PHYSICS 632 Winter 2006 Midterm #1

Name:______________________________

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. $H = \frac{L^2}{2I} + \mu B L_z$. To simplify the problem, we will adjust B so that $\mu B = 3/I$, which gives us:

$$H = \frac{1}{2I}\left[L^2 + 6L_z\right]$$

(a) Find the ground state(s).

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

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 zero for L_x, and L_z is measured at time t_2, what are the possible results and their probabilities?

2) Particle Confined to a Sphere of Radius R. At time $t = 0$, $|\psi(\mathbf{r}, t = 0 >= N * (R - r)$ for $r < R$ and zero for $r > R$.

(a) Find N by normalizing $|\psi(t = 0)>$.

(b) What is $\psi(\mathbf{r}, t>$? Write your answer as a sum and compute any integrals that appear.

(c) What is $< r > (t) = \int d^3r |\psi(\mathbf{r}, t)|^2 \, r$?

3) 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 $|\psi(t=0)>= \frac{1}{\sqrt{2}}\left[|100> + |211>\right]$.

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

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