BALASORE SCHOOL OF ENGINEERING, BALASORE

BRANCH – ELECTRICAL ENGINEERING

SEMESTER – 3 RD

SUBJECT – ELECTRICAL ENGINEERING MATERIAL (EEM)

SUB. CODE – EET – 302

SUBMITTED BY

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Chapter – 1

Short question type – (2 marks)

1. **Explain why conducting materials like copper & aluminium are not used for making the element for electrical heater. (W -14, Q1-a)**

   Conducting materials like copper & aluminium are not used for making the element for electrical heater because, these materials have low resistivity which is not suitable for heater element. The material used for electrical heater should posses high resistivity.

2. **What are the factors affecting resistivity? (W -14, Q1-a /BP)**

   The factor affecting resistivity is

   - Temperature
   - Alloying
   - Mechanical strength

3. **What is Brass? (W -14, Q2-a /BP)**

   When copper mix with Zinc makes an alloy then it is called brass.

   (Brass = 60 % Cu + 40% Zn)

   It is used in plug point, socket outlet, switches, lamp holder etc.…

4. **What is ACSR? Where it is used? (W- 13, Q1-a)**

   ACSR means Aluminium conductor steel reinforced. It is used for overhead distribution & transmission purpose.

5. **What is skin effect? (W- 13, Q2-a)**

   In case of AC, the current is not distributed uniformly over the whole cross section of the conductor, rather it has tendency to concentrate near the surface of the conductor. This phenomena is known as Skin effect.

6. **What is superconductor? (W- 11, Q1-g)**

   There are some metals whose resistivity become zero when their temp. is brought near or below 0˚ Kelvin (-273˚ C). At this stage such metals are said to be superconductor.
   For Ex. Mercury becomes superconductor at approximately 4.5 kelvin.

Medium type question (5 marks)

1. **Explain Bronze & its application. (W -14, Q2-b /BP)**
   - Copper when alloyed with tin (8% - 16%) and a very small percentage of third element like cadmium, beryllium, phosphorous, silicon etc.. is called bronze.
   - Bronze are given name as per addition of third element. Ex. If silicon is used as third element then it is called silicon bronze.
   - Bronze posse's high mechanical strength compares to copper but have lower conductivity than copper.
   - Bronze are more corrosion free then brass.

- Bronze is used in current carrying spring, sliding contact, knife switch etc…

2. What do you understand by the term resistivity? Mention the factors which effect the value of resistivity. (W -14, Q1-b)

- Resistivity or specific resistance of a material may be defined as the resistance offered between the opposite faces of a metre cube of that material. The unit of resistivity is ohm metre (Ω-m).
- According to law of resistance:

The resistance of a material (R) depends- directly to the length of the conductor (L) & area of cross section of the material (A)

Or R α L/A

Or R = ρ L / A (Where ρ is known as resistivity of the material)

The factor which effect the value of resistivity are

- Temperature – Increase or decrease of temperature effects the value of resistivity of the material
- Alloying – Alloy have higher resistance than pure metal.
- Mechanical stress – Mechanical stress increases the resistivity but decreases the conductivity.

3. Enumerate application of stranded conductor. How they are formed and explain.[W-15 Q-7(b)]

Stranded conductors are used as flexible conductor (copper, aluminium) in house wiring, over head conductor (ACSR), in many industrial applications.

A stranded conductor is made by twisting the wire together to form layer. Generally strand ding is done in opposite direction for successive layer. This means if the wires of one layer are twisted in left hand direction the next layer of wire will be twisted in the right hand direction and so on.

A standard stranding consists of six wires around one wire then twelve wire around the previous six, then eighteen wire around the twelve and so on.

The total number of wire in a stranded conductor having n layer

- One wire in centre = 1+3n(1+n)
- Three wire in centre = $3(1+n)^2$

Stranded conductors are expressed as 7/2.24, 19/2.50, 37/2.06 etc…..

The first number I,e 7 19 37 indicate the total number of wire and 2.24, 2.50 2.06 are represent the diameter of each wire in mm.

4. Explain the effect of temperature on resistivity.[W-12 Q-3(b),[W-15 Q-5(b), W-12 Q-3(b)]

Based on temperature effect on resistivity, electrical materials can be classified into two groups (i) positive temperature coefficient materials and (ii) negative temperature coefficient materials.

(i) Positive temperature coefficient means that the resistance of some of the metals and alloys increases when their temperature is raised.

(ii) Negative temperature coefficient means that the resistance of some of the materials, i.e., carbon and insulators and electrolytes, decreases when their temperature is raised.

If the resistance of a conductor is R_0 at 0^0 C, then its resistance at t^0C is given by the equation $R_t = R_0 \alpha t$

where α is the temperature coefficient of resistance at 0^0C and

t is the difference in temperature.

While selecting a material for a specific purpose in electrical engineering, its electrical, mechanical and economical properties are to be considered.

5. Write notes on Mercury.

Properties:

- It is good conductor of heat and electricity.
- It is a heavy silver-white metal.
- It is the only metal which is liquid at room temperature.
- Its electrical resistivity is 95.8 micro hom cm.
- Oxidation takes place if heated beyond 300^0C in contact with air or oxygen.
- It expands and contracts in regular degrees when temperature changes.

Uses : Mercury vapour lamps, mercury arc rectifiers, gas filled tubes; for making and breaking contacts; used in valves, tubes, liquid switch.

6. Compare the properties and uses of tungsten & carbon. (W -13, Q2-b)

Tungsten	**Carbon**
1) It is grayish in colour when in metallic form. 2) It has a very high melting point (3300^0C) 3) It is a very hard metal and does not become brittle at high temperature. 4) It can be drawn into very thin wires for making filaments. 5) In its thinnest form, it has very high tensile strength. 6) It oxidizes very quickly in the presence of oxygen even at a temperature of a few hundred degrees centigrade.	1) Carbon has very high resistivity (about 4600 micro ohm cm). 2) It has negative temperature coefficient of resistance. 3) It has a pressure-sensitive resistance material and has low surface friction. 4) The current density is 55 to 65 A/cm^2 5) This oxidizes at about 300^0C and is very weak. 6) It has very good abrasive resistance.
Uses It is used as filaments of electric lamps and as a heater in electron tubes. It is also used in thermionic valves, radars. Grids of electronic valves, sparking and contact points	Uses Carbon is used as brushes for electric machine, electrode for arc furnace, carbon film resistor, telecommunication equipment, arc lamp, welding purpose etc…

Long type question (7 marks)

1. What is meant by superconductivity? Does it occur with all metals? Where does it find application? (W-14 , Q1- c)

There are some metals whose resistivity become zero when their temp. is brought near or below 0˚ Kelvin (-273˚ C). At this stage such metals are said to be superconductor. For Ex. Mercury becomes superconductor at approximately 4.5 Kelvin.

Nearly all metal can be made superconductor. But it expensive to made all metal super conductor.

Application

- Magnetic-levitation is an application where superconductors perform extremely well. Transport vehicles such as trains can be made to "float" on strong superconducting magnets.
- superconductors can perform a life-saving function is in the field of biomagnetism
- Electric generators made with superconducting wire are far more efficient than conventional generators wound with copper wire.
- Commercial power projects in the works that employ superconductor technology include energy storage to enhance power stability.

- ❖ Recently, power utilities have also begun to use superconductor-based transformers and "fault limiters".
- ❖ An idealized application for superconductors is to employ them in the transmission of commercial power to cities.
- ❖ In the electronics industry, ultra-high-performance filters are now being built in super conducting material.
- ❖ Superconductors have also found widespread applications in the military.
- ❖ Low-temperature superconductors are expected to continue to play a dominant role in well-established fields such as MRI and scientific research.

2. Why copper & Aluminium are used as electrical conductor, explain? (W-14 , Q1- c /BP)

Copper & Aluminium are used as electrical conductor because of the following reason,

- ❖ Compared to other materials, copper or aluminium offer the least resistance to electricity and conduct it without much transmission loss.
- ❖ Aluminium is used extensively in wires owing to its easy availability and price.
- ❖ At one time, copper used to be cheaper, but is expensive now pushing up the price of electrical wire.
- ❖ They are excellent electric conductor and do not rust.
- ❖ The resistance produce is lower than the other metals when conducting electric through it. Thus, the efficiency is higher.
- ❖ Aluminium & copper have more ductile in nature, which is good for making thin & flexible wires.
- ❖ Aluminium & copper cause's lower corona losses compared to other metal.

3. Explain the effect of temperature, alloying and mechanical stressing on the value of resistivity of a conducting material. [W-13 Q-1(c)]

The resistivity of a material is not constant. The factors which affect the value of resistivity are temperature alloying and mechanical stress

Temperature

Based on temperature effect on resistivity, electrical materials can be classified into two groups (i) positive temperature coefficient materials and (ii) negative temperature coefficient materials.

(i) Positive temperature coefficient means that the resistance of some of the metals and alloys increases when their temperature is raised.

(ii) Negative temperature coefficient means that the resistance of some of the materials, i.e., carbon and insulators and electrolytes, decreases when their temperature is raised.

Alloying

Alloying is another factor which affect the resistivity of material by adding some impurities to a metal. Its resistivity can be increased. Alloys have

higher resistivity than the pure base metal. But its conductivity decreases, for example if zinc is alloy with copper than its resistivity is increased but conductivity is decreased by four times.

Mechanical stressing

The resistivity of a material also changes under the influence of mechanical treatment. Mechanical stresses increase the resistivity of the material and decreases the conductivity of the material. On the other hand it increases the tensile strength of the material.

4. State the advantages & disadvantages of Aluminium as compared to Copper for used as conductor. (W-12 , Q4- c)

Both Aluminium & copper is good conductor of electricity. Both have advantages & disadvantage.

Advantages of Aluminium over copper

- It is cheaper than copper.
- It is lighter in weight.
- It is second in conductivity.
- For the same ohmic resistance, its cross-section is about 1.27 times that of copper.
- At higher voltages, it causes lower coronal loss

Disadvantages of Aluminium over copper

- As the diameter of the conductor is more, it is subject to greater wind pressure due to which the swing of the conductor and sag will be greater.
- Since the conductors are liable to swing, it requires larger cross-section.
- As the melting point of the conductor is low, the short-circuit current will damage it.
- Welding of aluminium is much more difficult than that of any other material.
- For the same ohmic resistance, its cross-section is about 1.27 times that of copper.

5. Explain the principle of thermocouple and difference types of thermocouple. [W-15 Q-3(c)] (7 mark)]

When two wires of different metals are joined together an emf exist across the junction. This emf is directly proportional to the temperature of the junction. When one tries to measure this emf more junctions are to be made which will give rise to emfs. When all the junctions are at the same temperature, the resultant emf will not be zero. This resultant emf is proportional to the temperature difference of the junctions and is known as thermoelectric emf.

Thermo couples are made of different materials such that copper / constantan, iron / constantan, platinum / platinum rhodium.

the applications of Thermocouple include measurement of temperature of Kilns , diesel engines , gas turbines and its uses at offices , as a temperature sensor in thermostat , as a flame sensor in various safety devices used at homes and offices

Chapter - 2

Short type question – (2 marks)

1. **What is intrinsic semiconductor? (W – 14, Q2 –a)**

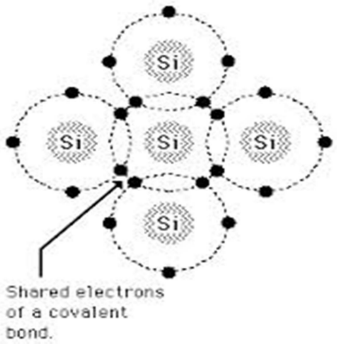
   If a crystal (silicon or germanium) does not contain any impure atoms (contains only one type of atoms), it is called an intrinsic material. When an electron is freed from the atom of an intrinsic material, it breaks a covalent bond and leaves behind a vacancy (called a *hole*). The free electron and the hole form an electron-hole pair. Higher the temperature the greater the number of free electrons and holes.

2. **What are most widely used semiconducting material. (W – 14 , Q3- a / BP)**

   Most widely used semiconductor materials are Boron, Carbon, Silicin, Germanium, Arsenic, antimony etc…

3. **What is covalent bond?**

   When each atom fills it valance band by sharing electron with neighboring atoms the covalent bond is formed. Each bond with two electrons is an electron pair bond.



4. **What is forbidden zones?**

   The energy of no two electrons is same. Each electron occupies an energy level of different form that of any other. The energy level is grouped into energy band. The area between them is called forbidden zones.

5. **What is the the use of strain gauge. [W-15 Q-4(a),W-12 Q-5(a)](2 mark)]**

   Strain gauge is used by civil engg. to test the tensile strength of material.

6. **Define Thermistor.**

   If the temperature of a semiconductor material is increased, that causes a decrease in its resistance. This property is used in temperature sensitive elements which are called as Thermistors. The Thermistors are thermally sensitive material (resistors). They are made from oxides of certain metals such as copper, manganese, cobalt, iron and zinc.

   Applications of Thermistors: Thermistors find application in temperature measurements and control.

7. **What is varistors?**

   The resistance of semiconductors varies with the applied voltage. This property is used in devices called varistors.

   Application:- They are used in voltage stabilizers and for motor speed control

Medium type question – (5 marks)

1. **What are the factors affecting the semiconductor? (W – 14, Q2 –b)**

The factor affecting semiconductor are ,

- Temperature
- Doping
- Light

Temperature – Semiconducting material are highly sensitive to temp. variation. The resistance of the material is decreases when temp. increases & vice versa. Very low temp. it behaves as an insulator.

Doping – Semiconducting materials also depends upon the doping. The process of doping increases or decreases the electron & hole pair in both P-type & N- type semiconductor. The amount of current flow also depends upon the doping.

Light – This type of material are light sensitive inn nature. The resistance of the material decreases when light falls on it. Hence semiconducting material are used in light sensing devices.

2. **Write merits of semiconductor material for use in electrical engineering.**
(W – 14, Q3 –b/ BP)

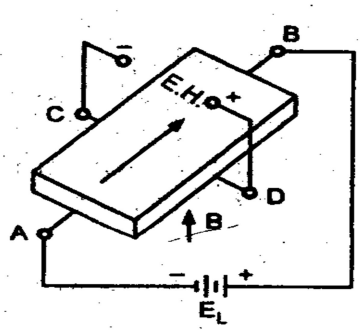
- They are much smaller in size & light in weight.
- They do not require any heater or filament when used as rectifier & transistor.
- They consume low power resulting in high efficiency.
- They have long life & hardly show ageing effect.
- They are almost shock proof.
- They operate on low voltage.

3. **Describe Hall Effect generator. (W – 11, Q2 –c, W-13, Q7-f)**

When current flows through a semiconductor bar placed in a magnetic field, a voltage is developed at right angles to both current and the magnetic field. This voltage is proportional to the current and the intensity of the magnetic field. This is called the "Hall effect".

Consider the semiconductor bar shown in Fig.3.9, which has contacts on all four sides. If a voltage E_1 is applied across the two opposite sides A and B_2 a current will flow.

If the bar is placed perpendicular to magnetic field B as shown in the figure, an electrical Potential $E_{H\ is}$ generated between the other two contacts C and D. This voltage E_H is a direct measure of the magnetic field strength and can be detected with a simple voltmeter.

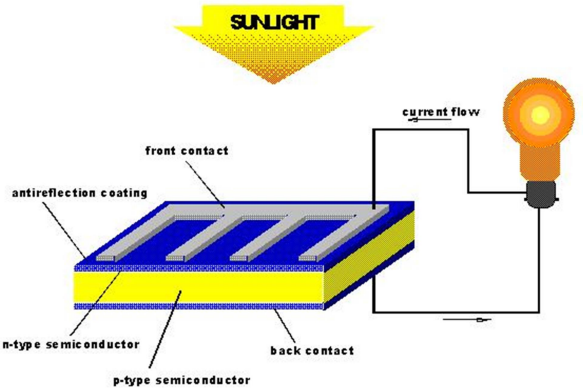


Hall Effect Device

Applications:- The Hall Effect generators may be used to measure magnet is fields. It is capable of measuring magnetic field strengths that have strength of 10^{-6} of the magnetic field of the earth

4. Describe Solar cell.

- Solar cell is most important photovoltaic device which directly converts solar radiation into electrical energy.
- It is basically a thin disc of p-n junction with large surface area.
- It is enclosed in a glass container with anti reflection (silicon grease) coating at the top layer.
- When light ray falls on the surface electron start moving from n-plate to p-plate by means of photoemission process.



- This gives an potential difference & constitute flow of electric current.
- The output depends upon the intensity of the sunlight.
- The presence of moisture or carbon dioxide affects badly a solar cell.
- Application of solar cell is in watches, calculator, telephone in rural area, solar pump, space research etc…

Long type question – (7 marks)

1. Give the application of semiconducting material. (W-14/13 ,Q3-c)

Semiconducting materials are used in various electronics & electrical equipment. The following application of semiconducting materials are described as follow,

Rectifier: - Semiconducting material are used as rectifier. The main function of the rectifier is to convert AC to DC. Germanium & silicon is mostly used semiconductor for rectifier purpose.

Transistor: - Semiconducting material are used to make transistor which extensively used in electronic circuit. The main function of the transistor is to amplify signal from low level to high level. It is used for switching ckt.

Thermistor: - Thermistords are temperature sensitive resistors. Thermistor are used in temperature measurement and control, measurement of radio frequency etc…

Photoconductive cells: - The resistance of semiconducting materials is low under light and increase in darkness. This phenomena used in photoconductive cell. It is used for door opening, alarms, flame detector, smoke detectors etc…

Photovoltaic cells: - Photovoltaic cells are device that develop an emf when light falls on it. Thus convert light energy to electric energy. It is used as solar panel.

Varisters:- The resistance of the semiconductors varies with the applied voltage. The properties are used in device called varisters. It is used in voltage stabilizer, motor speed control etc..

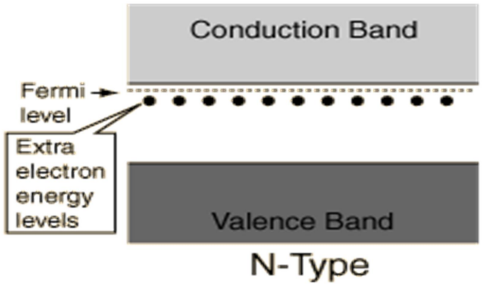
Hall effect generator:- hall effect generator may be used to measure magnetic field.

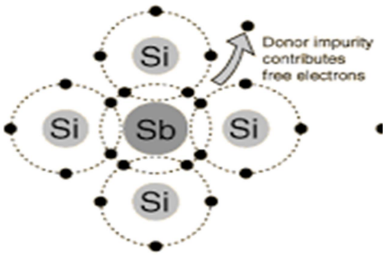
Strain gauge:- Strain gauges are used extensively by civil engineer to test the tensile strength of materials & in determining the change in the length of structure.

2. Explain with the help of energy diagram N- type & P- type semiconductor. (W-11, Q3)

N-Type Semiconductor

The addition of donor impurities contributes electron energy levels high in the semiconductor band gap so that electrons can be easily excited into the conduction band. This shifts the effective Fermi level to a point about halfway between the donor levels and the conduction band.

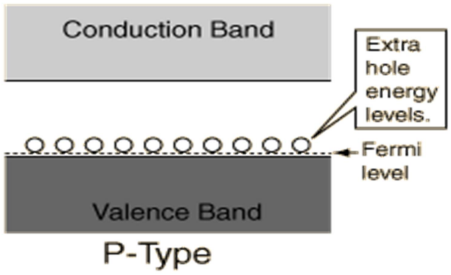


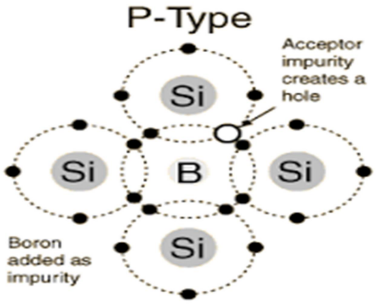


Electrons can be elevated to the conduction band with the energy provided by an applied voltage and move through the material. The electrons are said to be the "majority carriers" for current flow in an n-type semiconductor

P-Type Semiconductor

The addition of acceptor impurities contributes hole levels low in the semiconductor band gap so that electrons can be easily excited from the valence band into these levels, leaving mobile holes in the valence band. This shifts the effective Fermi level to a point about halfway between the acceptor levels and the valence band.





Electrons can be elevated from the valence band to the holes in the band gap with the energy provided by an applied voltage. Since electrons can be exchanged between the holes, the holes are said to be mobile. The holes are said to be the "majority carriers" for current flow in a p-type semiconductor.

3. Explain the difference between intrinsic & extrinsic semiconductor.

(W – 13, Q3 –b)

Intrinsic Semiconductor	**Extrinsic Semiconductor**
i) It is pure form of semi- conducting materials and no impurities atoms are added to it.	i) It is prepared by doping a small quantity of impurity atom to the pure semiconducting materials.
ii) Ex- crystalline forms of pure silicon & germanium.	ii) Ex- Silicon & germanium crystal with impurity of As, Sb, In, B etc…
iii) The no of electron in the conducting band and the no of holes in the valence band is exactly equal and very small indeed.	iii) The no of holes and electrons are never equal. There is excess of electron in N- type semiconductor and excess of hole in P type semiconductor.
iv) Its electrical conductivity is low.	iv) Its electrical conductivity is high.
v)Very less used in making semiconductor device	v)Mostly used in making semiconducting device

Chapter – 3

Short type question – (2 marks)

1. What is the function of oil which is used in transformer? (W-14. Q3 – a)

The oil used in transformer has mainly two functions

- It act as an insulating oil
- It is used for cooling the transformer.

2. What is the factor effect ageing?

The factor affecting ageing are

- Heat
- Chemical action
- Voltage application

3. What is PVC?

It is obtained by polymerization of vinyl chloride in the presence of a catalyst at 50°C. PVC exhibits good electrical and mechanical properties. It is hard, brittle, and non-hygroscopic and can resist flame and sun light.

PVC used as insulation material for dry batteries, jacketing material for wires and cables.

4. Mention the specific uses of paper, relating to insulating material.

Major applications are

- Cables – In all type of cable i.e. underground power cable, mining cables & submarine cables in the operating voltage range of 220 V to 400 KV.
- Transformer – Paper dielectric is frequently used in high voltage power transformer.
- Capacitor.

5. Write application of ceramics.

Ceramics used for the following purpose

- Porcelain insulator
- Line insulator
- Other ceramic materials
- steatite

6. What is Porosity?

Porosity means the moisturing holding capacity of material. High porosity insulating material will increase the moisturing holding capacity and consequently adversely affect electrical properties. Normally high porosity is not desirable for dielectric material.

7. What is insulator?

The material which prevents the flow of electricity through it when a difference of potential is applied across it, is called insulator. For ex. Glass, ceramics, mica etc…

8. What is hygroscopicity?

Hygroscopicity means the water holding capacity. Many insulators come in contact with atmosphere during manufacture or operation. Moisture thus absorbed by the insulator can affects all the electrical properties adversely.

9. What are the applications of impregnated paper? [W-15 Q-6(a) (2 marks)]

Major application of impregnated paper are in :

- In all types of cables like underground power cable, mining cable, submarine cable etc…
- It is frequently used in high voltage power transformer
- Different type of capacitor as a dielectric

Medium type question – (5 marks)

1. State four factors which decide the selection of an insulating material for a given purpose. (W-14, Q3 – b)

Four factor decide the selecting of insulating material for given purpose are,

- ❖ The properties of the material,
- ❖ What purpose it is used.
- ❖ Availability in the market abundantly or not.
- ❖ Classes in which it belong to.

2. Classify insulating materials on the basis of physical & chemical structure. (W-14, Q5 – b/ BP, W-10, Q2-c)

Insulating material on the basis of their physical and chemical structure may be classified in various categories as follows,

Classification	Insulating material
Fibrous material	Wood, paper, cotton, adhesive tapes
Insulating liquids	Transformer oils, cable oils, silicone fluids
Non-resinous material	Bitumen‟s, wax
Glass and ceramics	Glass, porcelain etc.
Plastics	Molding powder, rubber laminations
Mineral	Mica, micanites
Gaseous	Air, H_2, N_2, Ne, CO_2, SF_6, Hg and Na vapor

3. What is enamel? State few enamel with their properties. (W-12, Q5 – b)

Enamel is a fusible insulated coating of normally some organic base material which is generally applied on conducting surface. Enamel finds use in winding of low rated motor, transformer, various type instruments etc.…

A few of the main enamel and their properties are described below,

Oleo resin enamels: -Natural resin and drying oils constitute this resin. Use is very restricted.

Polyamide resin enamels:- They are tough, resistance to solvents, non resistance to humid atmosphere and easily solderable.

Polyvinyl formal resin enamel:- They are tough and abrasion resistant.

Acrylic resin enamel:- Resistant to most of the industrial solvents. They possess good abrasion resistance and flexibility. However, these enamels are susceptible to humid atmosphere.

Polytetrafluorethylene resin enamels:- These enamels exhibits highest temperature stability upto 200° C. They are difficult to apply.

4. **Name the dielectric gases which are commonly use. What is sulphur hexafluoride? Mention a few applications of dielectric gases as insulating material.**

The dielectric gases commonly used are air, nitrogen, hydrogen & sulphur hexafluoride.

Sulphur hexafluoride:- When sulphur is burnt in an atmosphere of fluorine, sulphur hexafluoride is formed. It has many advantages as an insulating gas. It has remarkable dielectric strength and is non inflammable. At increased pressure, its dielectric strength increases and may even become equal to that of mineral transformer oil.

Application:-

- Air act as insulation in many electrical applications. Ex. Over head transmission line, condenser, plugs, switches, various electrical machine & apparatus.
- Nitrogen used as insulating gas in many high voltage applications.
- Hydrogen is used in electrical rotating machine to reduce windage loss.
- Sulphur hexafluoride is found application in transformer and switches.

5. **What are the various factors affecting on insulating material resistance and explain their effect. [W-15 Q4(b)] (6 mark)**

The various factor affecting insulation resistances are

- Temperature
- Humidity
- Applied voltage
- Ageing

Temperature: The insulation resistance of an insulating material is decreased by increasing the temp.

Humidity/Moisture: Exposer to moisture produces a marked decrease in the surface insulation resistance. This factor is very important as it is found to be one of the major reasons of insulation breakdown.

Applied voltage : The value of insulation resistance is also affected by the voltage applied and to a small extent by the direction in which the voltage is applied.

Ageing : A resistance of insulating material decreases with age therefore the ageing of insulating material is a factor which contribute to the life of apparatus and which it is used

6. Mica. [W-13 Q-7(b)] (5 mark)

MICA:

Mica is an inorganic mineral. It is one of the best insulating material available. two kinds of mica are used as neutral insulating material in electrical engineering. Those are

Muscovite mica and Phlogophite mica.

- ***Muscovite Mica****:* The chemical composition of muscovite mica is $KH_2 Al_3 (Si\,O_4)_3$ It is translucent green, ruby, silver or brown and is strong, tough and flexible. It exhibits good corrosion resistance and is not affected by alkalis. It is used in capacitors and commutators.
- ***Phlogophite Mica:*** The chemical composition of this is, $KH(MgF)8Al(SiO_4)_3$ It possesses less flexibility. It is amber, yellow, green or grey in colour. It is more stable, but electrical properties are poorer compared to Muscovite Mica. It is used in thermal stability requirements, such as in domestic appliances like iron, hotplates etc.

7. Porcelain. [W-13 Q-7(d)[(5 mark)

- Porcelain in most commonly used material for over head insulator in present days. The porcelain is aluminium silicate.
- The aluminium silicate is mixed with plastic kaolin, feldspar and quartz to obtain final hard and glazed porcelain insulator material.
- The surface of the insulator should be glazed enough so that water should not be traced on it.
- Porcelain also should be free from porosity since porosity is the main cause of deterioration of its dielectric property.
- It must also be free from any impurity and air bubble inside the material which may affect the insulator properties.
- Dielectric Strength - 60 KV / cm , Compressive Strength - 70,000 Kg / cm^2
- It is used to make Insulator, fuse holder, plug & socket etc……

Long type question – (7 marks)

1. **What are the properties of insulating material? Explain briefly. (W14,Q3 – c)**

The main properties of insulating materials are,

- Visual properties
- Electrical properties
- Mechanical properties
- Thermal properties
- Chemical properties

Visual properties:- The following are the visual properties of insulating material,

- Appearance
- Colour
- Crystallinity

Electrical properties:- The various electrical properties are

- Insulation resistance
- Dielectric strength
- Dielectric constant
- Dielectric loss

Mechanical properties:- The following are the mechanical properties of insulating material,

- Mechanical strength
- Visocity
- Porosity
- Solubility

Thermal properties:- The various thermal properties are,

- Melting point, flash point, volatility
- Thermal conductivity
- Thermal expansion
- Heat resistance

Chemical properties:- The various chemical properties are,

- Chemical resistance
- hygroscopicity

2. **How PVC is made? Explain how its properties are affect by adding different material. Write some application. (W-12, Q5 – c)**

When acetylene and hydrogen chloride are combined in the presence of catalysts like peroxides at about 50° C, polyvinyle chloride (PVC) resin is produced.

The properties affected by adding different material are as follow,

Filler:- By adding various types of filler material like wood, flour, powered mica, quartz etc… the properties of material changes.

Stabilizer:-By adding different type of stebilizer as metal soap, lead stearate, calcium carbonate etc…in PVC the properties of material changes.

Plasticizer:- plasticizer control the flexibility of the insulating material.

Supplementary additive:- They are used for colouring and lubricating purpose. Colouring is required when PVC is used as insulation on low voltage etc.…

Application:-

As insulation resistance or jacket material for various types of house wiring , power cable, control cable, military & aircraft wires, communication & signal wiring, wires for radio & television, PVC films, tapes & sheets are commonly used as insulation for dry batteries etc…

3. **What are ideal quality an insulating material posses? (W14,Q5 – c/ BP)**

An ideal insulating material should posses,

- Dielectric strength as good as that of mica.
- Volume and surface resistivity equal to that of sulphur.
- Mechanical strength as good as steel.
- Crushing resistance as good as granite.
- Ease of machining as good as wood.
- Fire proofing quality as good as silica.
- Chemical inertness equal to that of platinum.
- Surface finishing like that of ebonite.
- Water proofing as good as wax.

4. **Discuss the thermal property of insulating material. [W-15 Q-6(c) (7 mark)]**

Thermal Properties:

Following thermal properties are considered for selecting insulating material of different applications.

- Thermal stability: The insulating material must be stable (no change in physical state) within the allowed temperatures. Certain materials like wax and plastic get soft at moderate temperatures. So the mechanical property of the material is affected. Hence the operating temperature of the material is to be noted before its use.
- Melting point: The insulating material should have melting point (temperature bearing capacity without being melt), above that of operating temperature.
- Flash point: This is an important property of insulating oils used in transformer. Flash point of a liquid insulator is that temperature at which the liquid begins to ignite.
- Thermal conductivity: In electrical appliances heat is generated during operation, which should be transferred to atmosphere, to maintain the operating temperature within the limit. Hence the insulators should have very low thermal conductivity
- Thermal expansions: Rapid and repeated load cycle on electrical appliances cause corresponding expansion and contraction of the

insulators. In a result voids are created and affect the breakdown phenomenon. Thus two insulating material of different coefficient of thermal expansion should be wisely selected.

- Heat Resistance: The insulating material used must be able to withstand the heat Produced due to continuous operation and remain stable during the operation. At the same time it should not damage the other desired properties.

5. Ceramic. [W-14 Q7(b)](7 mark)]

- Ceramic are material made by high temperature firing treatment of natural clay and certain inorganic matters.
- Some of the Ceramic are composed as following:
  - Insulator porecelain : Clay, Quartz, Feldspar
  - High frequency porecelain : Clay, Quartz, Barium Carbonate
  - Steatite : Clay, Talc, Magnesite.

Main Features of Ceramic :

- Ceramic are hard, strong, and dense.
- Not affected by chemical action except by strong acid and alkalies.
- Excellent dielectric property
- Stability at high temperature
- Stronger in compression then tension.

Effect of various factors:

- Electrical resistance of ceramic decreases very rapidly with increase in temperature
- Effect of moisture also affects the surface resistivity of ceramic material.

Application: Porcelain insulator, line insulator, steatite, alumina etc.…

Chapter – 4

Short type question – (2 marks)

1. What is the function of dielectric material?

Function of the dialectical material is to store electrical energy. Some time it is used as an insulating material.

2. What is dielectric strength?

Dielectric strength is the minimum voltage which when applied to an insulating material will result in the destruction of its insulating properties. The value is expressed in volts or kilovolt per unit thickness of the insulating material.

3. What is permittivity?

The ratio of the capacitance using a material as the dielectric to the capacitance when air is substituted for the material is called the permittivity or dielectric constant of that material.
The dielectric constant of air is practically taken 1.

4. Write two application of dielectric material. [W-15 Q-5(a) (2 mark)]

i. Capacitors using vacuum, air or gases as dielectric.
ii. Capacitors using mineral oil as dielectric.
iii. Capacitors using a combination of solid and liquid dielectrics.
iv. Capacitors only with solid dielectrics like glass and mica etc.

5. State difference between a dielectric material and an insulating material regarding function. [W-13 Q-4(b)](2 mark)]

Insulating Material	Dielectric material
• Those materials which oppose the current are known as insulating material. • Ex- Mica, paper,wood,plastic rubber etc…	• Those materials which store electrical energy are known as dielectric material • Ex- Paper,Mica, Insulating oil etc…..
• All insulating material are not dielectric material.	• All dielectric material are not insulating material.

Medium type question – (5 marks)

1. Explain briefly factors affecting Dielectric loss. (W14 – Q4-b/BP)

- ❖ The loss increases proportionally with the frequency of applies voltage.
- ❖ Presence of humidity increases the loss.
- ❖ Temperature rise normally increase the loss.
- ❖ Voltage increase causes increased dielectric loss.

2. What is meant by the term dielectric strength? What are the factors which effect the dielectric strength of a dielectric materials? (W14 – Q4-b)

Dielectric strength is the minimum voltage which when applied to an insulating material will result in the destruction of its insulating properties. The value is expressed in volts or kilovolt per unit thickness of the insulating material.

Factor affecting dielectric strength.

- ❖ Dielectric strength decreases with rise in temperature in case of air.
- ❖ Humidity generally decreases the value of dielectric strength.

3. Describe electrolytic capacitor.

- ❖ Electrolytic capacitors are fixed value capacitor. They are polarized device with high capacitor rating normally used for bypass coupling & motor starting application.
- ❖ Certain metal such as tantalum, aluminium, magnesium etc… can be coated with an oxide film by electrochemical means. Such metal are made anode in suitable arrangement.
- ❖ The oxides of these material exhibit different characteristics.
- ❖ Boric acid is also used in electrolyte capacitor.
- ❖ These capacitor have high dielectric constant.

Long type question – (7 marks)

1. Explain briefly the phenomena of polarization taking place in capacitor. (W14, Q4-c)

- ❖ The dipole moment per unit volume is called the polarization **P**.

  P= ρ / Volume ,where p is the dipole moment and P is the polarization in coulomb. $meter^{-3}$

- ❖ Considering a parallel plate capacitor having two metal plates of area A and separated in vacuum by distance d and having a battery of voltage V connected across it.
- ❖ The electric field E between the plates is given by V/d $volt.m^{-1}$ arising from the charge density ±Q on the plates. The relation between Q and E is given by, $Q = \varepsilon_0 E$.
- ❖ Q can be considered as a source of electric flux lines in the space between the plates; the density of this flux lines is the electric displacement D.

$$D = Q = \varepsilon_0 E.$$

- ❖ Now consider that the battery is still connected and a dielectric medium is introduced to fill the space between the plates.
- ❖ The medium becomes polarized by the field E and dipoles appear throughout the material, lined up in the direction of the field.

- ❖ All dipole ends of opposite charge inside the material will cancel, but there will be an uncompensated surface charge on the plates, Positive on one plate and the negative on the other plate.
- ❖ These surface charges will attract and hold corresponding charges of opposite sign on the plates because the latter, unlike dipoles are able to move freely. The field in the dielectric will be still E.
- ❖ The field is the same as before and Q' = Q + Q_B.

Where Q_B is the bound charge density; Q has been multiplied by a factor ε_r such that Q' = ε_r.Q. Electric field density is now given by;

$$D = \varepsilon_0 \varepsilon_r E$$

- ❖ The bound charge density is called polarization P. This is identical with the dipole moment per unit volume.
- ❖ The polarization may be expressed in terms of elementary dipole moments p by, P = N.p ;

$$or, D = \varepsilon_0 E + Q_B$$

Where N is the number of dipoles per unit volume.

2. What is dielectric loss? What are the applications of dielectric material?

Dielectric Loss: The dielectric material separating the two electrodes or conductors is stressed when subject to a potential. When the potential is reversed, the stress also reversed. This change of stress involves molecularly arrangement within the dielectric. This involves the energy loss with each reversal. This is because the molecules have to overcome a certain amount of internal friction in the process of alignment. The energy expanded in the process is released as heat in the dielectric.

The loss appearing in the form of heat due to reversal of electric stresses, compelling molecular arrangement is known as dielectric loss.

When a dielectric material is subjected to an ac voltage, the leakage current I does not lead the applied voltage E by exactly 90°. As shown in vector diagram the phase angle φ is always less than 90°.

Application of Dielectrics:

The most common application of dielectric is as a capacitor to store energy. Capacitors are classified according to use of dielectrics used in their manufacture.

i. Capacitors using vacuum, air or gases as dielectric.
ii. Capacitors using mineral oil as dielectric.
iii. Capacitors using a combination of solid and liquid dielectrics.
iv. Capacitors only with solid dielectrics like glass and mica etc.

Chapter – 5

Short type question (2 marks)

1. **What are the materials used for permanent magnet & transformer cores. (W14, Q5 –a)**

   Materials used for permanent magnet are – Carbon steel, cobalt steel, tungsten steel, Alnico etc..

   Materials used for transformer core are – CRGO silicon – steel, Iron – silicon alloy.

2. **What is permeability? (W14, Q6 –a)**

   The property by virtue of which it allows itself to be magnetized is called permeability.

3. **What is Curie point?**

   A critical temperature above which the ferro-magnetic material lose their magnetic properties is known as curie point.

4. **What causes humming sound? Or what is magnetrostriction?**

   When ferromagnetic materials are magnetized a small change of dimension of material takes place. This rapid extension and compression of magnetic material cross section due to alternating current called magnetostriction.

   Magnetostriction is the major cause of hum in transformer and chokes.

5. **Write the material used for permanent magnet?**
   Hard-magnetic materials are used for making permanent magnets. The properties of material required of making permanent magnets are high saturation values, high coercive force and high residual magnetism.
   The hard-magnetic materials are carbon steel, tungsten steel, cobalt steel, alnico, hard ferrites.

6. **What is ALNICO?**

   It is known as Aluminium-nickel-iron-cobalt. Alnico is commercially the most important of the hard magnetic materials. Large magnets are made by special casting techniques and small one by powder metallurgy. As cobalt steel is cheaper so far these reason permanent magnets are most commonly made of Alnico.

Medium type question (5 marks)

1. **Explain briefly the phenomena of hysteresis.(W14, Q5-b)**

   Hystersis is especially pronounced in materials of high residual magnetism such as hard steel. In most cases hystersis is a liability as it causes dissipation of heat, waste of energy and humming due to change in polarity and rotation of element magnets in the material.

If a magnetic substance is magnetized in a strong magnetic field it retains some portion of magnetism after the magnetic force is withdrawn. The phenomenon of lagging of magnetization or induction flux density behind the magnetizing force is known as magnetic hysteresis.

The losses due to hystersis are known as hystersis loss. Hystersis loss depends upon the maximum flux density „B_m" and frequency of variation of flux is expressed as

Hysteresis loss = $\eta B_m^{1.6}$ fv J/S or Watt

Where η = is a constant. It is known as steinmetz hystersis coefficient

f = frequency of reversal of magnetization

B_m = Maximum flux density

V = Volume of magnetic material

2. Explain eddy current briefly. (W14, Q6-b / BP)

- When magnetic material is placed in alternating magnetic field, it cuts the magnetic flux. According to laws of electromagnetic induction an emf is induced.
- This emf causing current is known as Eddy current. The power loss due to the flow of this current is known as Eddy current loss.
- Eddy current loss is proportional to the square of the frequency and the square of the thickness of the material and is inversely proportional to the resistivity of the material.
- The expression for Eddy current loss is:

Eddy current loss = $KBm^2f^2t^2v^2$

Where Bm = Maximum flux density

f = Frequency of magnetic reversal

t = Thickness of lamination

v = Volume of magnetic material

3. Write the notes on hard magnetic material and their application. [W-15 Q-5(c)] (7 mark)

HARD MAGNETIC MATERIALS **:**

Hard-magnetic materials are used for making permanent magnets. The properties of material required of making permanent magnets are high saturation values, high coercive force and high residual magnetism.

The hard-magnetic materials are carbon steel, tungsten steel, cobalt steel, alnico, hard ferrites.

CARBON STEEL, TUNGSTEN STEEL, COBALT STEEL :

As the soft-magnetic material have narrow hysteresis loops, so when carbon is added in a material its hysteresis loop area is increased. Although it is cheap, magnets are made from carbon steel loss their magnetic properties very fast under influence of knocks and vibrations. When materials like tungsten, chromium or cobalt are added to carbon steel, its magnetic properties are improved.

ALNICO :

It is known as Aluminium-nickel-iron-cobalt. Alnico are commercially the most important of the hard magnetic materials. Large magnets are made by special casting techniques and small one by powder metallurgy. As cobalt steel is cheaper so far this reason permanent magnets are most commonly made of Alnico.

HARD FERRITES **:**

Hard magnetic ferrites like BaO $(Fe_2O_3)_6$ are used for the manufacture of light weight permanent magnets due to their low specific weight.

4. What are ferrites? What are their chief properties and field of application/ (W11, Q8)

or

What are ferrites? What are their chief properties and field of application? [W-12 Q-2(b)]

Ferrites are composed of iron oxide and one or more other metals in chemical combination, and their properties include:

- Hard , Brittle, Iron-containing , Polycrystalline
- Generally gray or blac.

Ferrites are two types called soft ferrite & hard ferrite.

Soft ferrite are Ceramic magnet called as ferro magnetic ceramic and ferrites. Ceramic magnet are made of an iron oxide, Fe_2O_3 with one or more divalent oxides such as NiO, MnO or ZnO.

Hard magnetic ferrites like BaO $(Fe_2O_3)_6$ are used for the manufacture of light weight permanent magnets due to their low specific weight.

Ferrite is a ceramic-like material with magnetic properties, which is used in many types of electronic devices. Ferrite is used in:

- Permanent magnets
- Ferrite cores for transformers and toroidal inductors
- Computer memory elements
- Solid-state devices

5. Write notes on soft & hard magnetic material?

S.No.	Hard Magnetic Materials	Soft Magnetic Materials
1	Materials which retain their magnetism and are difficult to demagnetize are called hard magnetic materials. These materials are used for making permanent magnets	Soft magnetic materials are easy to magnetize and demagnetize. These materials are used for making temporary magnets.
2	They have large hysteresis loss due to large hysteresis loop area.	They have low hysteresis loss due to small hysteresis area.
3	Susceptibility and permeability are low.	Susceptibility and permeability are high.
4	Coercivity and retentivity values are large.	Coercivity and retentivity values are less.
5	Magnetic energy stored is high.	Magnetic energy stored is less.
6	The eddy current loss is high.	The eddy current loss is less because of high resistivity.

6. Explain briefly about Magnetostriction.[W-12 Q-4(b]) (5 marks)

When ferromagnetic material is magnetized a small change of dimension of the material takes place. There is small extension & reduction of cross section takes place inside the material. When subject to rapid alternating magnetic field there is a rapid & continuous extension & contraction of the material takes place. This is called Magnetostriction.

It is the major cause of hum in transformer & chokes.

Long type question (7 marks)

1. Mention two types of hard magnetic materials explaining their properties & uses. (W14, Q5-c)

Hard magnetic materials are used for making permanent magnet. It posses the following properties,

- ❖ They have large hysteresis loss due to large hysteresis loop area.
- ❖ Susceptibility and permeability are low.
- ❖ Magnetic energy stored is high.
- ❖ The eddy current loss is high.

Two type of hard magnetic material are

- ❖ Carbon steel, tungsten steel, cobalt steel
- ❖ Alnico

Carbon steel, tungsten steel, cobalt steel – When carbon added to steel its hysteresis loop area is increased. Although It's cheap but the uses is limitation. On the other tungsten steel have superior magnet but expensive.

Uses – automotive, electronic device, consumer electronic, data processing etc..

Alnico – Aluminium – Nickel – cobalt mixed together to make permanent magnet used extensively for commercial purpose.

Uses – Vending machine, generator, hand – tool, military purpose, space flight, voltmeter, ammeter, relay, magnetic sensor, automobile etc…

2. Distinguish between peramagnetism, diamagnetism & ferromagnetism material. (W11, Q5)

Ans - Ferromagnetic materials

Ferromagnetic materials are strongly attracted by a magnetic force. The elements iron (**Fe**), nickel (**Ni**), cobalt (**Co**) and gadolinium (**Gd**) are such materials.

The reasons these metals are strongly attracted are because their individual atoms have a slightly higher degree of magnetism due to their configuration of electrons, their atoms readily line up in the same magnetic direction and the magnetic domains or groups of atoms line up more readily.

Alloys of iron, nickel, cobalt, gadolinium and certain ceramic materials can become "permanent" magnets, such that they retain their magnetism for a long time.

Paramagnetic materials

Paramagnetic materials are metals that are weakly attracted to magnets. Aluminium and copper are such metals. These materials can become very weak magnets, but their attractive force can only be measured with sensitive instruments.

Temperature can affect the magnetic properties of a material. Paramagnetic materials like aluminium, uranium and platinum become more magnetic when they are very cold.

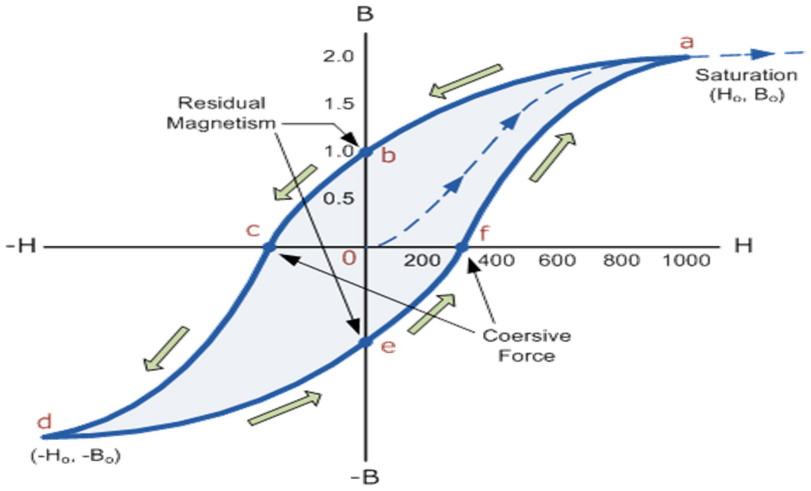
Diamagnetic materials

Certain materials are diamagnetic, which means that when they are exposed to a strong magnetic field, they induce a weak magnetic field in the opposite direction. In other words, they weakly repel a strong magnet. Some have been used in simple levitation demonstrations.

Bismuth and carbon graphite are the strongest diamagnetic materials. They are about eight times stronger than mercury and silver. Other weaker diamagnetic materials include water, diamonds, wood and living tissue.

3. Draw hysteresis loop for ferromagnetic material and explain.(W12/11, Q6-c)

Magnetic Hysteresis Loop



The **Magnetic Hysteresis** loop above shows the behaviour of a ferromagnetic core graphically as the relationship between B and H is non-linear. Starting with an un-magnetised core both B and H will be at zero, point 0 on the magnetisation curve.

If the magnetisation current, i is increased in a positive direction to some value the magnetic field strength H increases linearly with i and the flux density B will also increase as shown by the curve from point 0 to point a as it heads towards saturation.

Now if the magnetising current in the coil is reduced to zero, the magnetic field circulating around the core also reduces to zero. However, the coils magnetic flux will not reach zero due to the residual magnetism present within the core and this is shown on the curve from point a to point b.

To reduce the flux density at point b to zero we need to reverse the current flowing through the coil. The magnetising force which must be applied to null the residual flux density is called a “Coercive Force”.

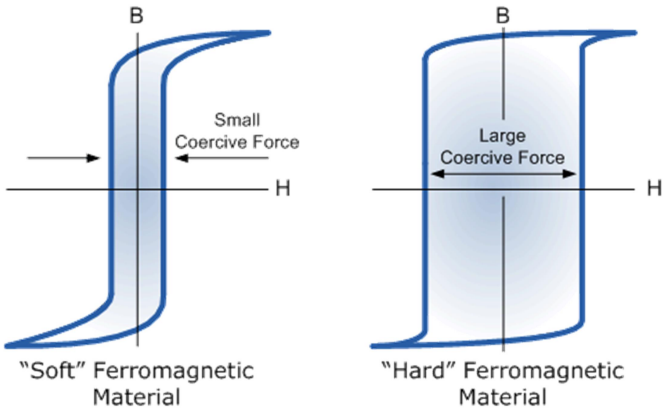
An increase in this reverse current causes the core to be magnetised in the opposite direction and increasing this magnetisation current further will cause the core to reach its saturation point but in the opposite direction, point d on the curve.

This point is symmetrical to point b. If the magnetising current is reduced again to zero the residual magnetism present in the core will be equal to the previous value but in reverse at point e.

Again reversing the magnetising current flowing through the coil this time into a positive direction will cause the magnetic flux to reach zero, point f on the curve and as before increasing the magnetisation current further in a positive direction will cause the core to reach saturation at point a.

Then the B-H curve follows the path of a-b-c-d-e-f-a as the magnetising current flowing through the coil alternates between a positive and negative value such as the cycle of an AC voltage. This path is called a **Magnetic Hysteresis Loop**.

Magnetic Hysteresis Loops for Soft and Hard Materials



Magnetic Hysteresis results in the dissipation of wasted energy in the form of heat with the energy wasted being in proportion to the area of the magnetic hysteresis loop.

Chapter – 6 (Material for special purpose)

Short type question (2 marks)

1. What is thermocouple material? (W14 , 6-a)

When two wires of different metals are joined together an emf exists across the junction. This emf is directly proportional to the temperature of the junction.

Ex- copper / constantan, iron / constantan, platinum / platinum rhodium.

2. What is fuse material?

The materials posses' Low resistivity, Low conductivity & low melting point are used as fuse material. Ex- lead, copper etc…

Medium type question (5 marks)

1. Explain properties of dehydrating materials with example. (W14,Q6-b)

- It is inorganic chemical, colloidal highly absorbent silica used as a dehumidifying and dehydrating agent.
- It is sometimes as a catalyst carrier.
- Calcium chloride and silicagel are used in dehydrating breather to remove moisture from the air entering a transformer as its breather.
- Silica gel when dry is blue in colour and colour change to pale as it becomes saturated with moisture.
- It can be dried by heating it in open container.

2. Describe fuse & fuse material. [2013 (W) Q5/b]

A fuse is a protective device, which consists of a thin wire or strip. This wire is placed with the circuit which heave to protect, so that the circuit. Current flows through it.

When this current is too high the temperature of the wire or strip will increase till the wire or strip melts. So braking the circuit and interrupting the power supply

Fuse materials have following properties:

a. Low resistivity

b. Low conductivity

c. Low melting point

Lead is used as fuse material because of its low melting point. But the resistivity of lead is high, thick wires are used. For re-wirable fuses alloys of tin and lead are used.

3. Describe thermocouple material. [2015 (W) B/P]

When two wires of different metals are joined together an emf exists across the junction. This emf is directly proportional to the temperature of the junction. When one tries to measure this emf more junctions are to be made which will give rise to emfs. When all the junctions are at the same temperature, the resultant emf will not be zero. This resultant emf is proportional to the temperature difference of the junctions and is known as thermoelectric emf.

Thermo couples are made of different materials such that copper / constantan, iron / constantan, platinum / platinum rhodium.

Thermo couples can be used for the measurement of temperature

4. Silica gel.[W-13 Q-7(a)](5 mark)

- It is an inorganic chemical highly absorbent silica used as dehumidifying and dehydrating agent.
- It is sometime used as a catalyst carrier and sometime as a catalyst.
- Silica gel are used in dehydrating breather to remove moisture from the air entering a transformer as it breathes.
- Now a days Silica gel breather replacing the Calcium Chloride breather.
- Silica when dry is blue in colour and colour changes to pale pink as it becomes saturated with moisture.
- It can be dried by heating it in an open container at a temperature between 150 to 200

Long type question (7 marks)

1. Explain soldering materials & state its application. (W14, Q6-c)

An alloy of two or more metals of low melting point used for base metals is known as soldering. The alloy used for joining the metals is known as solder. The solder is composed of 50% lead and 50% tin.

Its melting point is $185^{o}C$ tensile strength is 385 kg./cm^2 and electrical conductivity is 10% of copper.

For proper soldering flux is to be used. In soldering process the application of flux serves to removes oxides from the surface to be soldered. They deoxidize the metals at the time the soldering element is added.

Solders are two types such as 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.

The application of soft solders is in electronic devices and hard solder in power apparatus for making permanent connection

EYRE NO.7 FLUX : It is an improved variety of organic flux which is used with Alca P for alumnimum cable jointing.

2. Bimetal [2015 (W) B/P]

- A bimetal is made of two metallic strips of unlike metal alloy with different co-efficient of thermal expansion.
- At a certain temperature the strips will bend and actuate a switch or a lever of a switch.
- When heated the element bens so that the metal with the greater co-efficient 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.
- Iron & nickel with low coefficient of thermal expansion are used as one element.
- Material like constantan, brass having high coefficient of thermal expansion are used as other element.
- Bimetal strips are used in electrical apparatus & devices such as relay, regulator, and temp. control etc.....