3. Since $E_n \propto L^{-2}$ in Eq. 39-4, we see that if L is doubled, then E_1 becomes (2.6 eV)$(2)^{-2}$ = 0.65 eV.

4. We first note that since $h = 6.626 \times 10^{-34}$ J·s and $c = 2.998 \times 10^{8}$ m/s,

$$hc = \frac{(6.626 \times 10^{-34}\ \text{J}\cdot\text{s})(2.998 \times 10^{8}\ \text{m/s})}{(1.602 \times 10^{-19}\ \text{J/eV})(10^{-9}\ \text{m/nm})} = 1240\,\text{eV}\cdot\text{nm}.$$

Using the mc^2 value for an electron from Table 37-3 (511×10^3 eV), Eq. 39-4 can be rewritten as

$$E_n = \frac{n^2h^2}{8mL^2} = \frac{n^2(hc)^2}{8(mc^2)L^2}.$$

The energy to be absorbed is therefore

$$\Delta E = E_4 - E_1 = \frac{(4^2 - 1^2)h^2}{8m_eL^2} = \frac{15(hc)^2}{8(m_ec^2)L^2} = \frac{15(1240\,\text{eV}\cdot\text{nm})^2}{8(511\times10^3\,\text{eV})\,(0.250\,\text{nm})^2} = 90.3\,\text{eV}.$$

8. The frequency of the light that will excite the electron from the state with quantum number n_i to the state with quantum number n_f is

$$f = \frac{\Delta E}{h} = \frac{h}{8mL^2}\left(n_f^2 - n_i^2\right)$$

and the wavelength of the light is

$$\lambda = \frac{c}{f} = \frac{8mL^2c}{h\left(n_f^2 - n_i^2\right)}.$$

The width of the well is

$$L = \sqrt{\frac{\lambda hc(n_f^2 - n_i^2)}{8mc^2}}$$

The longest wavelength shown in Figure 39-27 is $\lambda = 80.78$ nm which corresponds to a jump from $n_i = 2$ to $n_f = 3$. Thus, the width of the well is

$$L = \sqrt{\frac{\lambda hc(n_f^2 - n_i^2)}{8mc^2}} = \sqrt{\frac{(80.78\text{ nm})(1240\,\text{eV}\cdot\text{nm})(3^2 - 2^2)}{8(511\times10^3\,\text{eV})}} = 0.350\,\text{nm} = 350\text{ pm}.$$

13. The position of maximum probability density corresponds to the center of the well: $x = L/2 = (200\text{ pm})/2 = 100\text{ pm}.$

(a) The probability of detection at x is given by Eq. 39-11:

$$p(x) = \psi_n^2(x)dx = \left[\sqrt{\frac{2}{L}}\sin\left(\frac{n\pi}{L}x\right)\right]^2 dx = \frac{2}{L}\sin^2\left(\frac{n\pi}{L}x\right)dx$$

For $n = 3$, $L = 200\text{ pm}$ and $dx = 2.00\text{ pm}$ (width of the probe), the probability of detection at $x = L/2 = 100\text{ pm}$ is

$$p(x = L/2) = \frac{2}{L}\sin^2\left(\frac{3\pi}{L}\cdot\frac{L}{2}\right)dx = \frac{2}{L}\sin^2\left(\frac{3\pi}{2}\right)dx = \frac{2}{L}dx = \frac{2}{200\text{ pm}}\left(2.00\text{ pm}\right) = 0.020\,.$$

(b) With $N = 1000$ independent insertions, the number of times we expect the electron to be detected is $n = Np = (1000)(0.020) = 20$.