

## Sample Questions For Midterm #1

1)  $j=1$ , states:  $|+1\rangle, |0\rangle, |-1\rangle$

general state  $|\psi\rangle = \alpha|+1\rangle + \beta|0\rangle + \gamma|-1\rangle$

$$\langle J_z \rangle = ?$$

$$\langle J_x^2 \rangle = ?$$

harder  $\langle \vec{J} \rangle = ?$

2) Compute  $[L_i, \vec{R} \cdot \vec{P}]$

3) Two spin-1 particles interact with

$$H = -\vec{J}_1 \cdot \vec{J}_2$$

What are the eigenstates and eigenvalues?

4)  $\psi(\vec{r}) = N(x+y+z) e^{-r^2/\alpha^2}$

Using  $Y_1^0 = \sqrt{\frac{3}{4\pi}} \cos \theta$ ,  $Y_1^{\pm 1} = \mp \sqrt{\frac{3}{8\pi}} \sin \theta e^{\pm i\phi}$

determine possible values of  $L^2$  and  $L_z$  and

their probabilities.

5) A particle with spin  $\frac{1}{2}$  (states  $|+\rangle$  and  $|-\rangle$ )

has  $H = \omega_0 S_z$ .

$$|\psi(t=0)\rangle = \frac{1}{\sqrt{2}} (|+\rangle - |-\rangle)$$

What is  $|\psi(t)\rangle$ ?

What is  $\langle S_x \rangle(t)$ ?

6) Spin  $\frac{1}{2}$  particle with basis  $|+\rangle$  and  $|-\rangle$ .

What are the eigenstates of  $S_y$  and their eigenvalues?

7)  $j=1$ , states  $|+1\rangle$ ,  $|0\rangle$ ,  $|-1\rangle$ .

$$H = \omega_0 L_x$$

$$|\psi(t=0)\rangle = |0\rangle$$

$$|\psi(t)\rangle = ?$$

8) A particle is in a rectangular box with sides :

$$a_x = a, a_y = 2a, a_z = 2a$$

Using integers  $n_x, n_y$  and  $n_z$ , what are the possible energies,  $E(n_x, n_y, n_z)$ ?

What are the first three energy levels and their degeneracies?

9) A particle is confined to a sphere of radius  $R$ , and has  $l=3, m=2$ . What is the probability that  $r < R/2$  if it is in the lowest energy state of this type?

10) A particle with  $l=m=0$  is confined to a sphere of radius  $R$  and is in its ground state. At  $t=0$  the sphere is removed. What is  $|\psi(t)\rangle$ ?