1. Show that the radial wave function $R_{20}$ for $n = 2$ and $\ell = 0$ satisfy equation 7.13. What energy $E$ results? Is this consistent with the Bohr model?

2. Show that the radial wave function $R_{21}$ for $n = 2$ and $\ell = 1$ is normalized.

3. For a $3p$ state find the possible values of $n, \ell, m_\ell, L, L_z, L_x, L_y$.

4. Draw for a $3d$ state all the possible orientations of the angular momentum vector $\vec{L}$. What is $L_x^2 + L_y^2$ for the $m_\ell = -1$ component?

5. Prove that the degeneracy of an atomic hydrogen state having principal quantum number $n$ is $n^2$ (ignore the spin quantum number).

6. For hydrogen atoms in a $4d$ state, what is the the maximum difference in potential energy between atoms when placed in a magnetic field of 2.4T? Ignore intrinsic spin.

7. For hydrogen atoms in a $d$ state sketch the orbital angular momentum with respect to the $z$ axis. Use units of $\hbar$ along the $z$ axis and calculate the allowed angles of $\mu_\ell$ with respect to the $z$ axis.

8. The red line of the Balmer series in hydrogen ($\lambda = 656.5$ nm) is observed to split into three different spectral lines with $\Delta \lambda = 0.04$ nm between two adjacent lines when place in a magnetic field $B$. What is the value of $B$ if $\Delta \lambda$ is due to the energy splitting between two adjacent $m_\ell$ states?

9. The magnetic field in a Stern-Gerlach experiment varies along the vertical direction as $\frac{dB}{dz} = 20$T/cm. The horizontal length of the magnet is 7.1 cm, and the speed of the silver atoms averages 925 m/s. The mass of the silver atoms is $1.8 \times 10^{-25}$ kg. Show that the $z$ component of its magnetic moment is 1 Bohr magneton. What is the separation of the two silver atom beams as they leave the magnet?
10. Using all four quantum numbers \((n, \ell, m_\ell, m_s)\), write down all possible sets of quantum numbers for the 5f state of atomic hydrogen. What is the total degeneracy?

11. In figure 7.12, the radial distribution function \(P(r)\) for the 2s state of hydrogen has two maxima. Find the values of \(r\) (in terms of \(a_0\)) where these maxima occur.

12. Calculate the probability of an electron in the ground state of hydrogen atom being inside the region of the proton(radius \(\approx 1 \times 10^{-15}\) m). (Hint: note that \(r \ll a_0\)).

13. Calculate the probability that an electron in the ground state of the hydrogen atom can be found between 0.95\(a_0\) and 1.05\(a_0\).

14. Find the most probable radial position of an electron in the 3d state of the hydrogen atom.