7-25. Show that the radial probability density for the $n = 2$, $\ell = 1$, $m = 0$ state of a one-electron atom can be written as

$$P(r) = A\cos^2\theta\, r^4 e^{-Zr/a_0}$$

where A is a constant.

7-40. Consider a system of two electrons, each with $\ell = 1$ and $s = \frac{1}{2}$. (*a*) What are the possible values of the quantum number for the total orbital angular momentum $\mathbf{L} = \mathbf{L}_1 + \mathbf{L}_2$? (*b*) What are the possible values of the quantum number S for the total spin $\mathbf{S} = \mathbf{S}_1 + \mathbf{S}_2$? (*c*) Using the results of parts (*a*) and (*b*), find the possible quantum numbers j for the combination $\mathbf{J} = \mathbf{L} + \mathbf{S}$. (*d*) What are the possible quantum numbers j_1 and j_2 for the total angular momentum of each particle? (*e*) Use the results of part (*d*) to calculate the possible values of j from the combinations of j_1 and j_2. Are these the same as in part (*c*)?

7-47. Using Figure 7-34, determine the ground-state electron configurations of tin (Sn, $Z = 50$), neodymium (Nd, $Z = 60$), and ytterbium (Yb, $Z = 70$). Check your answers with Appendix C. Are there any disagreements? If so, which one(s)?

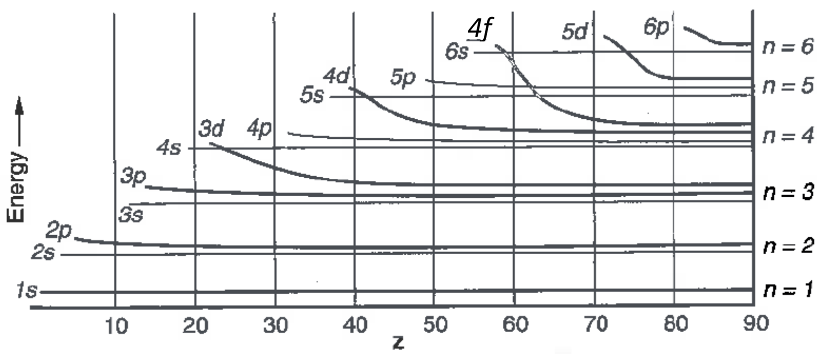

FIGURE 7-34 Energy of electron ground-state configurations versus Z.

7-67. In a Stern-Gerlach experiment hydrogen atoms in their ground state move with speed $v_x = 14.5\,\text{km/s}$. The magnetic field is in the z direction and its maximum gradient is given by $dB_z/dz = 600\,\text{T/m}$. (*a*) Find the maximum acceleration of the hydrogen atoms. (*b*) If the region of the magnetic field extends over a distance $\Delta x = 75$ cm and there is an additional 1.25 m from the edge of the field to the detector, find the maximum distance between the two lines on the detector.

7-69. The wavelengths of the photons emitted by potassium corresponding to transitions from the $4P_{3/2}$ and $4P_{1/2}$ states to the ground state are 766.41 nm and 769.90 nm. (*a*) Calculate the energies of these photons in electron volts. (*b*) The difference in energies of these photons equals the difference in energy ΔE between the $4P_{3/2}$ and $4P_{1/2}$ states in potassium. Calculate ΔE. (*c*) Estimate the magnetic field that the $4p$ electron in potassium experiences.