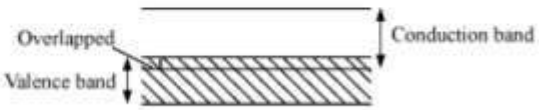
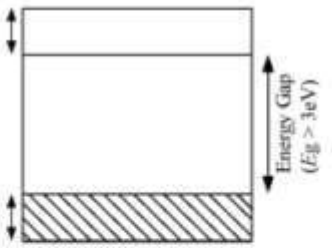
Semiconductors: These have conductivity and resistivity in-between metal conductors and insulators.

Energy band diagrams:

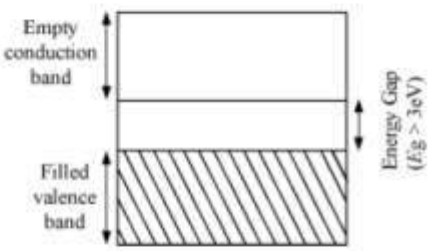
- Energy band diagram for conductors:



- Energy band diagram for insulators:



- Energy band diagram for semiconductors:



Intrinsic semiconductors: A pure semiconductor which is free from impurity is called an intrinsic semiconductor.

Doping: In the process of doping, desirable impurity atoms are added deliberately to a pure semiconductor so as to modify its properties in a controlled manner. The impurity atoms added are called dopants.

Extrinsic semiconductors: A semiconductor with suitable impurity atoms added to it is called an extrinsic semiconductor.

- p-type semiconductor → Trivalent impurity atoms are added to increase the conductivity; holes are the majority charge carriers

- n-type semiconductor → Pentavalent impurity atoms are added; electrons are the majority charge carriers

P–N Junction: When a p-type semiconductor crystal is brought into close contact with an n-type semiconductor crystal, the resulting arrangement is called a p-n junction diode. P-N junction is the 'key' to all semiconductor devices. When such a junction is made, a 'depletion layer' is formed consisting of immobile ion cores, devoid of their electrons or holes. This is responsible for a junction potential barrier.

By changing the external applied voltage, junction barriers can be changed. In forward bias (n-side is connected to negative terminal of the battery and p-side is connected to the positive terminal), the barrier is decreased; the barrier increases in reverse bias.

Diodes can be used for rectifying an AC voltage (restricting the AC voltage to one direction). With the help of a capacitor or a suitable filter, a DC voltage is obtained.

Special purpose diodes:

- Zener diodes: It is used for voltage regulation
- Photodiodes: Help us to measure light intensity
- Solar cells: Convert photon energy into electricity
- Light emitting diode: Electron excitation by a bias voltage results in the generation of light

Transistor

Transistor is an n-p-n or p-n-p junction device. The central block is called 'Base' while the other electrodes are the 'Emitter' and the 'Collector'. The emitter–base junction is forward biased while the collector–base junction is reverse biased.

Transistor as a device:

- Can be used as a switch
- Can be used as an amplifier
- Can be used as an oscillator

Amplifier:

Amplifier can be used in two configurations

- Common base configuration
- Common emitter configuration

Various gains in common base amplifier:

- **DC current gain**

$$\alpha_{dc} = \frac{I_c}{I_e}$$

- **AC current gain**

  $\alpha_{ac} = \left(\frac{\Delta I_c}{\Delta I_e}\right)$, when V_{cb} is constant

- **AC voltage gain**

  $A_v = \frac{\Delta I_c}{\Delta I_e} \times \frac{R_o}{R_i}$

  Or $A_v = \alpha_{ac} \times$ Resistance gain

  - **AC power gain**

    AC power gain $= \frac{\Delta I_c \times R_o}{\Delta I_e \times R_i} \times \frac{\Delta I_c}{\Delta I_e} = \left(\frac{\Delta I_c}{\Delta I_e}\right)^2 \times \frac{R_o}{R_i}$

    $= \alpha_{a.c}^2 \times$ Resistance gain

Various gains in common emitter amplifier:

- **DC current gain**

  $\beta = \frac{\alpha}{1-\alpha}$, where $\alpha = \frac{I_c}{I_e}$

- **AC current gain**

  $\beta_{ac} = \frac{\Delta I_c}{\Delta I_b}$

- **AC voltage gain**

  $A_v = \frac{\Delta V_c}{\Delta V_i} = \frac{\Delta I_c \times R_o}{\Delta I_b \times R_i} = \beta_{ac} \times \frac{R_o}{R_i}$

  $= \beta_{a.c} \times$ Resistance gain

- **AC power gain**

  AC power gain $= \beta_{a.c} \times A_v$

Logic Gates:

The important digital circuits performing special logic operations are called logic gates. These are: OR, AND, NOT, NAND, and NOR gates.