- 5-5. According to statistical mechanics, the average kinetic energy of a particle at temperature T is 3kT/2, where k is the Boltzmann constant. What is the average de Broglie wavelength of nitrogen molecules at room temperature?
- 5-25. The wave function describing a state of an electron confined to move along the x axis is given at time zero by

$$\Psi(x,0) = Ae^{-x^2/4\sigma^2}$$

Find the probability of finding the electron in a region dx centered at (a) x = 0, $(b) x = \sigma$, and $(c) x = 2\sigma$. (d) Where is the electron most likely to be found?

- 5-38. An excited state of a certain nucleus has a half-life of 0.85 ns. Taking this to be the uncertainty Δt for emission of a photon, calculate the uncertainty in the frequency Δf , using Equation 5-25. If $\lambda = 0.01$ nm, find $\Delta f/f$.
- **5-43.** Using the relativistic expression $E^2 = p^2c^2 + m^2c^4$, (a) show that the phase velocity of an electron wave is greater than c; (b) show that the group velocity of an electron wave equals the particle velocity of the electron.
- **5-46.** A particle of mass m moves in a one-dimensional box of length L. (Take the potential energy of the particle in the box to be zero so that its total energy is its kinetic energy $p^2/2m$.) Its energy is quantized by the standing-wave condition $n(\lambda/2) = L$, where λ is the de Broglie wavelength of the particle and n is an integer. (a) Show that the allowed energies are given by $E_n = n^2 E_1$, where $E_1 = h^2/8mL^2$. (b) Evaluate E_n for an electron in a box of size L = 0.1 nm and make an energy-level diagram for the state from n = 1 to n = 5. Use Bohr's second postulate $f = \Delta E/h$ to calculate the wavelength of electromagnetic radiation emitted when the electron makes a transition from (c) n = 2 to n = 1, (d) n = 3 to n = 2, and (e) n = 5 to n = 1.