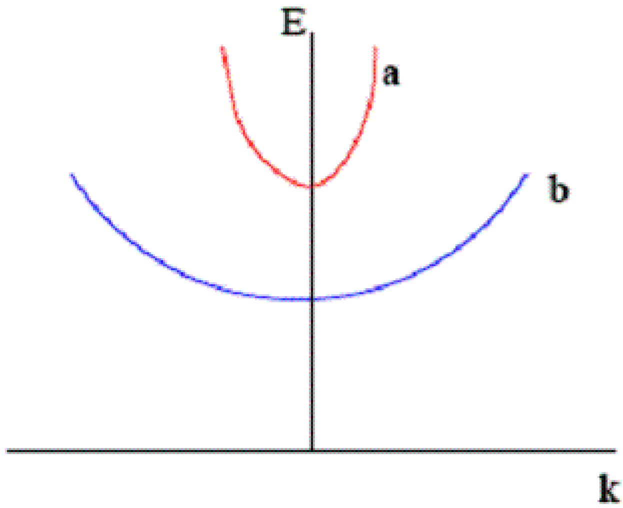
Exercise 1

Draw a picture of covalent band formation in Ammonia molecule.

(Hint : Nitrogen has 7 electrons with electronic configuration $k = 0$).

Exercise 2

Which one of the bands has higher effective mass near $k = 0$?



Exercise 3

The energy of an electron in the valence band of a certain one dimensional semiconductor may be written as

$$E = E_0(1 - \cos(ka))$$

where E_0 and a are constants. Sketch the variation of the energy and of the effective mass of the electron as functions of k.

Calculate the effective mass at $k = 0$ and at $k = \pi/a$ given that $a = 3$Åand $E_0 = 0.75$ eV.

(Ans. 1.02×10^{-30} kg)

Exercise 4

Electrons in a two dimensional square lattice are in a band whose structure is given by

$$E(k) = E_0 - 2t(\cos(k_x a) + \cos(k_y a))$$

where E_0, t and a are constants. Analyze the behaviour of electrons near the centre (0,0) and at the edges ($\pm\pi/a, \pm\pi/a$)

of the Brillouin zone and show that near these points, the structure may be approximated as $E(k) \sim \text{constant} + \frac{\hbar^2 k^2}{2m^*}$

where m^* is the effective mass. Determine the value of the effective mass at $k = 0$.

(Ans. 3.83×10^{-31} kg)

Exercise 5

The $E - k$ relationship for the conduction band of Ge is given by

$$E = E_c + \frac{\hbar^2}{2m_l^*}k_x^2 + \frac{\hbar^2}{2m_t^*}(k_y^2 + k_z^2)$$

where E_c is the energy of the bottom of the conduction band. The *longitudinal effective mass* m_l^* is 1.6 times the free electron mass while the *transverse effective mass* m_t^* is 0.082 times the free electron mass. Show that the energy surface is an ellipsoid of revolution with the major and minor axes being respectively $\sqrt{(2m_l/\hbar^2)(E - E_c)}$ and $\sqrt{(2m_t/\hbar^2)(E - E_c)}$.