

# PH 451: Capstone in Quantum Mechanics

## Homework 9

Due 3/13/09

1. Calculate the lifetime (in seconds) of each of the four  $n = 2$  states of hydrogen ( $|n, \ell, m\rangle$ ). The lifetime is the inverse of the spontaneous emission rate (Einstein A coefficient).
2. A particle of mass  $m$  is initially in the ground state ( $E_1$ ) of an infinite square well of width  $a$ . From  $t = 0$  to  $t = T$ , the potential is perturbed so that it becomes

$$V(x) = \begin{cases} V_0 & \text{for } 0 \leq x \leq a/2 \\ 0 & \text{for } a/2 \leq x \leq a \\ \infty & \text{elsewhere} \end{cases}$$

where  $V_0 \ll E_1$ . Find the probability that the energy after time  $T$  is measured to be  $E_2$ .

3. a) Consider the following states:

$${}^1D, {}^2P, {}^4D$$

What  $J$  values are associated with each?

- b) Consider the states:

$${}^1D, {}^3P, {}^3S$$

Given that each state consists of 2 equivalent (*i.e.*, in same  $nl$  state) electrons, are these states allowed by the Pauli Exclusion Principle?

4. For two non-interacting distinguishable particles in a 1-d infinite square well potential (width  $a$ ), find the allowed energy levels that are less than  $30 \frac{\pi^2 \hbar^2}{2ma^2}$ . Consider the cases where (a)  $m_1 = m_2 = m$  and (b)  $m_1 = m$  and  $m_2 = 2m$ . Find an appropriate numbering scheme for the levels, and make an ordered table, noting any degeneracy. Is the degeneracy accidental?