ELECTRICAL ENGINEERING MATERIALS

Unit II : Conducting and Semi-Conducting Materials

Topic: Semiconductor Materials

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

-----By Sunil Saharan

Short Answer Questions

Q.1 Define semiconductor. Mention any four applications of semiconductors.

Ans. A semiconductor is a material whose electrical conductivity lies between that of a conductor and an insulator.

Main points:

1. It has a small forbidden gap between the valence band and the conduction band.
2. At very low temperature the valence band is almost full and the conduction band is almost empty, so it does not conduct.
3. At room temperature some electrons cross the gap, so it conducts a little.
4. Its resistance decreases as temperature rises (negative temperature coefficient of resistance), the opposite of metals.

Applications:

1. Diodes: rectifiers that change AC to DC, as in mobile chargers.
2. Transistors: amplifiers and electronic switches.
3. Integrated circuits (ICs): computers, mobile phones, TVs and microcontrollers.
4. Thyristors (SCR, TRIAC): motor speed control, light dimming and fan regulators.
5. Solar cells: conversion of sunlight into electricity.
6. LEDs and photodiodes: lighting, displays and remote-control sensors.
7. Thermistors and sensors: temperature and light measurement.

Q.2 Write the properties of germanium and silicon. Compare them.

Ans. Germanium (Ge) and silicon (Si) are the two most commonly used semiconductor materials. Both have four valence electrons and form a crystal in which each atom shares one electron with each of its four neighbours (covalent bonds). The comparison is given in the table.

Basis	Germanium (Ge)	Silicon (Si)
Atomic number	32	14
Valence electrons	4	4
Forbidden energy gap (room temperature)	About 0.67 eV	About 1.1 eV
Melting point	Lower (about 940 °C)	Higher (about 1410 °C)
Effect of temperature	More affected; more leakage current	Less affected; leakage current is small
Safe working temperature	Lower (about 75 °C)	Higher (about 150 °C)

Basis	Germanium (Ge)	Silicon (Si)
Voltage drop of forward biased diode	About 0.3 V	About 0.7 V
Availability	Rare and costly	Very plentiful (sand) and cheap
Use today	Limited and special uses	Most widely used

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

Q.3 Why is silicon preferred to germanium for making semiconductor devices?

Ans. Silicon is preferred because:

1. It works safely at higher temperature (about 150 °C, against about 75 °C for germanium).
2. Its leakage current is much smaller.
3. It is very plentiful and therefore cheaper.
4. It forms a strong and stable oxide layer (silicon dioxide), which makes it easy to build integrated circuits.

Q.4 What are the types of semiconductor? Differentiate between intrinsic and extrinsic semiconductors.

Ans. Semiconductors are of two types: intrinsic and extrinsic.

Doping with a pentavalent impurity (such as phosphorus) gives an N-type semiconductor. Doping with a trivalent impurity (such as boron) gives a P-type semiconductor.

Basis	Intrinsic semiconductor	Extrinsic semiconductor
Meaning	Pure semiconductor with no impurity added	Semiconductor to which a small amount of impurity is added (doping)
Examples	Pure silicon, pure germanium	N-type and P-type semiconductors
Conduction	Low; depends mainly on temperature	Much higher; controlled by the amount of doping
Charge carriers	Free electrons and holes in equal number	One type of carrier is in majority (electrons in N-type, holes in P-type)

Note: Details of doping are given in the note Semiconductor Fundamentals.

Points to Remember (for MCQ and True/False)

1. A semiconductor has an almost empty conduction band and an almost filled valence band.
2. The forbidden gap is largest in insulators, small in semiconductors, and absent in conductors.
3. Germanium and silicon each have four valence electrons.
4. Doping is the process of adding a small amount of impurity to a pure semiconductor.
5. The conductivity of a semiconductor increases when temperature rises.
6. Germanium has atomic number 32 and gap about 0.67 eV; silicon has atomic number 14 and gap about 1.1 eV.
7. Silicon is preferred: higher temperature limit, less leakage, cheap and plentiful.
8. Pentavalent impurity gives N-type; trivalent impurity gives P-type.