Home Work Set Chapter 7 (part 1)

1) A quantum rotator can be described by $H = A\,L^2 + B\,L_Z$. $A = 5eV/\hbar$ and $B = 1eV/\hbar$. Draw an energy level diagram fo the first 3 energy levels, $\ell = 1,2,3$

2) Find the degeneracy in the 1st 4 Energy levels of the Particle in a 3d box.

3) The Laguerre Polynomials are an Orthonormal Set of eigenfunctions (like i,j,k unit vectors).

Show that $\int_0^\infty R_{10} R_{10} r^2 dr = 1$ and $\int_0^\infty R_{10} R_{20} r^2 dr = 0$

4) An electron is in the 2p atomic state $\psi_{2p} = A(\psi_{200} + i\psi_{210} - \sqrt{2}\psi_{21-1} + \sqrt{2}\psi_{21+1})$

(a) Determine the normalization constant A. $(h\text{int}: \psi^*_{2p}\psi_{2p} = 1)$

(b) What is the average energy of this state

$E = <\psi^*_{2p} H \psi_{2p}> \quad e.g \;\; <\psi^*_{100} H \psi_{100}> = -13.6eV$?

(c) What is the average $<L^2>$ and $<L_Z>$ of this state?

5) See the ReducedMass attachment. Make the substitution and derive the Lagangian (L=T-V) in terms of the reduced mass for this two body to one body transform. (similar for Hamiltonian H=T+V)

6) The form of the radial wave function for two orthonormal states are $R_{10}(r)=Ae^{-r/a}$ and $R_{20}(r)=Be^{-r/a}(1-br)\,e^{-r/2a}$. Can we determine A,B, and b? Give the concise argument.