# ELECTRICAL ENGINEERING MATERIALS

## Unit II : Conducting and Semi-Conducting Materials

## Topic: High Resistivity Materials

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

**By Sunil Saharan**

### Short Answer Questions

### Q.1 Write the properties and applications of constantan (eureka).

**Ans.** Constantan is an alloy of copper (about 55–60%) and nickel (about 40–45%).

**Properties:**

1. High resistivity (about $4.9 \times 10^{-7}$ Ω·m).
2. Very low temperature coefficient of resistance, so its resistance stays almost constant.
3. Good ductility, so it can be drawn into fine wire.
4. Gives a high thermoelectric voltage with copper or iron.

**Applications:**

1. Rheostats, potentiometers and resistance boxes.
2. Low-temperature heating elements.
3. Thermocouples (copper-constantan, iron-constantan).

### Q.2 State the important properties and applications of tungsten.

**Ans.** Tungsten is a metal with the highest melting point of all metals.

**Properties:**

1. Melting point about 3400 °C.
2. Resistivity about $5.6 \times 10^{-8}$ Ω·m, higher than copper.
3. Very hard and strong at high temperature.
4. Brittle at normal temperature, but can be drawn into very thin wire by special methods.
5. Burns away in air at high temperature, so it works in vacuum or inert gas.

**Applications:**

1. Filaments of incandescent lamps.
2. Contacts facing sparking and arcing.
3. Heating elements of vacuum furnaces.
4. Electrodes and parts in X-ray tubes and electronic valves.

### Q.3 Write the properties and applications of nichrome.

**Ans.** Nichrome is an alloy of nickel (about 80%) and chromium (about 20%).

**Properties:**

1. Very high resistivity (about $1.1 \times 10^{-6}$ Ω·m).
2. High melting point (about 1400 °C).

3. Does not oxidise easily when red hot, as a chromium oxide layer protects it.
4. Good ductility.

**Applications:**

1. Heating elements of heaters, irons, toasters and furnaces.
2. Coils of DC motor starters.
3. Rheostats.

## Q.4 Write the properties and applications of manganin.

**Ans.** Manganin is an alloy of copper (about 84%), manganese (about 12%) and nickel (about 4%).

**Properties:**

1. High resistivity (about $4.8 \times 10^{-7}$ Ω·m).
2. Zero (almost zero) temperature coefficient of resistance.
3. Its resistance stays stable for many years.

**Applications:**

1. Standard resistances and resistance boxes.
2. Shunts of ammeters.
3. Precision measuring instruments.

## Q.5 Write the properties and applications of carbon.

**Ans.** Carbon (graphite) is a non-metal that conducts electricity.

**Properties:**

1. High resistivity compared with copper.
2. Negative temperature coefficient of resistance: resistance decreases as temperature rises.
3. Very high melting (sublimation) point.
4. Soft and slippery, so it acts as a lubricant.
5. Cheap, and does not weld to the commutator.

**Applications:**

1. Brushes of DC machines and slip-ring induction motors.
2. Carbon resistors.
3. Electrodes of arc lamps and furnaces.
4. Carbon rods in dry cells and granules in microphones.

## Q.6 Write the properties and one application each of platinum, mercury, lead, phosphor bronze and tin-lead alloy.

**Ans.** The properties and applications are given in the table.

| Material | Key properties | Application |
|---|---|---|
| **Platinum** | Does not oxidise or corrode; melting point about 1770 °C; very costly | Contacts of sensitive relays; resistance thermometers |

| | | |
|---|---|---|
| **Mercury** | Only metal that is liquid at room temperature; poisonous | Tilt switches; mercury vapour lamps |
| **Lead** | Soft and heavy; melting point about 327 °C; resists corrosion and acids | Sheath of underground cables; lead-acid battery plates |
| **Phosphor bronze** | Copper and tin with a little phosphorus; hard, springy, wear and corrosion resistant | Springs and relay contacts |
| **Tin-lead alloy** | Tin and lead (for example about 60% and 40%); low melting point (below 200 °C) | Solder for joints; fuse wire |

Note: Soldering and fuse are studied in Unit V.

## Long Answer Question

### Q.7 Discuss high resistivity conducting materials with their properties and applications.

**Ans.** High resistivity materials offer large opposition to the flow of current, so electrical energy changes into heat. They are used for heating elements, resistors, filaments and similar applications.

**Properties needed:**

1. High resistivity.
2. Low or zero temperature coefficient of resistance (for measuring instruments).
3. High melting point (for heating elements).
4. Good resistance to oxidation.
5. Ductility, so that it can be drawn into wires.

**Main materials:**

| Material | Composition / nature | Key property | Applications |
|---|---|---|---|
| **Constantan** | Copper and nickel | Very low temperature coefficient | Rheostats, resistance boxes, thermocouples |
| **Manganin** | Copper, manganese and nickel | Zero temperature coefficient | Standard resistances, shunts |
| **Nichrome** | Nickel and chromium | High resistivity and melting point | Heaters, irons, starter coils |
| **Tungsten** | Metal | Highest melting point | Lamp filaments, arcing contacts |
| **Carbon** | Non-metal | Negative temperature coefficient | Brushes, resistors, electrodes |
| **Platinum** | Noble metal | Does not oxidise | Sensitive contacts, thermometers |
| **Mercury** | Liquid metal | Liquid at room temperature | Tilt switches, vapour lamps |

| | | | |
|---|---|---|---|
| **Lead** | Soft metal | Low melting point, corrosion resistant | Cable sheath, batteries, fuse |
| **Phosphor bronze** | Copper, tin and phosphorus | Springy and hard | Springs, relay contacts |
| **Tin-lead alloy** | Tin and lead | Low melting point | Solder, fuse wire |

Note: Resistivity values are approximate textbook values and are not given in the syllabus.

## Points to Remember (for MCQ and True/False)

1. Manganin has zero temperature coefficient of resistance.
2. Carbon has a negative temperature coefficient of resistance.
3. Nichrome is used for winding the coils of DC motor starters.
4. Brushes of a slip-ring induction motor are made of carbon.
5. Tungsten has the highest melting point of all metals.
6. Constantan is also called eureka (copper and nickel).
7. Nichrome is an alloy of nickel and chromium.
8. High resistivity materials produce heat; low resistivity materials carry current.