**Insulator:**

In an insulator the valence band is filled with electrons, so electrons cannot move within the valence band. In order to produce conduction of electricity, the electrons from the valence band must go into the conduction band. Thus, energy of more than the energy gap must be supplied to the electrons in the valence band, in order to transfer them into the conduction band. Because the energy gap in insulator is large, it prevents this change in energy by the electrons. Thus, insulators are poor conductors. The structure of the energy levels of an insulator can be seen in figure 1.19a.

![Energy levels of an insulator](image)

**Conductor**

In a conductor (metal) - The valence and conduction bands overlap, so practically the energy gap is zero. Thus, electrons need very little energy to stay in the conduction band, and conduct electricity. The structure of the energy levels of a conductor can be seen in figure 1.19a.

![Energy levels of a conductor](image)

**Semiconductor**

In a semiconductor - the energy gap is very small, and very little energy is needed to transfer electrons from the valence band into the conduction band. Even the thermal energy at room temperature is enough. By raising the
temperature, more and more electrons will be transferred to the conduction band. This process results in an increase in conductivity with increase in temperature. The structure of the energy levels of a semiconductor can be seen in figure 1.20.

![Energy levels of a semiconductor](image)

**Figure 1.20: Energy levels of a semiconductor.**

After an electron is transferred from the valence band into the conduction band, a "hole" remains in the valence band. These "holes" are similar in behavior to positive charges moving in the valence band as a result of applied voltage. In the process of electrical conduction, both the electrons in the conduction band, and the "positive holes" that remain in the valence band after the electrons "jumped" to the conduction band, participate.

To control the type and the density of charge carriers in a semiconductor, impurities which have extra charge carriers are added to the semiconductor. These impurity atoms are electrically neutral.

**Impurities**

In a "pure" semiconductor material the structure of the energy bands and energy gap are determined by the material. By adding a material with different number of charge carriers, additional energy levels appear inside the band gap (as can be seen in figure 1.21).

If the impurity contains more electrons than the pure semiconductor, these extra charge carriers are negative (electrons), and the material is called "Type n semiconductor". In such material, extra energy levels very close to the conduction band are added.
A very small amount of energy is enough to excite electrons from these levels to the conduction band, so free charge carriers are available to conduct electricity.

If the impurity contains less electrons than the pure semiconductor, extra energy levels are added very close to the valence band. Electrons from the valence band can move to these levels, leaving behind "positive holes". This material is called "Type p semiconductor". The influence on the shape of the energy bands of adding impurities is described in figure 1.21.

Figure 1.21: Energy levels in a semiconductor with impurities.