PHYSICS 632 Winter 2007 Exam #1

Write your name on the test booklet. Do NOT simply write an answer. Give a calculation and/or reasoning that supports your answer. Do all work and write all answers in the test booklet. Circle or clearly delineate all relevant work so that I do not take points off for errors in your scratch work.

1) Rigid Rotor in a Magnetic Field. $H = \frac{L^2}{2I} + \mu B L_z$, where $\mathbf{L}$ *is an orbital angular momentum, not a spin.* To simplify the problem, we will adjust B so that $\mu B = 2/I$, which gives us:

$$H = \frac{1}{2I}\left[L^2 + 4L_z\right]$$

(a) Find the ground state(s).

(b) $|\psi(t=0)> = \frac{1}{\sqrt{2}}\left[|0,0> -i\ |1,0>\right]$

If L_x is measured at time t_1, what are the possible results and their probabilities?

(c) If the measurement at time t_1 yields -1 for L_x, and L_z is measured at time t_2, what are the possible results and their probabilities?

2) Hydrogen Atom. The hydrogen eigenstates are $< \mathbf{r}|nlm >= \phi_{nlm}(\mathbf{r})$, where the energies are $E_n = -\mathcal{R}/n^2$. Any specific states you need are given in the notes. The initial state is $|\psi(t=0)> = \frac{1}{\sqrt{2}}\left[|100> + |210>\right]$.

(a) What are $< x > (t)$ and $< z > (t)$?

(b) As a function of time, what is the probability of finding $z > 0$?

3) Spin-1/2. For spin one-half there are two eigenstates, $|+>$ and $|->$, where $S^2|\pm> = 3/4|\pm>$ and $S_z|\pm> = \pm 1/2|\pm>$. $H = \frac{S^2}{2I} + \omega_0 S_z$. At $t = 0$, we measure S_x and find $-1/2$. At time t we measure S_x again. What are the possible results and their respective probabilities?