



SOLID STATE DEVICES VIVA & INTERVIEW QUESTIONS

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Q-1 What is Thermoplastic materials?

Ans **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 Fluoroethylene (P.T.F.E. or Teflon), Polyvinyl Chloride (P.V.C.).

Q-2 What mean by Thermosetting Plastic Materials?

Ans **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-3 Give four examples of natural insulating materials.

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

Q-4 State the functions of a fuse.

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.

Q-5 Mention the desirable properties of fuse materials

Ans 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 normal currents 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 rewirable fuses alloys of tin and lead or tinned copper wires are commonly used. In cartridge fuses silver and silver alloys are used of lower ratings. Copper alloys are used in fuses of higher ratings.

Q-6 What is n semiconductors?

Ans **n – 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.

(ii) The majority and minority carriers are electrons and holes respectively.

(iii) The impurity level is just below the bottom of conduction band.

Q-7 What is p semiconductors?

Ans p - type semiconductor:-

(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 charge carriers are holes and electrons respectively.

(iii) The impurity level is just above the valence band.

Q-8 On the basis of atomic structure classified engineering materials.

Ans On the basis of atomic structure the materials are classified as

1. Metal or conductor: - 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. Insulator: - When the No. of valence electrons of an atom is more than 4 , the material is a insulator. Example As, Se and Bromine have 5, 6 and 7 valence electrons respectively.

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

Q-9 Discuss briefly Lithography.

Ans Lithography-

It is one of the processes which is carried out during manufacture of integrated circuits. SiO₂ 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 SiO₂ serves as a mask.

Q-10 Discuss briefly Superconductivity.

Ans 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° Kelvin (-273°C). At this stage such metals or compounds are said to have attained superconductivity. Example – mercury becomes superconducting at approximately 4.5 Kelvin (-268.5°C). 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°K. 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 Diamagnetic are two essential and independent properties of super conducting materials. The super conducting properties can be destroyed by applying magnetic field.

Q-11 Differentiate between Soft and hard magnetic materials.

Ans 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 used in the manufacture of permanent magnets.

Q-12 Describe the physical properties and uses of Brasses.

Ans

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

1. Its electrical resistivity is 7.0×10^{-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°C .
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-13 Discuss electrical properties of insulating materials

Ans

Electrical properties of an insulating material are:

1. Insulation resistance
2. Dielectric Strength
3. Dielectric Constant
4. Dielectric loss and Loss angle

Q-14 What is Insulation resistance?

Ans

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.

Q-15 What mean by Dielectric Strength?

Ans

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 losing 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.

Q-16 Discuss briefly Dielectric Constant.

Ans

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. $Q \propto V$, 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 (ϵ) and $\epsilon = C/C_0$, where C is capacity in presence of Dielectric and C_0 is the capacity in air or vacuum or in the absence of dielectric.

Q-17 Explain dielectric loss and loss angle.

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° 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 ϕ and $\delta = 90^\circ - \phi$ is the dielectric loss angle Also I is the phasor sum of I_d and I_c , where I_c is the conduction current which is in phase with the applied voltage and I_d is the displacement current which is in quadrature phase with applied voltage.

Q-18 Discuss important properties and uses of Rubber.

Ans

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. Maximum permissible operating temperature is 60°C . It can not be continuously exposed to Sun as it is harmful. It has high tensile strength.

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

Synthetic Rubber – The different types of synthetic rubber are

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

(ii) **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.

(iii) **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.

(iv) **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 1500 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.

(v) **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 –1000 to 1500 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.

Q-19 Discuss important properties and uses of Mica and Mica products.

Ans **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 Phlogopite mica.

Muscovite mica – Chemical composition is $\text{KH}_2\text{Al}_3(\text{SiO}_4)_3$.

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.

Phlogopite mica – Chemical composition is $\text{KH}(\text{MgF})_8\text{MgAl}(\text{SiO}_4)_3$.

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 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 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.

Q-20 Discuss important properties and uses of Glass and glass products.

Ans **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 alkalis and acids and is used in PCB making, terminal holders and instrument cases.

Q-21

Discuss important properties and uses of Ceramics.

Ans

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 alkalis.

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

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

(ii) Steatite – These are low dielectric loss porcelains, used for variable capacitor coils, switches, resistor shafts and bushings. It is also used for low voltage and high frequency applications.

(iii) 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.

(iv) 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-22

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

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 4percent

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 1 Wb/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-23 Describe soldering materials and their uses.

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°C . 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, Cadmiumsilver solders etc.

Q-24 Write short notes on Soft ferrites and their applications.

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. 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 and recording heads make use of cores made of soft ferrites.

Q-25 Write short notes on PVC and its applications.

Ans PVC and its applications – This is obtained from polymerisation of vinyl chloride in the presence of a catalyst like peroxides at about 50°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-26 What are the desirable properties of an insulation material?

Ans The desirable properties of an insulation material are:

1. Very good dielectric strength as that of mica (up to 80 kV/mm at 25°C).
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-27 Explain the Permeability.

Ans **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.

Q-28 Explain the Dielectric constant.

Ans **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 $C = \epsilon A/t$ where ϵ is the permittivity of the material in F/m, A = Area of the plates and t = thickness of dielectric. Thus permittivity ϵ 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 $\epsilon = C/Co$, where C is capacity in presence of Dielectric and Co is the capacity in air or vacuum or in the absence of dielectric.

Q-29 Explain the Corrosion.

Ans **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.

Q-30 Explain the Contact resistance.

Ans **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-31 On the basis of energy band define Insulators.

Ans **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). 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.

Q-32 On the basis of energy band define Conductors.

Ans 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. 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.

Q-33 On the basis of energy band define Semiconductors.

Ans 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). 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 coefficient of resistance.

Q-34 Write a note on superconductors.

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°Kelvin (-273°C). At this stage such metals or compounds are said to have attained superconductivity. Example – mercury becomes superconducting at approximately 4.5 Kelvin (-268.5°C). 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°K. 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, I²R 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. HC is the critical magnetic field and TC critical temperature.

Q-35 Classify the conducting materials.

Ans **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.

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.

Q-36 Describe Low resistivity materials properties.

Ans Low resistivity materials Properties:

- Low temperature coefficient:** For minimum variations in voltage drop and power loss with the change in temperature, these materials should have low temperature coefficient.
- Sufficient mechanical strength:** These materials must withstand the mechanical stresses developed during its use for particular applications.
- Ductility:** The material to be used for 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 a good solderability.
- 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.

Q-37 Describe High resistivity materials properties.

Ans High resistivity materials 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) **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-38 Explain the chemical properties of insulating materials.

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-39 What are plastics?

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, thermosetting.

Q-40 Give the properties and applications of Teflon

Ans

Teflon: It is obtained by the polymerisation of tetrafluoroethylene.

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°C.
7. Its maximum useable temperature is 300°C.

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.

Q-41 Give the properties and applications of Bakelite

Ans

Bakelite: It is most common type of phenol formaldehyde. It is hard, thermosetting, dark 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°F.

6. Its water absorption is 0.13 percent 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-42 Explain Ferromagnetic Materials with example.

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 hysteresis loop. The susceptibility of these is given by $\chi = C/T - TC$, where C is curie constant, TC is the Curie temperature above which the ferromagnetic material exhibits paramagnetic behaviour. The ferromagnetic materials are widely used in industries. Ex. Iron, nickel, cobalt.

Q-43 Explain Paramagnetic Materials with example.

Ans **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.

Q-44 Explain Diamagnetic Materials with example.

Ans **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-45 What are hard magnetic materials? Name the various magnetically hard alloys.

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, tungsten steel, cobalt steel, alnico and hard ferrites.

Q-46 Give the properties and application of brass.

Ans **Brass-** Is an alloy of copper and zinc with 60 percent copper and 40 percent zinc.

Its properties are-

1. Its electrical resistivity is 7.0×10^{-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°C .
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 utensils etc.

Q-47 Give the properties and application of bronze.

Ans

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 equipment's. It is also used for making current carrying springs, sliding contacts, knife switches, bearings, marine work, turbine blading etc.

Q-48 Give the properties and application of glass.

Ans

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 thermosetting compound. It is immune to alkalies and acids and is used in PCB making, terminal holders and instrument cases.

Q-49 Give the properties and application of asbestos.

Ans

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°C.

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-50 What is the effect of temperature on conductivity of semiconductor?

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, E_g 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-51 Name the materials used in Fuses, give reasons.

Ans **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.

Q-52 Name the materials used in Solder

Ans **Solder:** For soft solders tin, lead (in 50:50 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: 40percent Pbt 60percent Sn
(ii) Tinman's solders: 38percent Pbt + 62percent Sn
(iii) Plumber solders: 60percent Pbt 37.5percent Sn + 2.5percent Antimony Similarly lead silver cadmium silver, tin-zinc solders etc.

Q-53 Which materials used in Bimetals and why?

Ans **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-54 Explain the principle of a thermocouple.

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 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-55 Define pnp transistors.

Ans **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 5percent) combine with electrons to constitute the base current I_B . The remaining holes (more than 95percent) 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. $I_E = I_C + I_B$.

Q-56 Explain Hysteresis loop.

Ans

A hysteresis loop shows the relationship between the induced magnetic flux density (B) and the magnetizing force (H). It is often referred to as the B-H loop.

Principle and working: Hysteresis, lagging of the magnetization of a ferromagnetic material, such as iron, behind variations of the magnetizing field. When ferromagnetic materials are placed within a coil of wire carrying an electric current, the magnetizing field, or magnetic field strength H, caused by the current forces some or all of the atomic magnets in the material to align with the field. The net effect of this alignment is to increase the total magnetic field, or magnetic flux density B. The aligning process does not occur simultaneously or in step with the magnetizing field but lags behind it.

If the intensity of the magnetizing field is gradually increased, the magnetic flux density B rises to a maximum, or saturation, value at which all of the atomic magnets are aligned in the same direction. When the magnetizing field is diminished, the magnetic flux density decreases, again lagging behind the change in field strength H. In fact, when H has decreased to zero, B still has a positive value called the remanence, residual induction, or retentivity, which has a high value for permanent magnets. B itself does not become zero until H has reached a negative value. The value of H for which B is zero is called the coercive force. A further increase in H (in the negative direction) causes the flux density to reverse and finally to reach saturation again, when all the atomic magnets are completely aligned in the opposite direction. The cycle may be continued so that the graph of the flux density lagging behind the field strength appears as a complete loop, known as a hysteresis loop. The energy lost as heat, which is known as the hysteresis loss, in reversing the magnetization of the material is proportional to the area of the hysteresis loop. Therefore, cores of transformers are made of materials with narrow hysteresis loops so that little energy will be wasted in the form of heat.

Q-57 Which Factors are affecting the resistivity of conducting materials?

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. eg. Annealing decreases the resistivity.

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

Q-58 Give the applications and properties of aluminium and copper.

Ans

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°C.
- 4) It is resistant to corrosion.
- 5) Its tensile strength is 60MN/m².

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°C.

4) It easily alloys with other metals.

5) Electrical resistivity of copper is 1.7×10^{-8} W-m.

6) Tensile strength for copper is 210 MN/m².

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-59 Explain conductors with example.

Ans

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.

Q-60 Explain semiconductors with example.

Ans

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

Q-61 Explain insulators with example.

Ans

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-62 Discuss the advantages of aluminium as compared to copper as a conductor of electricity.

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 2.8×10^{-8} ohmm, 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°C. 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.

Q-63 Discuss the disadvantages of aluminium as compared to copper as a conductor of electricity.

Ans

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-64 Explain Resistivity.

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

Q-65 What is the effect of overheating on the life of an electric insulator?

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-66 Write notes on Bronze.

Ans 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.

Q-67 Write notes on Thermocouples.

Ans **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.

Q-68 Explain Fuse materials.

Ans **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.

Q-69 Classify 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 in various categories as follows:

1. Fibrous materials:
2. Impregnated fibrous material:
3. Non-resinous materials:
4. Insulating liquids:
5. Ceramics:
6. Mica and mica products:
7. Asbestos and asbestos products:
8. Glass:
9. Natural and synthetic rubber:
10. Insulating resins and their products:
11. Laminates, adhesives, enamels and varnishes:

Q-70 On the basis of hysteresis loop compare soft magnetic material and hard magnetic material.

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.

Q-71 **Write a note on Bimetals.**

Ans **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 heated directly or indirectly. When heated the element bends so that the metal with the greater coefficient of expansion is on the outside of the arc formed while that with smaller coefficient is on the inside. When cooled the element bends in the other direction. Alloys of iron and nickel with low coefficients of 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-72 **Explain Eddy currents.**

Ans **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.

Q-73 **Explain Magnetostriction.**

Ans **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.

Q-74 **Discuss the properties and uses of Cold rolled grain oriented steel.**

Ans **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.

Q-75 **Discuss the properties and uses of ALNICO.**

Ans **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/m^2 .
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-76 Explain the factors which change the resistivity of a conducting material

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-77 Explain superconductivity and explain the effect of magnetic field on superconductors.

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.

Q-78 What is polarisation? Explain.

Ans

When a dielectric material is subjected to an electric field the dipoles of the material get 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 three types of polarization/polarisability

- (i) Electronic or atomic polarization
- (ii) Oriental or dipole polarization

(iii) Ionic polarization

Q-79 Give the names of four alloys along with their composition, which are used for making heater and thermocouple elements.

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)
(in percent)

Q-80 Explain ferroelectricity.

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 hysteresis 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 parallelly 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.

Q-81 Explain piezoelectricity.

Ans **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-82 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) up to 500A and voltages (a.c or d.c) up to 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) up to 600V and direct currents up to 50A and alternating currents up to 200A. Such contacts are used in all types of industrial applications, relays, generator cut outs, thermal overload devices and thermostatic control.

Q-83 Explain the terms dielectric constant (Permittivity).

Ans Permittivity ϵ 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.

Q-84 Compare n-type and p-type semiconductors.

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-85 **Give the properties and uses of silicon iron alloy.**

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 percent 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.

Q-86 **Give the properties and uses of nickel iron alloy.**

Ans **Nickel Iron alloy**:- A group of iron alloys containing between 40 to 90percent nickel have much higher permeability 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 equipment's.

Q-87 **What is meant by doping? How does it affect a semiconductor?**

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-88 **Explain the factors affecting permeability and hysteresis loss.**

Ans **Factors affecting permeability and hysteresis loss: -**

If the initial permeability is high, the hysteresis loss is low and vice versa. The permeability and the hysteresis 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 hysteresis 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 hysteresis 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 of carbon is kept to a low value of 0.01 percent in commercial materials.

Q-89 Write notes on Germanium and silicon.

Ans **Germanium**:- It is one of the most common semiconductor material used for the application in electronics. The atomic number is 32. The number of electrons in the first, second, third and fourth orbit are 2, 8, 18 and 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 0.7 eV. So small energy is sufficient to lift the electrons from valence to conduction band.

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. 1.1 eV. It also needs small amount of energy to lift the electrons from valence to conduction band.

Q-90 What is resistivity? Explain the effect of temperature on the resistivity of conducting materials and define temperature coefficient of resistance.

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 while those of semiconductors and electrolytes decreases with increase of temperature. Many metals have vanishing resistivity at absolute zero of temperature. The phenomenon is known as superconductivity. The resistance of a conductor changes with temperature according to the law $R_t = R_0 (1 + \alpha t)$. Where R_t and R_0 are the resistances at " t " and zero degrees centigrade and α is 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-91 Explain the effect of temperature on electrical conductivity of metals.

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 to 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-92 Give the applications of carbon and steel.

Ans **Carbon**:- Carbon materials used in the field of electrical engineering are manufactured from graphite and other forms of 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 0.25percent of carbon; medium steel contains 0.45percent of carbon and high carbon steel about 0.70percent 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-93 Explain the phenomenon of breakdown in dielectric materials.

Ans

Breakdown in dielectric materials: - The electric strength at breakdown is defined as the 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-94 Give the properties and applications of PVC.

Ans

PVC— This is obtained from polymerisation of hydrogen chloride and acetylene in the presence of a catalyst like peroxides at about 50°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 electrical 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-95 Give some applications of constantan, German silver, manganin, and nichrome.

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-96 Explain ionic polarisation.

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.

Q-97 Explain oriental polarisation.

Ans **Oriental 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_A and Z_B represents the nuclear charges of the two atoms where Z represents the atomic numbers and 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 Oriental or Dipolar Polarisation.

Q-98 Explain Hall Effect and give some applications of Hall Effect.

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 semiconductor 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-99 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 semiconductor, 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-100 Explain a p-n junction.

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.

Q-101 **Explain the term Valence Electrons.**

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.

Q-102 **Explain the term Conduction Band.**

Ans **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.

Q-103 **Explain the term Valence Band.**

Ans **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.

Q-104 **Explain the term Energy Gap.**

Ans **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-105 **Explain ferrites and its uses in high frequency devices**

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 $\text{X} = \text{Mn, Co, Ni, Mg, Zn, Cd or Fe}^{++}$. 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 aeralis for radio sets, focussing magnets of TV picture tubes.

Q-106 **Define Antiferromagnetic magnetic materials.**

Ans **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.

Q-107 Define Ferrimagnetic Materials.

Ans 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-108 What is Intrinsic Semiconductor?

Ans 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.

Q-109 What is Extrinsic Semiconductor?

Ans 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-110 Explain Copper as electrical conducting materials.

Ans Copper:

Pure annealed is used for the winding of electrical machines. High purity copper is obtained by electrolytic refining. Traces (0.1percent) 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.

Q-111 Explain Aluminium as electrical conducting materials.

Ans 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 75percent 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-112 Give a few applications of superconductors.

Ans 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-113 Classify the magnetic materials.

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 hysteresis 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 or 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

Q-114 Explain the terms mobility.

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 $\text{m}^2/\text{volt}\cdot\text{sec}$

Q-115 Explain the terms Diffusion.

Ans 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.

Q-116 Explain junction transistors (npn and pnp).

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

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.

Q-117 Give the properties and application of permanent magnetic materials.

Ans Permanent magnetic materials:

Properties:

- i. These materials have a large area of hysteresis 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-118 Explain the significance of the loss tangent of a dielectric material.

Ans

The loss tangent has a very small value for free space. For solid materials $\tan \delta = 0.003$, 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 $\tan \delta$ with frequency will show normal resonance behaviour. The curve of $\tan \delta$ 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-119 Explain the magnetisation- curves of magnetic materials.

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 larger and 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.

Q-120 Explain the energy bands in solids.

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 valence 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 therefore not 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.

Q-121 Define polarization of a dielectric material.

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.

Q-122 Explain the different types of polarization.

Ans Polarization are of three types.

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

Q-123 What is Electric polarization or polarization density?

Ans 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.

Q-124 What is Ionic polarization?

Ans 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 centres of positive and negative charges might be in different locations. These centre positions are affected by the symmetry of the displacements. When the centres don't correspond, polarizations arise in molecules or crystals. This polarization is called ionic polarization.

Q-125 What is Dipolar polarization?

Ans 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.

Q-126 Explain effect of frequency of applied electric field on polarization.

Ans 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, 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-127 Discuss applications of dielectrics.

Ans Some of the important dielectric materials and their applications are:

1. **Mica**: Mica sheets are used for insulating leaves between commutator segments.
2. **Porcelain**: It is used for H.V. transmission line insulators, conductor rail support on railways and high voltage switch parts.
3. **Bakelite**: It is used for small moulded parts such as lamp holder, terminal blocks, switch covers etc.
4. **PVC**: Cables with PVC insulation are not affected by oil and petrol and are therefore widely used in aircraft and factories.

5. **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-128 Give Brief detail about Polymers and their applications.

Ans

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 terylene , 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