Name:________________________ Date:____________

Time for Completion:____________

Honours QM HW #7

1. Consider a volume of gas of hydrogen in its ground state irradiated by polarized monochromatic light. What is the transition rate for ionizing the gas for visible light (wavelengths $\sim$ 400-700 nm)? What is the transition rate for X-rays (wavelength $\sim 10^{-10}$ m)? For the latter case, choose a specific wavelength, say $\omega = 10^{-10}$ m. Set up your coordinates such that $\boldsymbol{k}$, the momentum of the light, is in the $\hat{z}$ direction; then, take the polarized light such that $\boldsymbol{\epsilon}_{\boldsymbol{k},1} = \hat{x}/\sqrt{2}$ and $\boldsymbol{\epsilon}_{\boldsymbol{k},2} = \hat{y}/\sqrt{2}$. Finally, integrate over the solid angle for the possible directions the ejected electron takes (whose momentum is $\boldsymbol{p}$), so the transition rate is

$$\int d\Omega\, w_{a\to B}(t) = \int d\Omega\, 2\pi \left(\frac{q}{m}\right)^2 \left(\frac{p_x + p_y}{\sqrt{2}}\right)^2 \left|\tilde{\psi}(\boldsymbol{q})\right|^2 \rho_b(E_a + \omega), \qquad (1)$$

   where $p_x = \boldsymbol{p} \cdot \hat{x}$, etc.

2. Show that the leading order in field strength contribution to the spontaneous emission transition rate in the electric dipole approximation from the $2s$ to $1s$ state in a hydrogenic atom is 0 (this is actually true to all orders in multipole expansion due to parity considerations). Optional: compute the leading order spontaneous emission transition rate from a $2p$ to the $1s$ state in the electric dipole approximation.