**CL33_Q1.** The "effective mass" of electrons depends on the curvature of the E-k plot. Explain this statement.

**Answer**

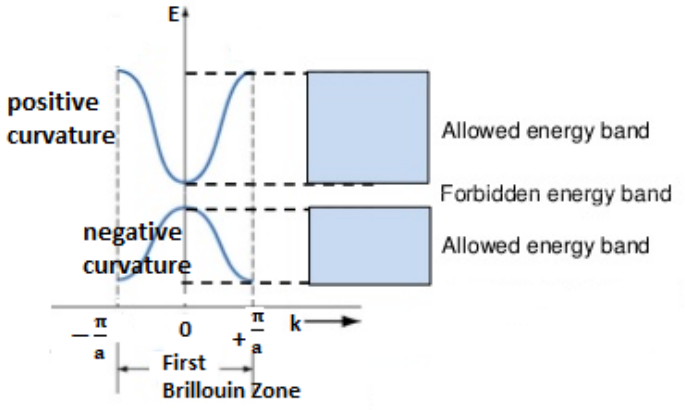


Image courtesy:adapted from slide share

In terms of energy and propagation constant, effective mass is given by $\boldsymbol{m^* = \left(\frac{1}{\hbar^2}\frac{d^2E}{dk^2}\right)^{-1}}$ .

The curvature of E-k diagram in the conduction band and valence band indicates whether the effective mass is positive or negative.

As the curvature of E-k diagram is positive in the conduction band, the effective mass is positive.

The curvature in the valence band is negative, indicating a negative mass (concept of hole conduction).

**CL33_Q2.** "The mass of an electron in the periodic potential of a solid is different from the free electron mass" Is the statement true or false? Can the effective mass be positive and negative? If yes, what are the specific conditions for the same.

**Answer**

True, the mass of electron in the periodic potential of a crystal is different from the free electron mass and is referred to as effective mass. In terms of energy and propagation constant, effective mass is given by

$$m^* = \left(\frac{1}{\hbar^2}\frac{d^2E}{dk^2}\right)^{-1}$$

In terms of the curvature of E-k diagram in the conduction band and valence band effective mass can be positive or negative.

As the curvature of E-k diagram is positive in the conduction band, the effective mass is positive.

The curvature in the valence band is negative, indicating a negative mass (concept of hole conduction).

**CL33_Q3.** With the help of a neat labelled diagram, explain the curvature of E-k in conduction band and valence band.

**Answer**

Effective mass is given by,

$m^* = \left(\frac{1}{\hbar^2}\frac{d^2E}{dk^2}\right)^{-1}$ is not a constant and depends on the non-linearity of E.

This means that the charge carriers have an effective mass which depends on the curvature of ***E-k.***

Higher curvature (larger $\frac{d^2E}{dk^2}$) means smaller effective mass and smaller curvature results in higher effective mass.

It can be seen that the slope of the E-K curve is minimum at the band edges and hence the effective mass of the charge carriers are highest at the band edges.

Since curvature of the ***E-k*** is positive in the conduction band the effective mass is +ve and the curvature in the valence band is negative indicating a negative mass. However, this can be construed to be the motion of a charge carrier with a charge of the opposite type as that of electrons. This leads to the concept of hole conduction in the valence band.