NAME:

QM, Qualifying Exam: 2009

Note: If a formula appears in the Shankar's book, please use that as a starting point, there is no need to show the derivation of that formula.

(1) (20 points)

Consider a system whose Hamiltonian H and an operator C are given by the following matrices:

$$H = \epsilon \begin{pmatrix} 1 & -1 & 0 \\ -1 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$$

$$C = c \begin{pmatrix} 0 & 4 & 0 \\ 4 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$$

where ϵ has the dimensions of energy.

(a) If we measure the energy, what values will we obtain?

(b) Suppose that when we measure energy, we obtain a value of $-\epsilon$. Immediately afterwords, we measure C. What values will we obtain for C and what are the probabilities corresponding to each value??

(2) (20 points)

Consider a system of three non-interacting particles (each of mass m) confined in a two-dimensional potential $V(x, y) = (x^2 + y^2)$. Calculate the total ground state energy and the first excited state energy of the system if, (a) Particles are non-interacting neutrons. (b) Particles are non-interacting He atoms. (c) Two particles are electrons and the other is a positron.

(3) (10 points)

Wave function of a particle moving in three dimension is $\psi(r, \theta, \phi) = Ae^{-r}$. Calculate the value of r where the particle is most likely to be found.

(4) (20 points)

At $t = 0$, a particle of mass m is equally likely to be in the ground and the first excited state of the system described by $V(x) = 2x^2$ for $x > 0$, $V(x) = \infty$ at $x = 0$. What is the wave function of the system? at $t = 0$. What is the wave function of the particle at $t = 1$ sec.

(5) (15 points)

An electron moving in a harmonic potential $V(x) = 2x^2$ is subjected to a constant electric field E. What is the ground state energy and the ground state wave function of the system.

(6) (15 points)

A particle in a spherically symmetric potential is described by a wave function, $\psi(x, y, z) = A(x + z)$ where A is a normalization constant. Calculate the possible angular momentum quantum numbers of the system and the probability of being found in those states.