored in large superconductors and drawn as required to counter the voltage fluctuations during peak loading. Superconductors can be used to perform logic and storage functions in computers. As there is no, I^2R losses in a superconductor, so power can be transmitted through the superconducting cables without any losses. By using superconducting materials it will be possible to have electric motors etc. in small sizes having very high efficiency. Superconducting electromagnets will work without producing any heat.

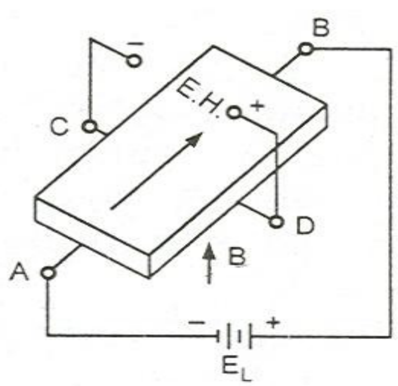
Q.64 Explain Hall Effect and give some applications of Hall Effect. **(8)**

Ans:

Hall Effect: When a current carrying conductor is placed in a magnetic field, a voltage is produced which acts in the perpendicular direction to the current as well as magnetic field. This voltage is proportional to the current and intensity of the magnetic field. This is called Hall Effect. If a voltage 'E_L' is applied across the opposite contacts A and B to a bar of semi-conductor material as shown in the figure, a current will flow. If the bar is placed at right angles to the magnetic field 'B', an electric potential E_H is generated between the other two contacts C and D. This voltage is a direct measure of the magnetic field strength and can be detected with a simple voltmeter.

Applications of Hall Effect:

1. It is used for determining whether a semi-conductor is N-type or P-type.
2. It is used in determining the carrier concentration.
3. In calculating the mobility.
4. It is used in flux meters, which measure magnetic fields.



Q.65 Explain the effect of impurity on the conductivity of a semiconductor.

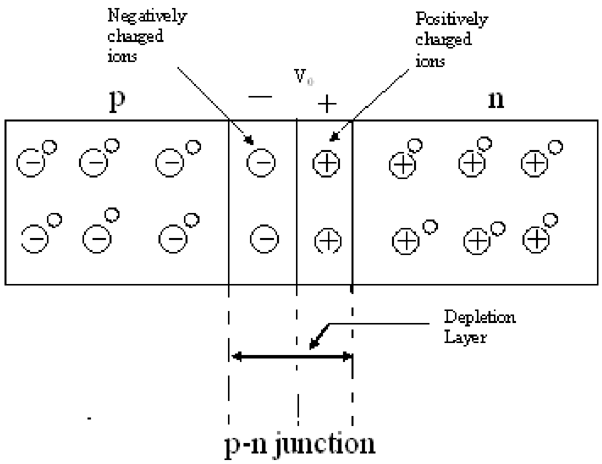
Ans:
To make a semi-conductor conductive, a small amount of suitable impurity is added. It is then called extrinsic semi-conductor. Depending upon the type of impurity added, extrinsic semi-conductor might be classified as n-type and p-type semi-conductor.

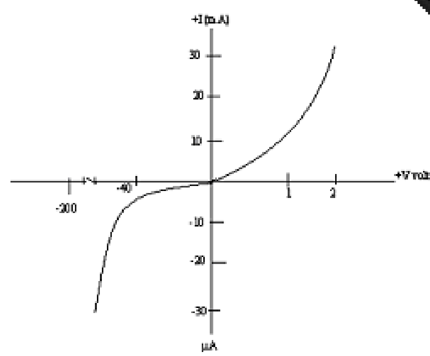
n-type semi-conductor: The addition of pentavalent impurity such as arsenic and antimony provide a large number of free electrons in the semi-conductor crystal. Such impurities, which produce n-type semi-conductors, are known as donor impurities, because each atom of them donates one free electron to the semi-conductor crystal. When an electric field is applied to a crystal of n-type material having sufficient donor impurity the effect of the donor electrons is much more predominant than the effect of electron hole pairs achieved by the breaking of the covalent bonds. The Fermi level of an n-type semi-conductor occurs in the forbidden energy gap but near to the bottom of the conduction band.

p-type semi-conductor: When a trivalent impurity like indium, gallium are added to a semi-conductor, a large number of holes are created and the semi-conductor formed is known as p-type semi-conductor. Such impurities, which produce p-type semi-conductor, are known as acceptor impurities. Conduction is now by means of positive holes. The Fermi level in this case occurs near the top of the valence bonds in the forbidden energy gap.

Q.66 Explain a p-n junction. **(6)**

Ans:
P – N junction: When a p- type semiconductor is suitably joined to an n-type semiconductor the contact surface so formed is called p-n junction. All the semiconductor devices contain one or more p-n junction. P-N junction is fabricated by special techniques namely growing, alloying and diffusion methods. The p-type semiconductor is having negative acceptor ions and positively charged holes. The n-type semiconductor is having positive donor ions and negatively charged electrons. When the two pieces are joined together and suitably treated they form a p-n junction. The moment they form a p-n junction, some of the conduction electrons from n-type material diffuse over to the p- type material and undergo electron – hole recombination with the holes available in the valence band. Simultaneously holes from p-type material diffuse over to n- type material and undergo hole-electron combination with the electrons available in the conduction band. This process is called diffusion. When a p-n junction is connected across an electric supply, the junction is said to be under biasing. The potential difference across the p- n junction can be applied in two ways, namely- forward biasing and reverse biasing. When the positive terminal of a dc source is connected to p-type, and negative terminal is connected n-type semiconductor of a p-n junction, the junction is said to be in forward biasing. When the positive terminal of a dc source is connected to n-type, and negative terminal is connected p-type semiconductor of a p-n junction, the junction is said to be in reverse biasing. With forward bias, a low resistance path is set up in the p-n junction, and hence current flows through the circuit. With reverse bias, a high resistance path is set up and no current flows through the circuit. This property is best suited for rectification of ac into dc.



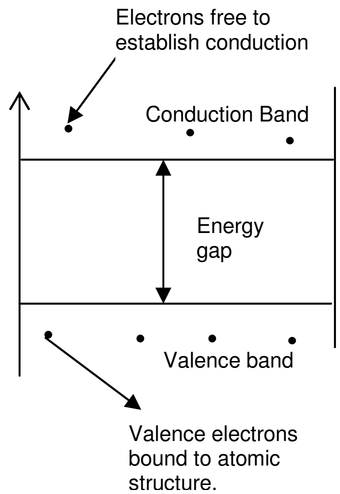


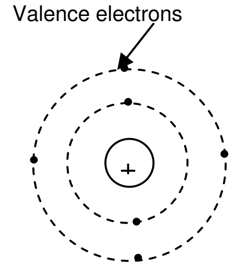
Characteristics of a typical p-n junction diode

The leakage current for reasonable voltages in the reverse direction ranges between 0.01 and 1 μA depending on the semiconductor material and the doping level of the impurities. Several variations of this simple diode have been developed.

Q.67 Explain the terms: valence band, conduction band, valence electrons, and energy gap with the help of suitable diagrams. **(2 x 4)**

Ans:
Valence Electrons: The electrons in the outermost orbit are called valence electrons, since these electrons are fixed in the outer orbit with the neighbouring atom in a crystal. These electrons being far away from the nucleus possess the least binding energy and are easily affected by external influences. A very little energy is required to free them from their parent atoms. When the valence electrons of an atom are less than four, the material is usually a metal or a conductor. When the number of electrons in the outermost orbit is more than four, the material is usually an insulator. When the number of valence electrons in an atom is exactly four, the material is a semi-conductor.
Conduction Band: It represents a larger group of permissible energy levels. The orbits in the conduction band are very large and an electron in this band experiences almost negligible nucleus attraction. In fact an electron in the conduction band does not belong to any particular atom and it moves randomly throughout the solid. So these electrons in the conduction band are called free electrons. If any material has empty conduction band, no conduction band is possible.
Valence Band: It represents the range of energies possessed by the valence electrons, that is the electrons in the outermost orbit. This band has the electrons having the highest energy and it can be partially or completely filled. When this band is filled, it means that the electrons occupy all permissible energy levels in the band and no electrons can move in a filled band. Thus an electron in a completely filled band cannot contribute to electric current. The partially filled band can accommodate more electrons.
Energy Gap: The minimum amount of energy that is required to lift an electron from a valence band to the conduction band is called energy gap, and is represented by the separation between these two bands, i.e., valence and conduction bands. This gap is also called forbidden energy gap. It also indicates the bondage of valence electrons to the atom. This means if the energy gap is more, then the valence electrons are tightly bound to the nucleus. This energy gap determines the conductivity of a material.



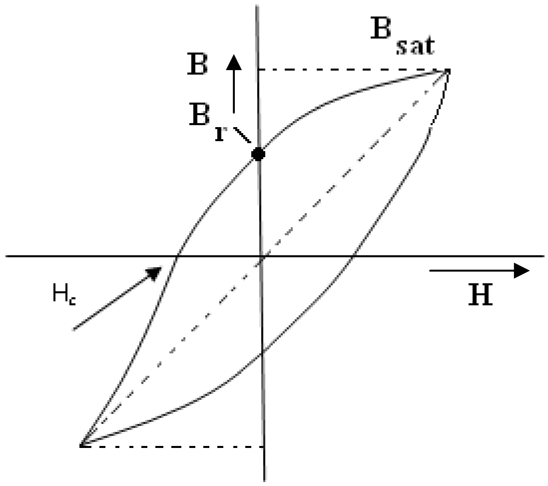


Q.68 Explain ferrites and its uses in high frequency devices. **(6)**

Ans:
A group of magnetic alloys exhibit the property of magnetisation, which changes, with percentage of different constituent atoms in the alloy. Example $XOFe_2O_3$ with X= Mn, Co, Ni, Mg, Zn, Cd or Fe++. The alloys are called ferrites. Manganese ferrite is a mixture of manganese oxide and iron oxide. Ferrites are widely used in computers and in microwave equipment. Ferrites are advantageous at high frequencies because of low eddy current losses. The ferrites crystallise in what is known as the spinel lattice. The resistivity of ferrites is much higher than that of the ferromagnetic metals. Ferrites are hard and brittle materials, which cannot be shaped by ordinary machining processes. Ferrites are also used in transducer applications; recording tapes, compact aerials for radio sets, focussing magnets of TV picture tubes.

Q.69 Explain the hysteresis loop of a magnetic material. **(6)**

Ans:
Hysterisis loop-Below the Curie temperature all-ferromagnetic materials exhibit the well-known hysterisis in the B (flux density) versus H (intensity of magnetic field) curves. Starting with an unmagnetised specimen, B varies reversibly with H for small fields. Since there is no hysterisis in this region, one defines the initial permeability μ_r in the same way as the permeability of a paramagnetic material. As the field H is increased, B begins to increase rapidly. Ultimately approaches a saturation value B_{sat}. Upon reducing the value of H from the saturation region to zero, it is observed that there remains a flux density B_r called remanent flux density. Since H = 0, the material must be permanently magnetised, infact the magnetisation corresponding to B_r is equal to B_r/μ_r. The field H_c required to reduce the flux density to zero is called coercive force. The energy required to take the material through one complete cycle of magnetisation is proportional to the area enclosed by the loop.



Hysterisis Loop

Q.70 Give the classification of magnetic materials and explain ea

Ans:

Diamagnetic Materials: - These are the materials whos magnetic dipoles. If an external magnetic field is applied to a magnetization in the direction opposite to the applied fiel relative permeability is negative. These are hardly used as magnetic material in electrical/ electronic engineering applications. Ex. Aluminium oxide, copper, gold, barium chloride.

Paramagnetic Materials: - The atoms of these materials contain permanent magnetic dipoles. Individual dipoles are oriented in random fashion such that resultant magnetic field is zero or negligible. For these materials relative permeability is slightly greater than unity and it is independent of magnetizing force. Ex. Chromium chloride, chromium oxide, manganese sulphate, air.

Ferromagnetic Materials: - These are materials in which magnetic dipoles interact in such a manner that they tend to line up in parallel. A ferromagnetic substance consists of a number of regions or domains, which are spontaneously magnetized. The direction of magnetization varies from domain to domain. The resultant magnetization is zero or nearly zero. The relative permeability is very high. The ferromagnetic materials are widely used in industries. Ex. Iron, nickel, cobalt.

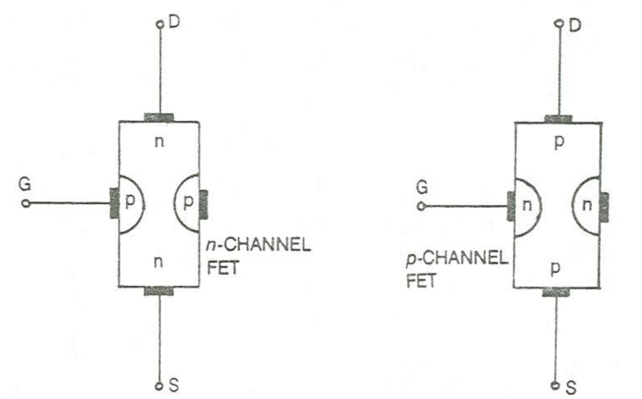
Antiferromagnetism: - The magnetic dipoles are aligned antiparallel to each other. Antiferromagnetic materials are not so well known as the common ferromagnetic materials. Only a few, such as manganese, chromium, ferrous, nickel oxides exist. The phenomenon occurs below a certain temperature known as the Neel temperature.

Ferrimagnetic Materials: - In these materials unequal magnetic dipoles are lined up antiparallel to each other. Permeabilities are of the order that of ferromagnetic materials under ordinary conditions the magnetic characteristics of ferromagnetic materials are similar to those of ferromagnetic materials, as they show spontaneous magnetization below a certain temperature, example: magnetite, nickel ferrite. The susceptibility of these is given by $\chi = C/T \pm \theta$ where C is curie constant, T is temperature

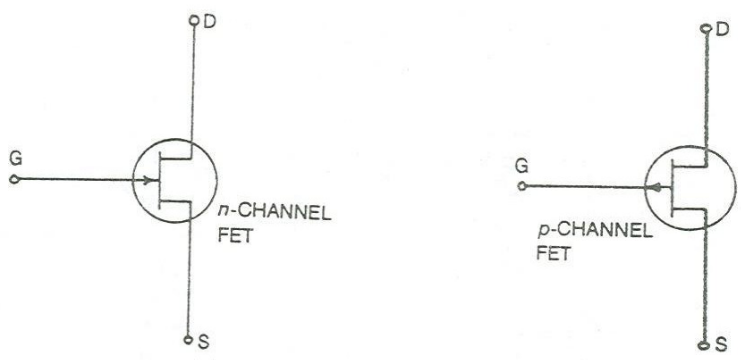
Q.71 Explain the construction of a MOSFET. Draw the symbols and diagrams of both and N-channel MOSFET.

Ans:

Like JFET, MOSFET also has source, gate and drain. Its gate is insulated from its conducting channel by an ultra-thin metal oxide insulating film (usually of silicon dioxide SiO_2), because of this insulating property, MOSFET is also called insulated gate field effect transistor (IGFET or IGT). Here also, gate voltage controls the drain current but the main difference between JFET and MOSFET is that, in the later case, we can apply both positive and negative voltages to the gate because it is insulated from the channel. More over the gate, SiO_2 insulator and channel form a parallel plate capacitor. Unlike JFET, a MOSFET has only one p- region or n-region called substrate as shown in the fig. (a) and fig (b). Normally it is shorted to the source internally. Symbols of both P- channel and N- channel MOSFET are shown below.



(a) (b)



Symbols of P and N channel MOSFET

Q.72 Write notes on

(i) Piezoelectricity and its applications. **(7)**

(ii) Intrinsic and extrinsic semiconductors. **(7)**

Ans:

(i) **Piezoelectricity:-** Piezoelectricity provides us a means of converting electrical energy to mechanical energy and vice versa.

When an electric field is applied to a substance it becomes polarized, the electrons and nuclei assume new geometric positions and the mechanical dimensions of the substance are altered. This phenomenon is called electrostriction. The reverse effect i.e. production of polarization by the application of mechanical stresses can take place only if the lattice has no centre of symmetry, this phenomenon is known as piezoelectricity. Example- Rochelle salt, Quartz, Barium titante.

Applications: Piezoelectric materials serve as a source of ultrasonic waves. At sea, they may be used to measure depth, distance of shore, position of icebergs, submarines.

(ii) **Intrinsic Semiconductor:** An extremely pure semiconductor is called intrinsic semiconductor. At absolute zero temperature its valence band is completely filled and the conduction band is completely empty. When the temperature is raised some electrons are lifted to conduction band leaving behind holes in the valence band. When an electric potential difference is applied across a pure semiconductor kept at room temperature, the current conduction takes place by two kinds of charge carriers, namely electrons and holes. Therefore the total current inside the semiconductor is the sum of currents due to free electrons and holes.

Extrinsic Semiconductor: An intrinsic semiconductor is capable to conduct a little current even at room temperature but as it is not useful for the preparations of various electronic devices. To make it conductive a small amount of impurity is added. This process is called doping. A semiconductor to which an impurity at controlled rate is added to make it conductive is known as an extrinsic semiconductor. If a pentavalent impurity is added a large of free electrons will exist and the semiconductor is known as n-type semiconductor. If a trivalent impurity is added a large number of holes will exist in the semiconductor and it is known as p-type semiconductor.

Q.73 Explain the effect of a dielectric on the behaviour of a capacitor. **(8)**

Ans:

When two parallel plates are separated by a distance 'd' (meters) in vacuum and are maintained at a potential difference V volts, the plates will become charged positively and negatively with a charge Q_0 and a uniform electric field with intensity E = V/d will be created between the plates. The magnitude of the charge accumulated on each plate is proportional to the potential difference i.e. $Q_0 \alpha V$ or $Q_0 = C_0 V$, where C_0 is defined as the capacitance. Since V = Ed, the capacitance of the system is given by $C_0 = \in_0 A/d$ where $\in_0$ is the absolute permittivity of free space. Where A is the area of cross section of the plates. If the space between the plates is filled with a dielectric and V is kept constant, it is found that the value of the charge is increased to a value given by $Q = CV$. The new capacitance is given by $C = \in A/d$ where $\in$ is the absolute permittivity of the dielectric and the ratio $\in_r = C/C_0 = \in / \in_0$ is called the relative permittivity or dielectric constant of the material. The dielectric constant varies between 1 to 10 for solid substances. It is greater than 10 for liquids and 1 for vacuum. It varies not only from substance to substance, but also with the physical state of any particular substance.

Q.74 Explain the suitability of copper and aluminium that is used as electrical [watermark obscured] materials.

Ans:
Copper: Pure annealed is used for the winding of electrical machines. High purity copper is obtained by electrolytic refining. Traces (0.1%) of iron, silicon or phosphorous seriously reduce the conductivity of copper. The conductivity of copper is also decreased when it is hard drawn into wires for use in machines. Annealing is therefore necessary before the material can be used in machines. Hard drawn copper because of its increased mechanical strength compared with annealed copper is used for conductors in low voltage overhead distribution lines. Long span lines of thin cross section require conductors of higher mechanical strength, which is achieved by adding small percentage of cadmium to copper. Copper is used in machine windings because it is easily workable without any likelihood of fracture.
Aluminium: Conductors are suitable for very high, ambient temperature. Use of aluminium as an electrical material particularly in aircraft industries has a considerable advantages because of the saving in weight. Aluminium because of its lightness is being used for bus bars. The current carrying capacity of aluminium is 75% that of copper and its density being approximately one third that of copper and aluminium bus bar is only about half the weight of copper bus bar of equal current carrying capacity. The steel reinforced aluminium conductor is extensively being used for long span transmission lines.

Q.75 What is super conductivity? Explain the effect of magnetic field on superconductors. Also give a few applications of superconductors. Also give three applications of superconductors. **(8)**

Ans:
Super Conductivity
A large number of metals become superconducting below a temperature, which is characteristic of the particular metal. The metals which are very good conductors at room temperature e.g. Cu, Ag, and Au do not exhibit superconducting properties, whereas metals and compounds which superconducting are rather bad conductors at ordinary temperatures. Monovalent metal and ferromagnetic and anti ferromagnetic metals are not superconducting.
The transition temperature of superconductor varies with the isotopic mass, showing that super conductivity may be the result of interactions between electrons and lattice vibrations .The resistivity of a superconductor is zero. At the same time it has been observed that the magnetic flux density B though such a substance also vanishes.
Effect of magnetic field on superconductors:
It is possible to destroy superconductivity by the application of a strong magnetic field. When the magnetic field exceeds a certain critical value, the superconducting state disappears, the magnetic field penetrates the material and the electrical resistance is restored. The transition from the superconducting to the conducting state is reversible. The critical magnetic field H_c is a function of temperature T.
The disappearance of superconductivity by means of a strong magnetic field is the principle on which switching elements like the cryotrons operate. Superconductors are used for producing a magnetic field of about 50 teals.
Application of superconductors in Electrical and Electronic Engineering
(i) The most important application of superconductor is the exploitation of zero electrical resistance. By making current carrying conductors superconducting, losses due to the

resistance of wire which carry electrical power over a long distance, transmission lines, would be eliminated.

(ii) In production of very powerful magnets

(iii) With the invent of high temperature superconducting materials, superconducting magnets find application in many areas like magnetic resonance Imaging (medical diagnose and spectroscopy) ore refining, magnetic shielding and in magnetic levitation high speed trains

(iv) In electronic engineering there are two areas in which superconducting properties can be advantageously used viz in chip interconnections and in electronics gates.

Q.76 What are thermocouples? Give two examples of the most commonly used thermocouples. **(4)**

Ans:

Thermocouples: Are used for the measurement of temperature. When two wires of different metals are joined together an emf exists across the junction which is dependent upon the types of metals or alloys used and also directly proportional to the temperature of the junction. Depending on the range of temperature to be measured, proper materials are to be chosen for a thermocouple. If one junction called the cold junction is held at a known constant temperature, the e.m.f. produced becomes measure of the temperature of the other junction. The emf produced by the thermocouple is very small but it can be measured with reasonable accuracy by a sensitive moving coil mili voltmeter, which can be calibrated in terms of temperature. Some of the materials used for thermocouples are copper/constantan, iron/constantan.

Q.77 Give the properties and application of PVC and glass. **(8)**

Ans:

i. **Polyvinylchloride (PVC**) : PVC is replacing rubber to a great extent in many applications. PVC insulated (non-sheathed) or PVC insulated and sheathed cables for general purpose wiring is now well established and the choice between VIR and PVC is very often largely a matter of relative price or personal preference on the part of the user. An attractive feature of PVC is that it can be produced in clear and permanent color simplifying identifications where large number of single core cable have to be used. Cables with PVC insulation are not affected by oils and petrol and therefore used in wireraft and factories.

ii. **Glass:** Ordinary glass is a good insulator but is too brittle to be used for anything but scientific instrument parts, accumulator container and for certain other special purposes. Increasing use is being made of toughened glass for insulation in extra H.V lines (above 100k.V)

Q.78 What are ferrites? Why are they used in high frequency devices? **(6)**

Ans:

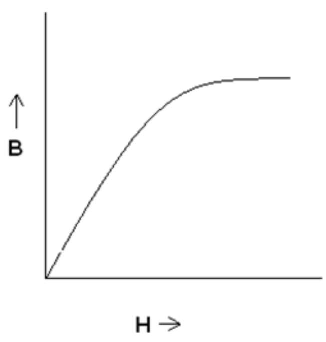
Ferrites

A group of magnetic alloys exhibit the property of magnetization which changes with the percentage of the different constitutes atoms in the alloy. A typical example of this type of alloy is $X0Fe_20_3$ with X=Mn, Co, Ni, Cu, Mg, Zn, Cd or Fe^{++}. The alloys are called ferrites. The manganese ferrite is a 1:1 mixture of manganese oxide and iron oxide.

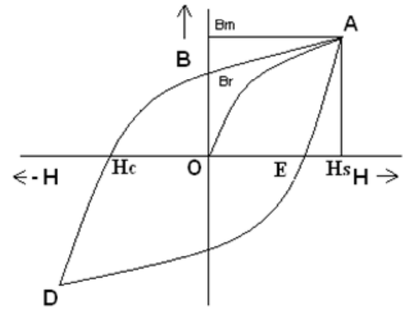
Suitability of ferrites for high frequency applications:-

Ferrites are widely used in computers and in micro wave equipments. F... advantageous at high frequencies because of low eddy current losses. Ferromagneti... and alloys cores have to be eliminated in order to reduce the losses. At high freque... laminations have to be so thin that both fabrication and assembly become expensi... processes. At these frequencies duet cores which consists of fine particles of ferromagnetic material insulated form each other may be used. But these have the disadvantage of diluting the ferromagnetic martial and decreasing the effective relative permeability. a further disadvantage is that the flux density varies through the core due to non-uniform spacing of the particle. At points where there is greater concentration of particles; the flux density is likely to be higher entailing larger hysterises losses.
For this reason, Ferrites are used for high frequency application

Hysterisis Loop Of Magnetic Materials



(i)



(ii)

A magnetic material is composed of magnetic dipoles oriented in random direction is zero. When a magnetic material is magnetized by applying a magnetizing force (= MI), the magnetic dipoles start orienting themselves in the direction of applied magnetic force. As the magnetizing force is increased by increasing the MI, more and more of the magnetic dipoles get oriented. A stage comes when almost all the magnetic dipoles gets oriented and as such any increase in magnetizing force does not result in any further increase in the dipoles getting oriented. The magnetic field is thus established in the forward direction.
This stage of magnetization is called magnetic saturation as shown in fig.
When the magnetizing force is gradually reduced it is found that the magnetic dipoles again get de-oriented , the rate of de-orientation now being little less than the rate of orientation at a particular magnetizing forces. Thus the demagnetizing curve does not retrace back the magnetization curve as shown in fig (ii)
In fig (ii), OA is the magnetization curve and AB is the demagnetization curve. It may be seen that even when the magnetization force is reduced to zero, a small magnetization is left in the magnetic material. In the fig. OB represents the residual magnetization. If now the magnetizing force is applied in the negative direction, a small amount of magnetizing force OC will be spent in totally de magnetizing the material. Further increase in magnetizing force will orient the magnetic dipoles in the opposite direction thus establishing a magnetic field in the reverse direction.
When the magnetizing force is reduced to zero and then again increased in the forward direction the magnetization curve will follow the path DEA. The total curve ABCDEA is called the hysterisis loop.

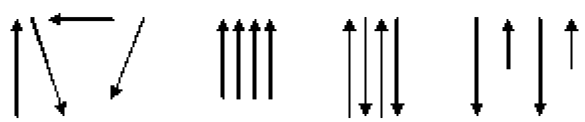
Q.79 Classify the magnetic materials into diamagnetic, paramagnetic, ferromag... ferrimagnetic materials. Also give examples of each.

Ans:

Classification of magnetic materials:-

Magnetic materials for which linear relationship between M and H exists are divided into classes depending upon the sign of χ (magnetic susceptibility). Materials, which have negative value of χ the order of 10^{-4} to 10^{-6} are called diamagnetic and those which have a positive value of χ of about the same order of magnitude are called paramagnetic. When the relationship between M and H is non-linear and exhibits hysterises effect, this group of materials in which the resultant magnetization is one to several orders of magnitude. Such materials are called Ferromagnetic materials.

Another classification of magnetic materials consists in the presence or absence of permanent magnetic dipolar in them, Materials, which lack permanent magnetic dipoles, are called diamagnetic. If permanent magnetic dipoles are present in the atoms of a material, it may be paramagnetic, ferromagnetic, anti- ferromagnetic of ferrimagnetic depending on the interaction between the individual dipoles. Thus, if the interact between the atomic permanent dipoles moments is zero or negligible and the individual dipole moments are oriented at random as shown in fig (i).



(i) (ii) (iii) (iv)

The material will be paramagnetic. If the dipole interact in such a manner that they tend to line up in parallel, as shown in fig (ii), the material will be ferromagnetic. When neighboring moments are aligned anti parallel as shown in fig (iii), the materials are anti- ferromagnetic. In ferromagnetic materials, there is a large resultant magnetization, whereas in anti-ferromagnetic materials the magnetisation vanishes. When the order of the magnetic moments is as shown in fig (iv), the phenomena is known as ferrimagnetisms.

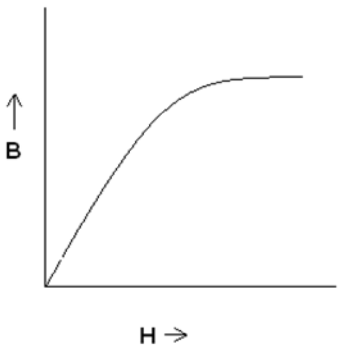
Examples of diamagnetic materials are Diamonds, Graphite and copper etc.

Examples of paramagnetic materials are Aluminium , Ebonite & platinum etc.

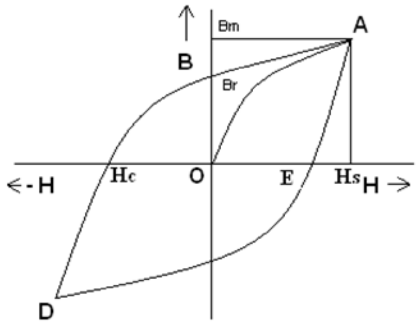
Examples of Ferromagnetic materials are Iron, cobalt and Nickel etc.

Q.80 Explain the hysteresis loop of a magnetic material. **(4)**

Ans:
Hysterisis Loop Of Magnetic Materials



(i)



(ii)

A magnetic material is composed of magnetic dipoles oriented in random direction is zero. When a magnetic material is magnetized by applying a magnetizing force (= MI), the magnetic dipoles start orienting themselves in the direction of applied magnetic force. As the magnetizing force is increased by increasing the MI, more and more of the magnetic dipoles get oriented. A stage comes when almost all the magnetic dipoles gets oriented and as such any increase in magnetizing force does not result in any further increase in the dipoles getting oriented. The magnetic field is thus established in the forward direction.
This stage of magnetization is called magnetic saturation as shown in fig(i).
When the magnetizing force is gradually reduced it is found that the magnetic dipoles again get de-oriented , the rate of de-orientation now being little less than the rate of orientation at a particular magnetizing forces. Thus the demagnetizing curve does not retrace back the magnetization curve as shown in fig (ii)
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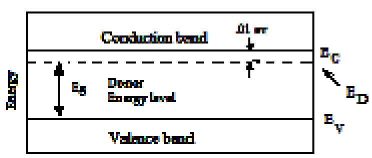
When the magnetizing force is reduced to zero and then again increased in the forward direction the magnetization curve will follow the path DEA. The total curve ABCDEA is called the hysterisis loop.

Q.81 What is meant by doping? Explain the two types of materials that are formed after doping. **(8)**

Ans:
Doping: Semiconductors in its extremely pure form are called intrinsic semiconductor These intrinsic semiconductor to which some suitable impurity is added in extremely small amount are called extrinsic semiconductor. This process is called doping and impurities are called doping agent. Usually the doping agents are pentavalent atom such as arsenic, antimony or trivalent atom such as gallium, indium, aluminium etc.

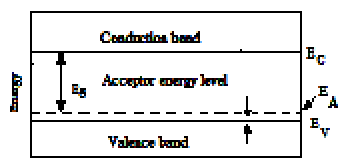
Depending upon the impurity added, extrinsic semiconductors can be further subd… two classes :
N-type semiconductor.
P- Type semiconductor.

N-type semiconductor.



Energy band diagram of n-type semiconductors

P- Type semiconductor.

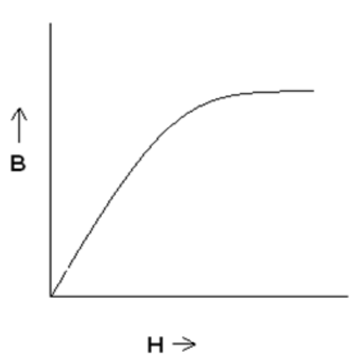


Energy band diagram of p-type semiconductors

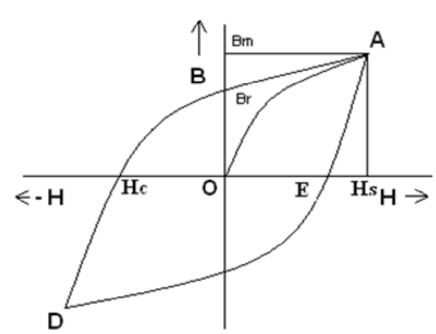
If to pure germanium, a small amount of pentavalent impurity i.e. antimony is added.Four of the five valence electrons will occupy covalent bonds, and the fifth will be nominally unbound and will be available as a carrier of current. These are called N-type semiconductor. In this type of semiconductor electron are the majority carriers.
If a trivalent impurity such as boron, Gallilium etc. is added to an intrinsic semiconductor, only three of the covalent bonds can be filled, and the vacancy that exists in the fourth bond constitutes a hole. These are called P type semiconductor in which holes are the majority carriers.

Q.82 Draw B.H. curve for magnetic materials used in electric machines and explain
(i) Hysteresis loop. (ii) Permeability. **(7)**

Ans:
B.H Curve for Magnetic Materials
A magnetic material is composed of magnetic dipoles oriented in random direction is zero. When a magnetic material is magnetized by applying a magnetizing force (= MI), the magnetic dipoles start orienting themselves in the direction of applied magnetic force. As the magnetizing force is increased by increasing the MI, more and more of the magnetic dipoles get oriented. A stage comes when almost all the magnetic dipoles gets oriented and as such any increase in magnetizing force does not result in any further increase in the dipoles getting oriented. The magnetic field is thus established in the forward direction.
This stage of magnetization is called magnetic saturation as shown in fig(i).



(i)



(ii)

When the magnetizing force is gradually reduced it is found that the magnetic dip[oles] get de-oriented, the rate of de-orientation now being little less than the rate of orienta[tion at] particular magnetizing forces. Thus the demagnetizing curve does not retrace back [the] magnetization curve as shown in fig (ii)

i. **Hysterisis Loop**

In fig (ii), OA is the magnetization curve and AB is the demagnetization curve. It may be seen that even when the magnetization force is reduced to zero, a small magnetization is left in the magnetic material. In the fig. OB represents the residual magnetization. If now the magnetizing force is applied in the negative direction, a small amount of magnetizing force OC will be spent in totally de magnetizing the material. Further increase in magnetizing force will orient the magnetic dipoles in the opposite direction thus establishing a magnetic field in the reverse direction.
When the magnetizing force is reduced to zero and then again increased in the forward direction the magnetization curve will follow the path DEA. The total curve ABCDEA is called the hysterisis loop.

(ii) **Permeability:-** In the above figure (hysterisis loop) we may define a number of permeabilties. The initial permeability is defined as the slope of the normal magnetization curves, at H=0. The incremental permeability is defined as $\Delta B/\Delta H$ about a given point on the hysterisis loop. Sometimes the differential permeability is used , it is defined as dB/dH, the slope of the magnetization curves at the point of intersect.

Q.83 What are the important requirements of a good insulating material? **(6)**

Ans:

Important requirements of good insulating materials:-

The requirement of good insulating materials can be classified as electrical, mechanical, thermal and chemical. Electrically the insulating materials should have high resistivity to reduce the leakage current and high dielectric strength to enable it to with stand higher voltage with out being punctured or broken down. Also the insulator should have small dielectric loss. Insulators should have low density, a uniform viscosity for liquid insulators ensures uniform thermal and electrical properties .Liquid and gaseous insulators are used also as coolants. For example, transformer oil, hydrogen and helium are used for both insulation and cooling purposes. For such materials, good thermal conductivity is desirable. The insulators should also have small thermal expansion to prevent mechanical damage. It should be non ignitable or if ignitable, it should be self-extinguishable.
Chemically, the insulators should be resistance to oils, liquids, gas fumes, acids and alkalies. It should not deteriorate by the action of chemicals in soils or by contact with other metals. The insulators should not absorb water particles, since water lowers the insulation resistance and the dielectric strength. Insulating materials should have certain mechanical properties depending on the use to which they are put. Thus when used for electric machine insulation the insulator should have sufficient mechanical strength to withstand vibration. Good heat conducting property is also desirable in such cases Example of insulating materials are mica & porcelain. Mica sheets are used for the insulating leaves between commutator segments. Porcelain insulators are used for transmission line insulators, conductor, rail support on railways etc.

Q.84 Discuss classification of conducting materials into low resistivity and high [resistivity] materials, give their properties and applications with examples.

Ans:
Conducting materials are classified as low resistivity materials and high resistivity materials.

1. **Low resistivity materials:** The conducting materials having resistivity between 10^{-8} to 10^{-6} ohm-m come under this category and are used in transmission and distribution lines, transformers and motor windings. Examples are:- Copper, Aluminium, Gold etc

Properties:-
- **Low temperature coefficient:** For minimum variations in voltage drop and power loss with the change in temperature, these materials should have low temperature cofficient.
- **Sufficient mechanical strength:** These materials must withstand the mechanical stresses developed during its use for particular applications.
- **Ductility:** The material to be used, as conductors must be ductile so that it can be drawn and moulded into different sizes and shapes.
- **Solderability:** The conducting materials are required to be joined and the joint must have minimum contact resistance. These materials must have good solder ability.
- **Resistance to corrosion:** The material must have a high resistance to corrosion so that it should not be corroded when used in different environmental conditions.

2. High resistivity materials: The conducting materials having resistivity between 10^{-6} to 10^{-3} ohm-m come under this category and are used for making resistance elements for heating devices, precision instruments, rheostats etc.. Examples are:- Constantian, Nichrome, Mangnesium etc.

Properties:
- **Low temperature coefficient:** For minimum variations in voltage drop and power loss with the change in temperature, these materials should have low temperature cofficient.
- **High mechanical strength:** These materials must withstand the mechanical stresses developed during its use for particular applications.
- **Ductility:** The material to be used, as conductors must be ductile so that it can be drawn and moulded into different sizes and shapes.
- **High melting point:** These materials which are used as heating elements should have high melting point.
- **Oxidation resistance:** The material should have a oxidation resistanceso that it should get oxidized when used in different environmental conditions.

Q.85 Explain temperature dependence of electrical resistivity and conductivity in conductors and semiconductors. **(10)**

Ans:
Temperature dependence of electrical resistivity and conductivity in conductors:
As the temperature is increased, there is a greater thermal motion in the atoms, which decreases the regularity in the atoms spacing with a consequent decrease in the mobility of

the electrons. The resistivity of most of the conductors therefore increases with a rise in the temperature. Since the number and the energy of the electrons at top of the distribution curve vary insignificantly with temperature, the change in temperature must be associated with a change in the mean free path. In a perfectly regular lattice, each electron will exist in a particular energy state and will have a fixed velocity. Practically metals do not have a perfect lattice because of impurities and because of deviations of the atoms about their mean positions due to lattice oscillations. Since the lattice oscillations decreases at low temperature the scattering of electron waves falls and the conductivity therefore increases rapidly as the temperature reaches absolute zero. There is a limiting value beyond which the conductivity will not increase. In general, purer the specimen higher is the conductivity. the conductivity of many conductors decreases linearly as the temperature is increased above the room temperature but below this temperature the conductivity increases markedly.

Temperature dependence of electrical resistivity and conductivity in semiconductors:
The electrical conductivity of the semiconductors changes appreciably with temperature variations. At absolute zero, it behaves as an insulator. At room temperature, because of thermal energy, some of the covalent bonds of the semiconductor break. The breaking of bonds sets those electrons free, which are engaged in the formation of these bonds. This results in few free electrons. These electrons constitute a small current if potential is applied across the semiconductor crystal. This shows the conductivity for intrinsic semiconductor increases with increase in temperature as given by $\eta = A \exp(-E_g/2kT)$ where η is the carrier concentration, E_g is the energy band gap and T is the temperature and A is constant. In case of extrinsic semiconductors, addition of small amount of impurities produces a large number of charge carriers. This number is so large that he conductivity of an extrinsic semiconductor is many times more than that of an intrinsic semiconductor at the room temperature. In n-type semiconductor all the donors have donated their free electrons at room temperature. The additional thermal energy only serves to increase the thermally generated carriers. This increases the minority carrier concentration. A temperature is reached when the number of covalent bonds that are broken is so large that the number of holes is approximately equal to the number of electrons. The extrinsic semiconductor then behaves as intrinsic semiconductor.

Q.86 What are ferrities? Give their properties and applications. **(6)**

Ans:
Ferrities
A group of magnetic alloys exhibit the property of magnetization, which changes, with the percentage of different constituent atoms in the alloy. Example: $XOFe_2O_3$ with X=Mn, Co, Ni, Mg, Zn, Cd or Fe^{++}. The alloys are called ferrites. Manganese ferrite is a mixture of manganese oxide and iron oxide. Ferrites are widely used in computers and in microwave equipments. Ferrites are advantageous at high frequencies because of low eddy current losses. The ferrites crystallise in what is known as the spinel lattice. The resistivity of ferrites is much higher than that of the ferromagnetic metals. Ferrites are hard and brittle materials, which cannot be shaped by ordinary machining processes. Ferrites are also used in transducer applications; recording tapes ,compact aerials for radio sets, focusing magnets of TV picture tubes.

Q.87 Explain Polarization. **(5)**

Ans:
Polarization: A dielectric consists of molecules the atomic nuclei of which are effectively fixed, relative to each other. In the absence of any external field the electrons are distributed symmetrically round the nucleus at any instant. When an electric field is applied the electrons of the atoms are acted upon by this field. This causes a movement of the electrons which are displaced in a direction opposite to that of the electrons which are displaced in a direction opposite to that of the field. This movement is opposed by the attractive forces between nuclei and electrons. The resultant effect is to separate the positive & negative charges in each molecule so that they behave like electric dipoles. The strength of each dipole is given by the dipole moment, which in its simplest form, consists of two equal point charges of opposite sign $\pm Q$ separated, by a distance d.

When the dipoles are created the dielectric is said to be polarized or in a state of polarization considers the dielectric to be composed of a large number of elementary cylinders each of length l in the direction of the applied field and of cross section δA. Let a uniform field of strength E be applied normal to the plates. This polarizes the dielectric inducing dipoles in each elementary cylinder, and charges δq appears on either end of the cylinder. The charge density, σ on the surface δA of the cylinder is given by $\sigma = \frac{\delta q}{\delta A}\left(\frac{c}{m^2}\right) = l\frac{\delta q}{\delta A} = \frac{m}{\delta V}$

Where m is the dipole moment and δV is the volume of the elementary cylinder. If the number of dipoles per unit volume be N i.e. if $N = \frac{I}{\delta V}$ then σ =Nm. The product Nm is called the polarization (P) of the dielectric and is the total dipole moment established within unit volumes of the insulating medium. Thus a dielectric subject to a homogeneous field carries a dipole moment P per unit volumes which may be written as P=Nm.

(ii) **Thermocouples:** Are used for the measurement of temperature. When two wires of different metals are joined together an emf exists across the junction which is dependent upon the types of metals or alloys used and also directly proportional to the temperature of the junction. Depending on the range of temperature to be measured, proper materials are to be chosen for a thermocouple. If one junction called the cold junction is held at a known constant temperature, the e.m.f. produced becomes measure of the temperature of the other junction. The emf produced by the thermocouple is very small but it can be measured with reasonable accuracy by a sensitive moving coil mili voltmeter, which can be calibrated in terms of temperature. Some of the materials used for thermocouples are copper/constantan, iron/constantan etc.

Q.88 Write notes on any **TWO**:-
(i) Iron and silicon iron alloys.
(ii) Electrical contact materials.
(iii) Polymers and their applications. **(8+8)**

Ans:
(i) **Iron:** Galvanised steel and iron wires which are generally used for earth conductor in low voltage distribtion systems may also be used for the phase conductor in rural areas.
Cast iron is used in the manufacturing of 'resistance grids' to be used in the starting of large dc motors.

Silicon iron alloy: Pure iron has low resistivity, which results in higher eddy current losses. These losses can be minimized by increasing the resistivity of the material, which is achieved by adding 1-4% of silicon to iron. Silicon increases the electrical resistivity of iron. It reduces hysterisis loss. The magnetostriction effect is also reduced. Silicon iron alloy is used in the form of thin sheets called laminations. These laminations are used in transformers, small machines and large turbo generators.

(ii) **Electrical contact materials:** Several elements, in their relatively pure forms such as copper, molybdenum, nickel, palladium, platinum, silver and tungsten are acceptable make and break contact materials. Alloys and heterogeneous mixtures which are, in general, combinations of the elements mentioned above are also used for electrical contacts. Silver is an important contact material. Copper added to silver reduces the cost of the contact material, whereas a combination of tungsten and silver results in a contact material having the advantages of the individual metals. A silver tungsten contact material will have high thermal and electrical conductivity, low contact resistance and high resistance to oxidation due to the presence of silver and a high melting point and a high resistance to electrical erosion due to the presence of tungsten.

(iii) **Polymers and their applications**

Polymeric materials or plastics comprise a large group of organic or organo metallic high molecules compound.

The common properties of these materials are their ability to soften and even melt, ability to pass into a liquid state, insolubility in water and solubility in one or more organic solvents. The mechanical properties of these materials vary widely, some can be spun into fibers like nylon and terrylene , other can be moulded and are hard and glass like in mechanical properties. Other group shows rubber like properties.

Plastic are synthetic resins obtained basically in two different ways, by linear polymerization and by polycondensation. The polymers obtained by linear polymerization are known as thermoplastics since they can be repeatedly melted or dissolved in various solvents. The properties of the thermoplastics do not change considerably if they are melted and then cooled and solidified. Example of thermoplastics is polystyrene.

Second types of polymers are thermosetting and are used as binding agents and varnish base. Thermosetting plastic melt on heating but are converted into a rigid solid mass if maintained at an elevated temperature. Examples of these polymer is phenol formaldehyde. Synthetic resins are widely used in electrical industry as insulating and structural components. Some of the important synthetic resins commonly used in electrical engineering are polystyrenes, P.V.C.(polyvinyl chloride.) etc

Q.89 Discuss applications of dielectrics. **(10)**

Ans:

Application of dielectrics:

For different applications different properties of dielectric materials are required such as: electrical, mechanical, thermal and chemical. Electrically the insulating material should have high resistivity to reduce the leakage current and high dielectric strength to enable it to withstand higher voltage without being punctured. Further, the insulator should have small dielectric loss. Since the insulators are used on the basis of volume and not weight, a low density is preferred.

Liqiid and gaseous insulators are used also as coolants. For example: transformer oil, hydrogen and helium are used both for insulation and cooling purpose. For such materials good thermal conductivity is a desirable property.

Materials with large electronic and ionic Polariability and therefore large permittivity are used for making dielectric capacitors. Titanium oxide which has a permittivity of about 100 is a good example of such a material.

Some of the important dielectric materials and their applications are :

- Mica: Mica sheets are used for insulating leaves between commutator segments.
- Porcelain: It is used for h.v. transmission line insulators, conductor rail support on railways and high voltage switch parts.
- Bakelite: It is used for small moulded parts such as lamp holder, terminal blocks, switch covers etc.
- PVC: Cables with PVC insulation are not affected by oil and petrol and are therefore widely used in aircraft and factories.
- Cotton and silk: Cotton covered wire is widely used for the winding of small magnet coils, armature winding of small and medium sized machines, small transformer coil choke etc. silk is more expensive than cotton but takes up less space and is therefore used for winding in fractional horsepower machines.

Q.90 Explain the effect of magnetic field on superconductivity. **(6)**

Ans:

Effect of magnetic field on superconductivity:

It is possible to destroy superconductivity by the application of a strong magnetic field. When the magnetic field exceeds a certain critical value, the superconducting state disappears, the magnetic field penetrates the material and the electrical resistance is restored. The transition from the superconducting to the conducting state is reversible. The critical magnetic field H_c is a function of temperature T.

The disappearance of superconductivity by means of a strong magnetic field is the principle on which switching elements like the cryotrons operate. Superconductors are used for producing a magnetic field of about 50 tesla.

Q.91 Write short notes on any FOUR:-

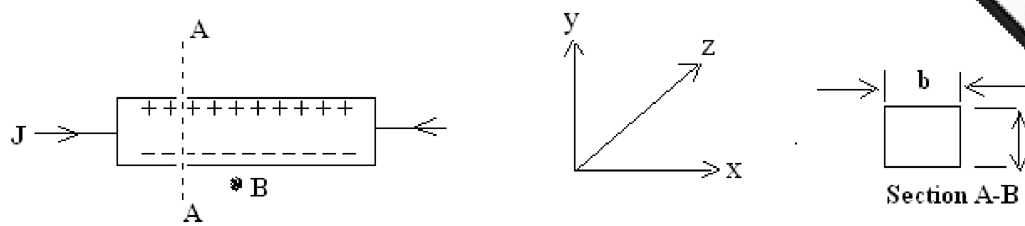
(i) Dielectric constant.
(ii) Hall Effect.
(iii) Carbon and graphite.
(iv) Ferroelectric materials.
(v) Einstein relation (between diffusion constant and mobility)
(vi) MOSFET. **(4 × 4)**

Ans:

(i) Dielectric Constant

Every insulation material has the capacity to store charge when placed in between two conducting plates as in capacitors. Relative permittivity or dielectric constant, it is the ratio of the capacitance of a capacitor with a specified dielectric material placed between the plates, to the capacitance of the same capacitor with free space i.e. air between the plates.

(ii) Hall effect:



Consider a slab of material in which there is a current density J resulting from an applied electric field Ex in the x- direction. The electrons will drift with an average velocity $\overline{V_x}$ in the x direction, when a magnetic field of flux density Bz (wb/m^2) is superposed on the applied electric field in the Z direction the electrons will experience a Lorentz force perpendicular to $\overline{V_x}$ and to B_z ; the magnitude of this force will be given by B_z (μ x)e.

Thus the electrons are driven towards one face in the sample resulting in an excess of electrons near one face and a deficiency of electrons near the other face. These charges will in turn create a counteracting electric field E_y in the y-direction. E_y would build up, until it is of sufficient magnitude to compensate the lorentz force exerted on the electrons due to the magnetic field we may therefore write e $E_y = B_z\, e(\overline{V_x})$

In the steady state , a Hall voltage, V_H,is thereby established in the y-direction given by

$$V_H, = E_y.a = B_z(\overline{V_x}),a.$$

The current density in the sample is given by

$$J_x = N.e(\overline{V_x})$$

Where N=no. of conduction electrons/m³

The current density can be calculated from the total current and the cross section (axb) of the sample.

Thus,

$$J_x = \frac{I}{axb} = Ne(\overline{V_x})$$

$$I = Ne(\overline{V_x})axb \text{ -------------------------------(i)}$$

$$V_H = B_Z(\overline{V_x}).a \text{ ------------------------------(ii)}$$

Eliminating ($\overline{V_x}$). from equating (i) and (ii) we have.

$$V_H = \frac{I}{N.e.b}$$

$$= \left(\frac{1}{Ne}.\frac{Bz.I}{b}\right)$$

The ratio $\pm\frac{1}{Ne} = \frac{Ey}{(Jx.Bz)}$ must be constant.

It is called the **hall coefficient** and is denoted by R_H.

Another variable which is often used to describe the Hall effect is the rato of the currents J_Y to J_X.

This is called the **Hall angle** and is denoted by θ

$\theta = J_Y / J_X = \sigma E_Y / J_X$

$= \sigma R_H B_Z$

$= \mu H B_X$

Where μ H is called the **Hall mobility.** The hall angle is equal to the average number of radians traversed by a particle between collisions

Application of Hall Effect:

1. It is used for determining whether a semi-conductor is n-type or p-type.
2. It is used in determining the carrier concentration.
3. In calculating the mobility.
4. It is used in flux meters, which measure magnetic fields.

iii. **Carbon and graphite**: The rate of commutator wear in electrical machines is greatly reduced by using brushes made of carbon. Carbon is also used in automatic voltage regulators for making the pressure sensitive pile resistors. Other uses of carbon are for making arc welding electrodes, fixed and variable resistors for light currents and contacts of certain classes of dc switch gear which are subjected to arcing. The resistance temperature coefficient of carbon is negative.

iv. **Einstein relation**:

There exists an important relation between the diffusion constant and the mobility. This is known as the Einstein relation and may be deduced as follows:

Consider a semiconductor in which there exists an electric field E_x and a concentration gradient such that the current is zero. Under these conditions the system is in thermal equilibrium and the Boltzmann statistics applies. Consider a potential V(x) producing at x an electric field E(x)= -dV/dx.

The Boltzmann expression for the density of holes as a function of x in thermal equilibrium is

$$p(x)= Ce^{-eV/KT}$$

Where C is a constant.

The gradient gradient of the hole density is therefore given by

$$dp/dx = (-e/KT)p.(dv/dx)$$
$$= (e/KT)p.E$$

The hole current vanishes in thermal equilibrium.

Therefore,

$$O=peu_p E_x-eD_p\ dp/dx$$
$$=peu_p E_x-(e^2/KT)D_p . Ex$$
$$Dp = (KT/e) Up \text{ (The Einstein relation)}$$

Q.92 Give three important, electrical properties of copper as a conducting material. Why copper is preferred over aluminium for transformer windings or generator windings?

(4+5)

Ans:

Electrical properties of copper as a conducting material:

i. The conductivity of copper is decreased when it is hard drawn into wires for use in machines. Annealing is therefore necessary before the material can be used in machine.
ii. Copper has the second highest electrical conductivity. The conductivity of copper is only few percent less than that of silver.

iii. Copper can be soldered easily.

Copper is preferred over aluminium for transformer windings or generator windings , because it is easily workable without any likelihood of fracture. Further, it can be soldered easily thus simplifying the jointing operation.

Q.93 What is superconductivity? Give a few applications of superconductors. **(3+4)**

Ans:
Super Conductivity
A large number of metals become superconducting below a temperature, which is characteristic of the particular metal. The metals which are very good conductors at room temperature e.g. Cu, Ag, and Au do not exhibit superconducting properties, whereas metals and compounds which superconducting are rather bad conductors at ordinary temperatures. Monovalent metal and ferromagnetic and anti ferromagnetic metals are not superconducting.
The transition temperature of superconductor varies with the isotopic mass, showing that super conductivity may be the result of interactions between electrons and lattice vibrations .The resistivity of a superconductor is zero. At the same time it has been observed that the magnetic flux density B though such a substance also vanishes. It is possible to destroy superconductivity by the application of a strong magnetic field when the magnetic field exceeds a certain critical value, the superconducting state disappears, the magnetic field penetrates the material and electrical resistance is restored.

Application of superconductors in Electrical and Electronic Engineering

(i) The most important application of superconductor is the exploitation of zero electrical resistance. By making current carrying conductors superconducting losses due to the resistance of wire which carry electrical power over a long distance through transmission lines, would be eliminated.
(ii) In production of very powerful magnets
(iii) With the invent of high temperature superconducting materials, superconducting magnets find application in many areas like magnetic resonance Imaging (medical diagnose and spectroscopy) ore refining, magnetic shielding and in magnetic levitation high speed trains
(iv) In electronic engineering there are two areas in which superconducting properties can be advantageously used viz in chip interconnections and in electronics gates.

Q.94 Explain the properties and applications of
(i) Cotton (ii) glass
(iii) Asbestos (iv) PVC. **(4 × 4)**

Ans:
i. **Cotton:** Cotton is hygroscopic and has low electric strength so that it must be impregnated with varnish or wax after winding. Cotton covered wire is widely used for winding of small magnet coils, armature winding of small and medium sized machine, small transformer coils, chokes etc.

ii. **Glass:** Ordinary glass is a good insulator but is too brittle to be used for anything but scientific instrument parts, accumulator container and for certain other special purposes.

Increasing use is being made of toughened glass for insulation in extra H.V lines (above 100k.V)

iii. **Asbestos:** Asbestos insulation can be used in very high temperature surroundings. It is also used as a covering for conductors in highly rated machines.

iv. **Polyvinylchloride (PVC)** : PVC is replacing rubber to a great extent in many applications. PVC insulated (non-sheathed) or PVC insulated and sheathed cables for general purpose wiring is now well established and the choice between VIR and PVC is very often largely a matter of relative price or personal preference on the part of the user. An attractive feature of PVC is that it can be produced in clear and permanent color simplifying identifications where large number of single core cable has to be used. Cables with PVC insulation are not affected by oil and petrol and used in aircraft and factories.

Q.95 Define polarization of a dielectric material. Explain the different types of polarization and the effect of frequency of applied electric field on them. **(2+8+6)**

Ans:

Polarization of a dielectric material:

A dielectric consists of molecules the atomic nuclei of which are effectively fixed, relative to each other. In the absence of any external field the electrons are distributed symmetrically round the nucleus at any instant. When an electric field is applied the electrons of the atoms are acted upon by this field. This causes a movement of the electrons which are displaced in a direction opposite to that of the electrons which are displaced in a direction opposite to that of the field. This movement is opposed by the attractive forces between nuclei and electrons. The resultant effect is to separate the positive & negative charges in each molecule so that they behave like electric dipoles. The strength of each dipole is given by the dipole moment, which in its simplest form, consists of two equal point charges of opposite sign $\pm Q$ separated, by a distance d.

When the dipoles are created the dielectric is said to be polarized or in a state of polarization. Consider the dielectric to be composed of a large number of elementary cylinders each of length l in the direction of the applied field and of cross section δA. Let a uniform field of strength E be applied normal to the plates. This polarises the dielectric inducing dipoles in each elementary cylinder, and charges δq appears on either end of the cylinder. The charge density, σ on the the surface δA of the cylinder is given by $\sigma = \frac{\delta q}{\delta A}\left(\frac{c}{m^2}\right) = l\frac{\delta q}{\delta A} = \frac{m}{\delta V}$

Where m is the dipole moment and δV is the volume of the elementary cylinder. If the number of dipoles per unit volume be N i.e. if $N = \frac{I}{\delta V}$ then σ=Nm. The product Nm is called the polarization (P) of the dielectric and is the total dipole moment established within unit volumes of the insulating medium. Thus a dielectric subject to a homogeneous field carries a dipole moment P per unit volumes which may be written as P=Nm.

Polarization are of three types.

i. Electric polarization
ii. Ionic polarization.
iii. Dipolar polarization.

Electric polarization or polarization density is the vector field that expresses the density of permanent or induced electric dipole moments in a dielectric material. The SI unit of measure is coulombs per square metre.

The electric polarization **P** is defined as the difference between the electric fields **D** (induced) and **E** (imposed) in a dielectric due to bound and free charges, respectively. In cgs,
$p = \frac{D - E}{4\pi}$ which can be written in terms of the electric susceptibility(χ_e) as $P = \chi_e E$

In MKS, $P = \in_0 \chi_e E$ where $\in_0$ is the permittivity of free space.

Ionic polarization is polarization which is caused by relative displacements between positive and negative ions in ionic crystals (for example, NaCl).

If crystals or molecules do not consist of only atoms of the same kind, the distribution of charges around an atom in the crystals or molecules leans to positive or negative. As a result, when lattice vibrations or molecular vibrations induce relative displacements of the atoms, the centers of positive and negative charges might be in different locations. These center positions are affected by the symmetry of the displacements. When the centers don't correspond, polarizations arise in molecules or crystals. This polarization is called **ionic polarization**.

Ionic polarization causes ferroelectric transition as well as dipolar polarization. The transition which is caused by the order of the directional orientations of permanent dipoles along a particular direction is called **order-disorder phase transition**. The transition which is caused by ionic polarizations in crystals is called **displacive phase transition**

Dipolar polarization is a polarization that is particular to polar molecules. This polarization results from permanent dipoles, which retain polarization in the absence of an external electric field. The assembly of these dipoles forms a macroscopic polarization.

Effect of frequency of applied electric field:

When an external electric field is applied, the distance between charges, which is related to chemical bonding, remains constant in the polarization; however, the polarization itself rotates. Because this rotation completes not instantaneously but in the delay time τ, which depends on the torque and the surrounding local viscosity of the molecules, dipolar polarizations lose the response to electric fields at the lowest frequency in polarizations. The delay of the response to the change of the electric field causes friction and heat

Q.96 Explain the energy bands in solids. Also classify the materials based on the energy bands and explain them. **(8)**

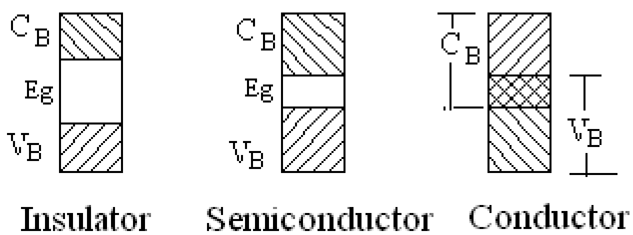
Ans:
There are as many energy bands in a solid as there are energy levels in the parent atoms. Most electrical properties of importance to engineers and scientists are related to the upper band of energy levels and to be specific the upper two called the conduction band and the valance band. The valence band contains energies of the same level as those of valence

electrons. Electrons in this band are in effect attached to individual atoms and the... free to move about.

The conduction band energies are high enough so that electrons attaining these levels of energy are loosely attached to individual atoms or practically free such that they could easily move under the influence of an electric field. Electrons in the valence band can leave their band to join the conduction band if given sufficient energy to jump the forbidden energy band (energy gap , E_g) . The size of E_g is a prime factor in determining whether a solid is a conductor, an insulator, or a semiconductor.

Classification of materials based on energy bands

With reference to different band structures shown in fig. below we can broadly divide solid into conductors, semiconductors, and insulators. Conductors contain a large number of electrons in the conduction band at room temperature. No energy gaps exist and the valence and conduction bands overlap.



Insulator is a material in which the energy gap is so large that practically no electron can be given enough energy to jump this gap.

These materials might conduct little electricity if their temperature are raised to very high values enabling a number of electrons to join the conduction band. A semiconductor is a solid with a energy gap small enough for electron to cross easily from the valence band to the conduction band. At room temperature sufficient energy is available for a valence electrons to bridge the energy gap to the conduction band, thus the material sustains some electric current.

The energy distribution of electrons in a solid are governed by the laws of Fermi – Dirac statistics.

The Fermi level is such that at any temperature, the number of electrons with greater energy than the Fermi energy is equal to the number of unoccupied energy levels lower than this. In conductors, the Fermi level is situated in a permitted band (since the valence band and conduction band overlap with no energy gap.). In insulators, it lies in the centre of the large energy gap while in semiconductors it lies in the relatively small energy gap.

Q.97 Explain the different types of semiconductors and the conduction process in them. **(8)**

Ans:

Semiconductors are of two types:

i. **Intrinsic semiconductors**:

An intrinsic semiconductor is one which is made of the semiconductor material in its extremely pure form.

In a semiconductor the energy gap is so small that even at ordinary room temperature, there are many electrons which posses sufficient energy to jump across the small energy gap from the valence to the conduction band. However , when each electron gets liberated into conduction band , a positively charge hole is created in the valence band, when an electric field is applied to intrinsic semiconductor at a temperature greater than 0^0K, conduction electrons move to the anode and the holes in the valence band move to the cathode. Hence semiconductor current consists of movement of electrons and holes in opposite direction.

ii. **Extrinsic semiconductor** :

Those intrinsic semiconductors to which some suitable impurity or doping agent is added in extremely small amount are called extrinsic semiconductors. Usually the doping agents are pentavalent. Antimony, arsenic atoms or trivalent atom (gallium, aluminium, boron).

Pentavalent doping atom is known as donor atom because it donates or contributes one electron to the conduction band of pure germanium. Trivalent doping atom known as accepter atom because it accepts one electron from the germanium atom.

Depending upon the impurity added, extrinsic semiconductors can be further subdivided into two classes :

(i) N-type semiconductor.

(ii) P- Type semiconductor.

If to pure germanium, a small amount of pentavalent impurity i.e. antimony is added. Four of the five valence electrons will occupy covalent bonds, and the fifth will be nominally unbound and will be available as a carrier of current. These are called N-type semiconductor. In this type of semiconductor electron are the majority carriers.

If a trivalent impurity such as boron, gallilium etc. is added to an intrinsic semiconductor, only three of the covalent bonds can be filled, and the vacancy that exists in the fourth bond constitutes a hole. These are called P type semiconductor in which holes are the majority carriers.

Q.98 Write notes on Thermocouple. **(4)**

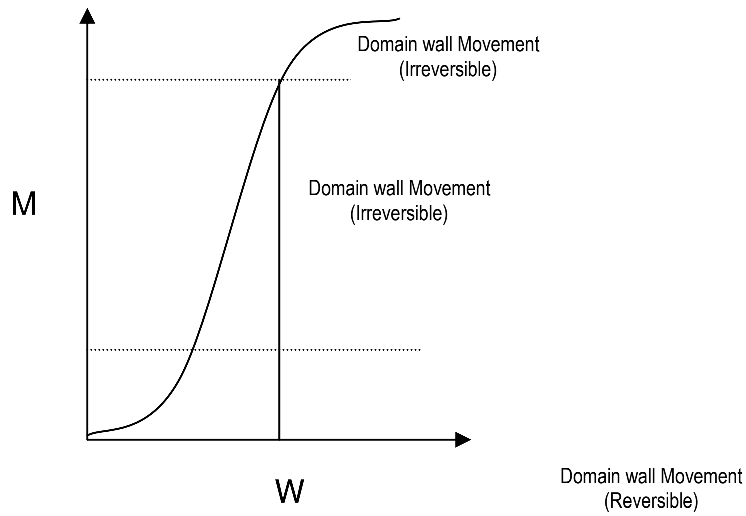
Ans:

Thermocouple was discovered by Seebeck in 1822. When he demonstrated hat a loop composed of 2 dissimilar metals could be made to carry a continuous current simply by maintaining the two junctions at different temperatures. The magnitude of the current depends on the resistance the metals happen to have; what is characteristic of the thermocouple is its electromotive force. When the two metals are placed in contact then a contact potential equal to the difference in the work function of the two metals is established at the junction. The work function is defined as the difference between the escape level and the Fermi level. The Fermi level is subjected to a small temperature change and this is of the order of $10^{-5} - 10^{-4} eV/^{\circ} K$. This causes a difference in the contact potentials at the two junctions due to the different temperatures at the two ends and the result is an e.m.f. which is free to drive the current. The magnitude of e.m.f. is of the order of a few microvolts per degree temperature difference between the two junctions.

Q.99 Explain the magnetisation- curves of magnetic materials. **(8)**

Ans:

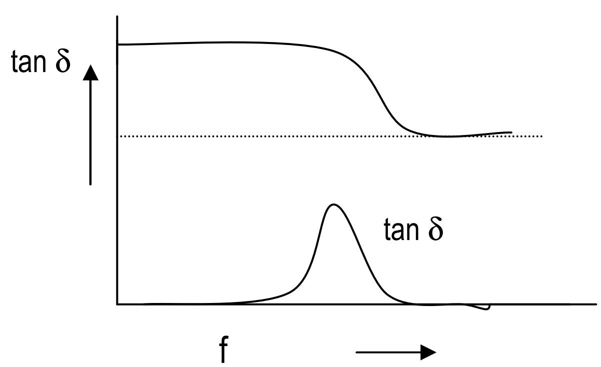
The main characteristic of a ferromagnetic substance is its domain structure. Every crystal of a ferromagnetic substance has a perpendicular crystallographic direction along which it is most easily magnetized. Higher fields are required to magnetize single crystals along some other directions. With small external fields the domain wall movements are reversible, corresponding to the known reversibility of the initial portion of the magnetization curve. In somewhat higher fields, these boundary movements continue but are often irreversible. The irreversible movements occur mostly in the steep part of the magnetization curve and finally result in all favourably oriented domains reaching their maximum size. At this stage each domain is still magnetized in what is locally the easiest direction. Application of still higher fields twists the magnetization into the field direction (domain rotation) and away from the easy directions, thus storing up energy.



Magnetization Curve

Q.100 Explain the significance of the loss tangent of a dielectric material. **(8)**

Ans:
The loss tangent has a very small value for free space. For solid materials tan δ = 0.003, which is equivalent to a Q (quality factor) of 3000. A fairly good value of Q for a coil is around 300. That is why more importance to losses in a coil is given. The variation of tan δ with frequency will show normal resonance behaviour. This is shown in the fig. below. The curve of tan δ has the largest value in the region of frequencies where there is a sharp change in the dielectric constant. In case of ionic resonance this change in the dielectric constant occurs from microwave to infrared regions of frequencies. The dielectric losses associated with ionic vibrations are usually referred to as infrared absorption. Similarly the losses in the optical region associated with electronic vibrations are referred to as optical absorption. Hence it is possible to predict whether the dielectric properties are due to ionic or electronic polarisation.



Q.101 Give the properties and application of permanent magnetic materials.

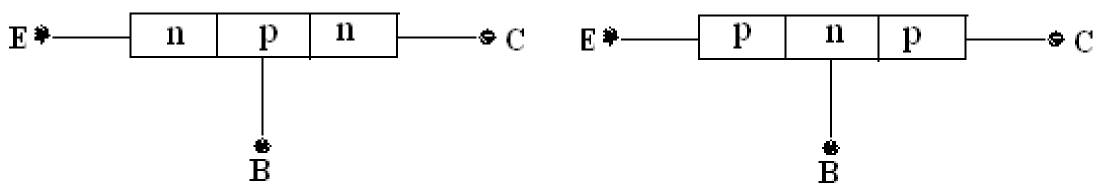
Ans:
Permanent magnetic materials:
Properties:

i. These materials have a large area of hysterisis loop.
ii. They have large retentivity and coercivity.
iii. High saturation values.
iv. High residual magnetism
v. These materials are hard to be magnetized.

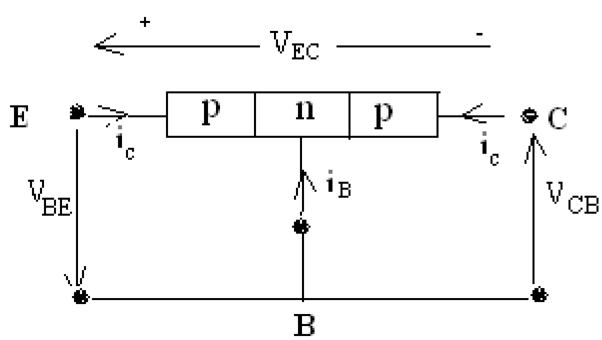
Applications: These materials are used to make permanent which finds application in relays, electric machines, measuring instruments, microwave devices, loudspeakers.

Q.102 Explain junction transistors (npn and pnp) **(8)**

Ans:
Junction Transistor:
The junction transistor consists of two p-n junctions combined in one crystal as shown in fig. below.

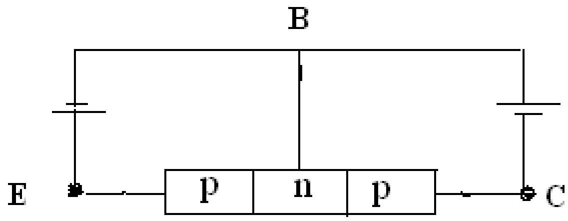


There are two main forms of junction transistors depending upon whether the middle section is on an n material or a p material. The middle sector is called the base and the outer regions are called the emitter and the collector respectively.
The transistor is a 3-terminal device and its properties may be specified in terms of characteristic curves connecting the three currents and the three voltages shown in fig. below.



In a transistor there is zero resultant current of electrons and holes across each junction. If the collector is joined directly to the base and a small positive voltage is applied between emitter and base then a current flows just as in a p-n junction diode in the forward direction. Similarly if the emitter is joined to the base and a negative voltage is applied between

collector and base, a current flows in the reverse direction, showing a saturation o... current.
If these voltages with the same polarity are applied simultaneously as shown in fig. belo...



The potential barrier between base and emitter is reduced and the flow of holes across the barrier greatly increased. There is an increased flow of electrons from base to emitter but since the hole density in the p- region is much greater than the electron density in the n-region, the current may be considered to be mainly due to the holes. The holes enter the n-region and diffuse through it, and combine with the electrons in that region since the base region is made sufficiently thin, a large number of holes reach the collector and base junction and very few arrive at the base terminal. At the collector base junction, holes fall easily in to the collector region on account of the field at the junction. Thus the collector current is very nearly equal to the emitter current and the base current is nearly zero. V_{CB} has little effect on the current as long as its magnitude is above some minimum value and the base is sufficiently thin. A small change in V_{EB} causes a change in I_C resulting in an almost equal change in I_C.

Q.103 Explain the terms: mobility, diffusion. **(8)**

Ans:
Mobility: Average drift velocity of the electrons in an applied field is proportional to the field, the absolute magnitude of the proportionality factor eq/m, called the mobility of the electrons, which is denoted by μ. The mobility may thus be defined as the magnitude of the average drift velocity per unit field.
The mobility of the electrons can be determined by knowing the conductivity of the material and estimating the number of free electrons. Unit of mobility is m²/volt.sec

Diffusion: Although the mobility of the carriers in a semiconductor is greater than that of the electrons in a metal, the conductivity in the former is much less than that in the latter because of the too few current carriers. The conductivity is so less that the random movement of the carriers due to unequal carrier densities plays a greater part in conduction than the drift due to the applied fields. Diffusion arises essentially from density difference and the resulting current are called diffusion currents .
The defining equation for diffusion currents in one direction are

$$J_n = eD_n \frac{\partial n}{\partial x} \quad \text{for electrons}$$

$$J_P = -eD_P \frac{\partial P}{\partial x} \quad \text{for holes}$$

Where J_n = diffusion current density of electrons

J_P = diffusion current density of holes

D_n =diffusion constant of electron

D_P = diffusion constant of holes

$_n \frac{\partial n}{\partial x}$ = gradient of electron density

$\frac{\partial P}{\partial x}$ =gradient of hole density.

Therefore, the diffusion current due to the random motion of carriers from the dense to the less dense regions is proportional to the gradient or rate of increase of carrier density with distance.

The coefficient of proportionality is called the diffusion constant and is denoted by D.

PART III

NUMERICALS

Q.1 An electric heater element is made of Nichrome wire having resistivity equal to 100×10^{-8} ohm-metre. The diameter of the wire is 0.3 mm. Calculate the length of the wire required to get a resistance of 30 ohms. **(4)**

Ans:

When the heater element is Nichrome ρ = 100x 10^{-8} Ω-m.

$$a = \frac{\pi}{4}(0.3\times10^{-3})^2 m^2$$

a = 7.069 x 10^{-8} m^2

R =30 Ω

$$R = \rho\frac{l}{a} \text{ or } 30 = \frac{100\times10^{-8}\times l}{7.069\times10^{-8}}$$

l = **2.12 m.**

Q.2 A heater element is made of nichrome wire having resistivity equal to 100×10^{-8} ohm-m. The diameter of the wire is 0.4mm. Calculate the length of the wire required to get a resistance of 40 Ω. **(6)**

Ans:

When the heater element is Nichrome ρ = 100x 10^{-8} Ω-m.

$$a = \frac{\pi}{4}(0.4 \times10^{-3})^2 m^2$$

a = 12.6 x 10^{-3} m^2

R = 40Ω

$$R = \rho\frac{1}{a} = 40 = 100 \times \frac{10^{-8} \times 1}{12.6 \times 10^{-3}}$$

l = 5 m.

Q.3 The resistance of a wire is 60 Ω at 25°C and 65Ω at 75°C. Find the resistance of wire at 0°C and value of temperature co-efficient at 0°C. **(6)**

Ans:

Given R_{25} = 60 Ω and R_{75} = 65 Ω

$R_t = R_O (1 + \alpha t)$

$R_t = R_O (1 + \alpha_O t)$

$R_{25} = R_O (1 + \alpha_O 25)$ -----------------(1)

$R_{75} = R_O (1 + \alpha_O 75)$ ------------------(2)

Divide (1) by (2)

$$\frac{R_{25}}{R_{75}} = \frac{R_O (1 + \alpha_O 25)}{R_O (1 + \alpha_O 75)}$$

$$\frac{60}{65} = \frac{1 + \alpha_O 25}{1 + \alpha_O 75}$$

$60 + 4500\ \alpha_O = 65 + 1625\ \alpha_O$
$2875\ \alpha_O = 5$
$\alpha_O = 5 / 2875 = \mathbf{0.001739\ /\ ^0C}$
$R_{25} = R_O\ (1 + 0.001739 \times 25)$
$R_O = 60 / 1.04348 = \mathbf{57.49\ \Omega}$

Q.4 The resistivity of pure copper is 1.56 micro-ohm –cm. An alloy of copper contains 1 atomic percent nickel has a resistivity of 2.81 micro-ohm –cm. An alloy of copper containing 3-atomic percent silver has a resistivity of 1.98 micro-ohm –cm. What is the resistivity of an alloy of copper containing 2 atomic percent nickel and 2 atomic percent silver? **(6)**

Ans:
$\rho_{cu} = 1.56$
$\rho_{(cu+Ni)} = 2.81$
ρ_1, increase in resistivity for one atomic percent-added impurity (Nickel)
$\rho_{1(Nickel)} = 1.25 = 2.81 - 1.56 = 1.25$.
$\rho_{1(Silver)} = \frac{1.98 - 1.56}{3} = 0.14$
$\rho_{alloy} = 1.56 + 2 \times 1.25 + 2 \times 0.14 = 4.34 \mu\Omega$ - cm.

Q.5 The field resistance of a dc machine is 50 ohm at 20° C. The resistance increases to 55 ohm at 50° C. Find the temperature coefficient of the resistance material. **(4)**

Ans:
Solution:
$R = R_o\ [1 + \alpha(t-t_o)$ where R and R_o are resistances at 50°C and 20°C
$50 \times 30 \times \alpha = 5$
$\alpha = 5/1500 = 3.3 \times 10^{-3}/^oC$

Q.6 A 6 V / 2.5 mA relay is connected in the output stage of a transistor. The coil is made of aluminium having $\alpha = 0.004$. The resistance of the coil is 600 Ω at $32^\circ C$. Calculate the resistance of the coil at $42^\circ C$. **(6)**

Ans:
$\alpha = 0.004$
R (at 32^0C) = 600 Ω
T = 273 + 32 =305
$R = R_0\ (1 + \alpha\ T)$
$600 = R_0\ (1 + 0.004 \times 350) = 2.4 R_0$

R_0 = 600 /2.4 =250 Ω
R (at 42^0C)
T = 273 + 42 = 315
R = R_0 (1+ α T) = 250 (1 + 0.004 x 315)
R = 565 Ω

Q.7 Calculate the diameter of copper wire of length 100 metres used as winding material in a transformer such that the resistance of the whole winding is 2 ohms. Calculate the diameter of wire if aluminium is to be used for the above winding, resistance remaining the same. Given the resistivity of Cu is 1.72×10^{-8} ohm-metre and of AI is 2.8×10^{-8} ohm-metre. **(8)**

Ans:
L = 100 meter
R = 2 Ω
$\rho_{cu} = 1.72 \times 10^{-8}$ Ω -meter
R = ρ l /A
= $1.72 \times 10^{-8} \times 100$ /A = 2
A = $1.72 \times 10^{-8} \times 100 / 2$
= 0.86×10^{-6}
$\pi r^2 = 0.86 \times 10^{-6}$

$r^2 = 0.86 \times 10^{-6} / \pi$
= 0.274×10^{-6}
r = 0.523×10^{-3}
diameter = 1.047×10^{-3} meter

For Aluminium
$\rho_{Al} = 2.8 \times 10^{-8}$ Ω -meter
R = ρ l /A
= $2.8 \times 10^{-8} \times 100$ /A = 2
A = $2.8 \times 10^{-8} \times 100 / 2$
= 1.4×10^{-6}
$\pi r^2 = 1.4 \times 10^{-6}$

$r^2 = 1.4 \times 10^{-6} / \pi$
= 0.446×10^{-6}
r = 0.667×10^{-3}
diameter = 1.335×10^{-3} meter