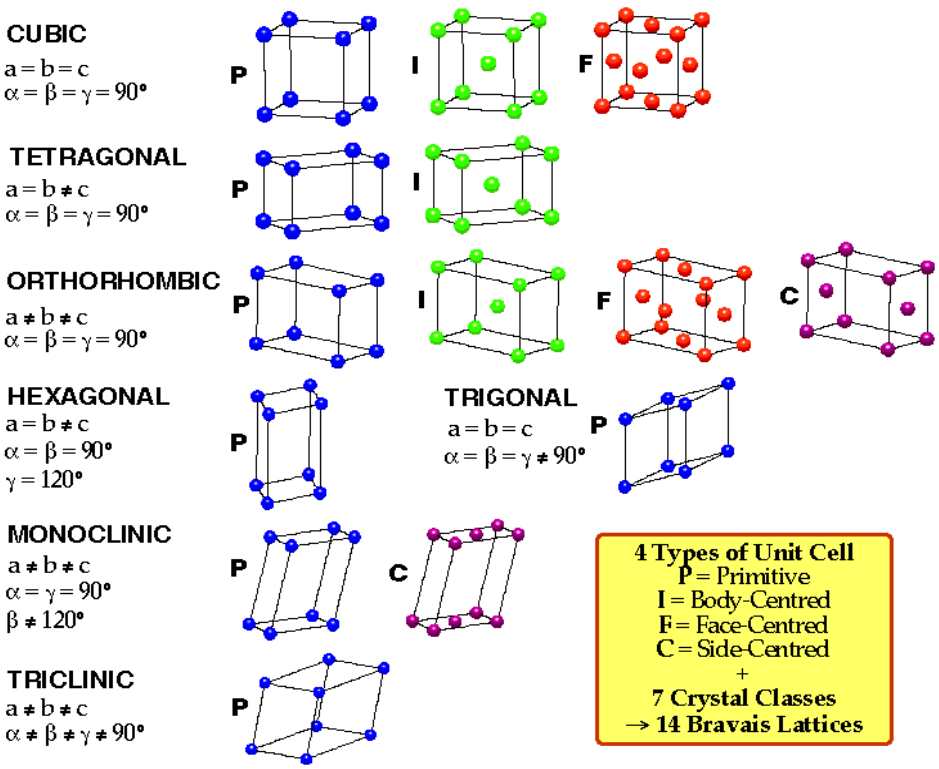
1.A.



1.B.

$$p = \frac{h}{\lambda} = \frac{6.625\times10^{-34}}{85\times10^{-10}} = 7.79\times10^{-26}$$

$$E = \frac{p^2}{2m} = \frac{\left(7.79\times10^{-26}\right)^2}{2\times9.11\times10^{-31}} = 3.33\,\text{J} = \underline{\underline{0.021\,\text{eV}}}$$

$$v = \frac{p}{m} = \frac{7.79\times10^{-26}}{9.11\times10^{-31}} = \underline{\underline{8.56\times10^{4}\ \text{m/s}}}$$

1.C.

$$\left(-\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2} + V(x)\right)\psi(x,t) = j\hbar\frac{\partial}{\partial t}\psi(x,t)$$

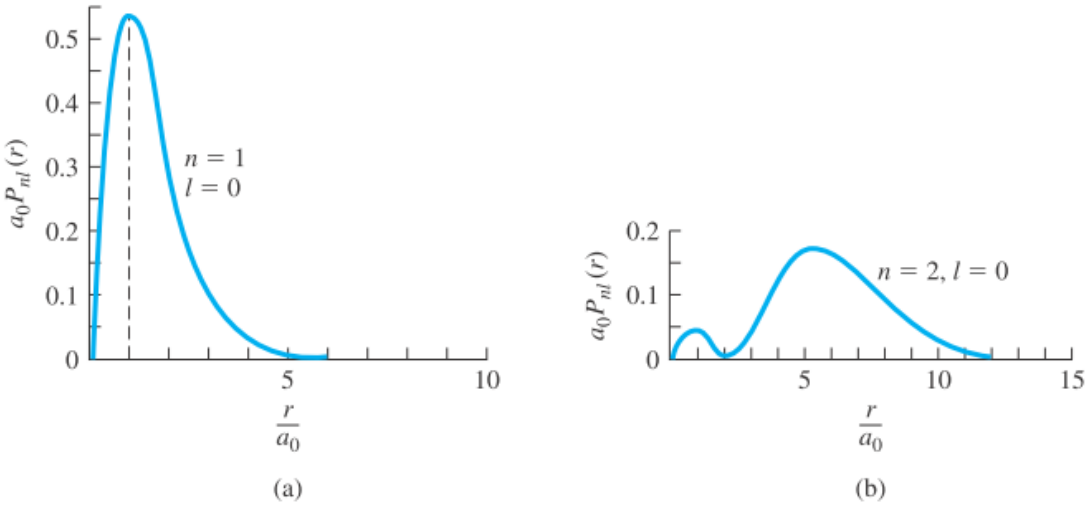


Figure 2.11 | The radial probability density function for the one-electron atom in the (a) lowest energy state and (b) next-higher energy state.
(From Eisberg and Resnick [5].)

2.A.

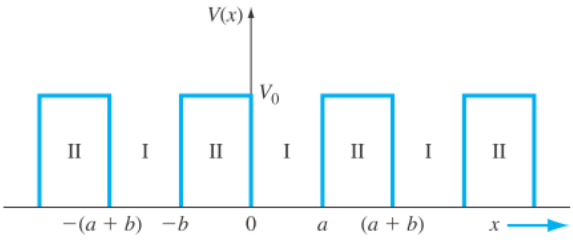


Figure 3.6 | The one-dimensional periodic potential function of the Kronig–Penney model.

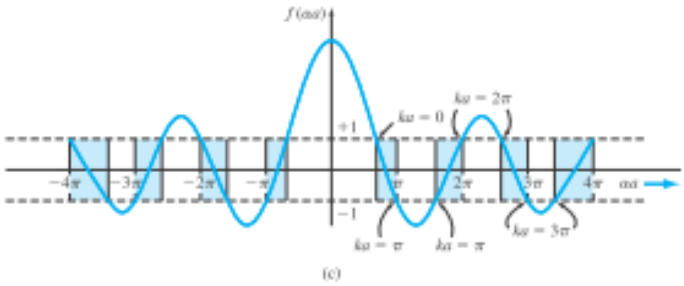
1. In periodic potential, the wavefunction must be a Bloch function, where

$$\psi(x) = u(x)e^{jkx}$$
$$u(x) = u(x + a + b)$$

2. The solution of this wavefunction will satisfy

$$P' \frac{\sin \alpha a}{\alpha a} + \cos \alpha a = \cos ka$$
$$P' = \frac{mV_0 ba}{\hbar^2}$$
$$\alpha^2 = \frac{2mE}{\hbar^2}$$

Therefore, k is periodic in $\frac{2\pi}{a}$. The discontinuous allowed bands and forbidden bands by solving the equation numerical, as shown in the following figures.



(c)

Figure 3.8 | A plot of (a) the first term in Equation (3.29), (b) the second term in Equation (3.29), and (c) the entire $f(\alpha a)$ function. The shaded areas show the allowed values of (αa) corresponding to real values of k.

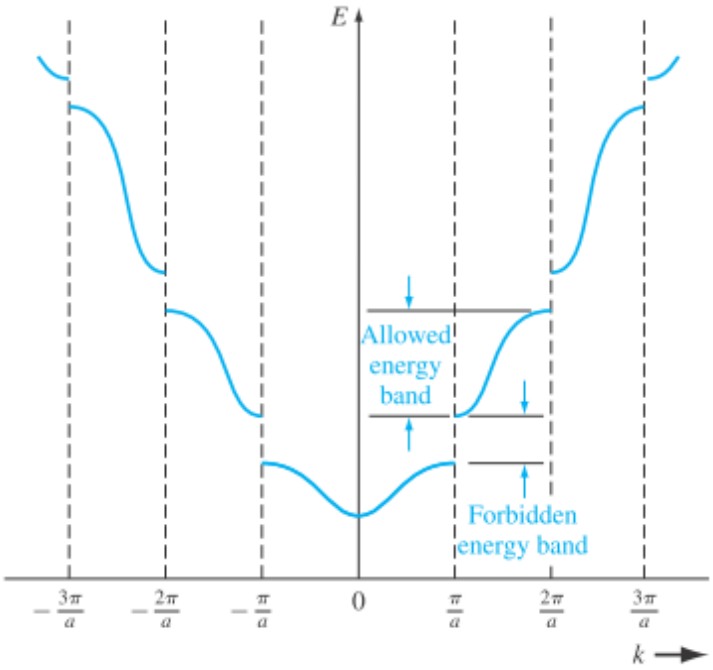


Figure 3.9 | The E versus k diagram generated from Figure 3.8. The allowed energy bands and forbidden energy bandgaps are indicated.

2.B.

$$f(E)=\frac{1}{1+\exp\left(\frac{E-E_F}{kT}\right)}=\frac{1}{1+\exp(5)}=0.269$$

3.A.

$$E_{F_i} - E_{midgap} = \frac{3}{4} kT \ln\left(\frac{m_p^*}{m_n^*}\right) = \frac{3}{4} \times 0.0259 \times \ln(10) = 0.0447 \text{ eV}$$

3.B.

(i) This is p-type. Acceptors are added.

(ii)

$$E_F - E_{midgap} = -0.45$$

$$E_F - E_{Fi} = -0.45 - 0.0447 = -0.4947$$

$$p_0 = n_i \exp\left[-\frac{E_F - E_{Fi}}{kT}\right] = 10^5 \exp\left[\frac{0.4947}{0.0259}\right] = 1.97 \times 10^{13} \text{ cm}^{-3}$$