

ELECTRICAL ENGINEERING MATERIALS

Unit II : Conducting and Semi-Conducting Materials

Topic: Conducting Materials: Low and High Resistivity Materials

Important Questions with Answers (3rd Semester, Electrical Engg.)

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Short Answer Questions

Q.1 What are conducting materials? Give examples.

Ans. Conducting materials (conductors) are materials that allow electric current to flow easily through them. They have a large number of free electrons. When a voltage is applied, these electrons move and form the current.

Examples:

1. Metals: silver, copper, gold, aluminium, steel, tungsten.
2. Alloys: brass, bronze, nichrome, constantan, manganin.
3. Non-metals: carbon (graphite).

Remember: Conductors are not only metals. Carbon and mercury also conduct.

Q.2 List the desirable properties of a good conductor.

Ans. A good conductor for general electrical use should have the following properties:

1. Low resistivity (high conductivity), so that power loss is small.
2. High tensile strength, so that it does not break under tension.
3. Ductility, so that it can be drawn into thin wires.
4. Malleability and flexibility, so that it can be bent and shaped easily.
5. Good resistance to corrosion, so that it lasts long.
6. Easy soldering and welding, so that joints are simple and reliable.
7. Low cost and easy availability.

Q.3 Compare low resistivity and high resistivity materials.

Ans. Low resistivity materials carry current with very little loss. High resistivity materials resist current and produce heat. The comparison is given below.

Basis	Low resistivity materials	High resistivity materials
Resistivity	Very low (about 10^{-8} ohm-m)	High (about 10^{-7} ohm-m and above)
Conductivity	High	Low
Heat produced by current	Very little	More
Main aim of use	To carry current with minimum loss	To produce heat or give a fixed resistance
Examples	Silver, copper, aluminium, ACSR, brass, bronze	Nichrome, constantan, manganin, tungsten, carbon
Applications	Cables, windings, bus bars, transmission lines	Heaters, rheostats, resistance boxes, filaments

Q.4 Define temperature coefficient of resistance. Name one material each with positive, negative and almost zero coefficient.

Ans. The temperature coefficient of resistance (α) is the change in resistance per ohm of original resistance for a one-degree rise in temperature. The resistance at a higher temperature is $R_t = R_0 (1 + \alpha \Delta T)$.

Type of coefficient	What happens on heating	Example
Positive	Resistance increases	Copper
Negative	Resistance decreases	Carbon
Almost zero	Resistance stays nearly constant	Manganin

Remember: Manganin and constantan are used in resistance boxes and measuring instruments because their resistance hardly changes with temperature.

Q.5 Define superconductivity with two examples and mention its applications.

Ans. Superconductivity is the property of some materials by which their electrical resistance becomes exactly zero when they are cooled below a certain temperature, called the critical temperature. Such a material is called a superconductor.

Examples:

1. Mercury (critical temperature about 4.2 K).
2. Lead (critical temperature about 7.2 K).

Applications:

1. Powerful electromagnets, for example in MRI machines.
2. Loss-free power cables and generators (mostly at the research and trial stage).
3. Magnetic levitation trains.

Note: The relative permeability of a superconductor is zero. Superconductors work only at very low temperatures, so they need costly cooling. The critical temperatures given are approximate and are not from the syllabus.

Long Answer Question

Q.6 Explain conducting materials and their two types (low resistivity and high resistivity). State the desirable properties of a good conductor and compare the two types with examples and applications.

Ans. Conducting materials are materials that allow electric current to flow easily through them because they have many free electrons. In terms of energy bands, the valence band and conduction band overlap, so there is no forbidden gap.

Resistivity:

The resistance of a conductor is $R = \rho l / A$. Here ρ is resistivity (ohm-metre), l is length and A is cross-section area. Resistivity is a property of the material only. Conductivity is $\sigma = 1 / \rho$.

Types of conducting materials:

1. **Low resistivity materials:** They offer very little opposition to current and are used to carry current with minimum loss. Examples: silver, gold, copper, aluminium, steel, ACSR, brass and bronze.

2. **High resistivity materials:** They offer large opposition to current and produce heat. They are used where heat or a fixed resistance is needed. Examples: carbon, tungsten, platinum, mercury, lead, constantan, nichrome, manganin, phosphor bronze and tin-lead alloy.

Desirable properties of a good conductor:

1. Low resistivity.
2. High tensile strength.
3. Ductility and flexibility.
4. Good corrosion resistance.
5. Easy soldering and welding.
6. Low cost and easy availability.

Applications:

1. Low resistivity: transmission lines, house wiring, windings of machines, bus bars, contacts.
2. High resistivity: heating elements, rheostats, resistance boxes, bulb filaments, fuse wire, solder.

Comparison:

Basis	Low resistivity materials	High resistivity materials
Resistivity	Very low	High
Heat produced	Very little	More
Purpose	Carry current with minimum loss	Produce heat or fixed resistance
Examples	Copper, silver, aluminium, ACSR	Nichrome, constantan, manganin, tungsten
Uses	Cables, windings, bus bars	Heaters, rheostats, filaments

Note: Tungsten is placed in the high resistivity group by the syllabus. Its main use as a filament comes from its very high melting point.

Points to Remember (for MCQ and True/False)

1. Materials that allow the flow of current through them are called conductors.
2. Ductility is the property of being drawn into wires.
3. Copper and aluminium are the most commonly used conducting materials. Copper is the most used.
4. Carbon has a negative temperature coefficient of resistance.
5. Manganin has a zero (almost zero) temperature coefficient of resistance.
6. The relative permeability of a superconducting material is zero.
7. Electrons in the outermost orbit are valence electrons, not free electrons (the statement that they are called free electrons is False).
8. Low resistivity materials carry current. High resistivity materials produce heat.