Homework Solution #4(PH312)

1-For hydrogen atoms in a 4d state, what is the maximum differenced in potential energy between atoms when placed in a magnetic field of 2.5 T ? Feel free to ignore intrinsic spin.

. The maximum difference is between the $m_l = -2$ and $m_l = +2$ levels, so $\Delta m_l = 4$. T

$$\Delta V = \mu_B (\Delta m_l) B = \left(5.788 \times 10^{-5} \text{ eV/T}\right) (4) (2.5 \text{ T}) = 5.79 \times 10^{-4} \text{ eV}$$

2. In an external magnetic field, can the electron spin vector S point in the direction of B ? Justify your answer briefly.

the electron spin vector cannot point in the direction of $\vec{B}$, because its magnitude is $S = \sqrt{s(s+1)} = \sqrt{3/4}\,\hbar$ and its z-component is $S_z = m_s\hbar = \hbar/2$. If the z-component of a vector is less than the vector's magnitude, the vector does not lie along the z-axis.

3. Demonstrate that the total degeneracy for an atomic hydrogen state having principal quantum number n is $2n^2$. Do not show it for just one state, attempt to show it for all possible
states.

There is one possible m_l value for $l = 0$, three values of m_l for $l = 1$, five values of $l = 2$, and so on, so that the degeneracy of the nth level is

$$1 + 3 + 5 + \ldots = n^2$$

The spin degeneracy is 2 and the n^2