

PH 451: Capstone in Quantum Mechanics

Homework 10

Due 3/14/08

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 in a square well potential (with walls at $x = 0$ and $x = a$; that is, $V(x) = 0$ for $0 < x < a$; $V(x) = \infty$ otherwise) starts out in the ground state

$$|\psi(t=0)\rangle = |\psi_1\rangle$$

where $|\psi_n\rangle$ are the normalized eigenstates of the unperturbed Hamiltonian. Starting at $t = 0$, a time-dependent perturbation is applied given by

$$H'(x,t) = V_0 \sin \frac{\pi x}{a} e^{-\gamma t}.$$

- a) Calculate the probability for the particle to make a transition to an excited state $|\psi_n\rangle$ ($n \neq 1$) after a long time. Define long time.
- b) Are there any selection rules for this transition? If so, what are they?