1) By setting up and solving the appropriate integral, calculate the probability that an electron (in a 1s orbital) will be found within a distance $2a_0$ from the nucleus.

2) Calculate (using the normalization integral) the normalization constant ($N$) for the unnormalized hydrogen 2s wavefunction given by $\psi_{2s} = N(2-\sigma)e^{-\sigma/2}$

3) Prove that the wavefunctions $\psi_{2p_x}$ and $\psi_{2p_y}$, are orthogonal to each other. You should use the real form of the wavefunctions given in Table 6-6.

4) (a) Calculate the energy difference (in J) between the 3p and 1s levels in atomic hydrogen and deduce the wavelength of light (in nm) needed for this transition. (b) Calculate the energies (in J) for all possible transitions between the 3p and 1s levels for atomic hydrogen when the spectrum is recorded in the presence of an external magnetic field of 10.00T. Explain your reasoning with a diagram to show the energy levels involved. Note: you may run into significant figures problems here due to the small nature of the splittings due to the field.

5) Set up (but do not solve) the expression that would be required to calculate the most probable distance of the electron from the nucleus in a hydrogen atom in the 2s state. How would you expect the most probable distance $\langle r_{mp}\rangle$ to compare to the average distance $\langle r\rangle$ in the 2s state? (There’s no need to do any calculations).

Interesting aside: the significance of the atomic unit of distance (the bohr, $a_0$) is that this is the most probable distance from the nucleus that you will find an electron in a hydrogen atom in the 1s state.