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

\[
P(r) = A \cos^2 \theta r^4 e^{-rz/\alpha_0}
\]

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](image)

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 \( \Delta x = 75 \text{ cm} \) 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 \( \Delta E \) between the \( 4P_{3/2} \) and \( 4P_{1/2} \) states in potassium. Calculate \( \Delta E \). (c) Estimate the magnetic field that the \( 4p \) electron in potassium experiences.