Chapter 5 Assignment

1a) Show $N = \sum_i a_i^\dagger a_i$ gives the total number of particles when operating on $\Psi = |n_1 n_2 \cdots n_k\rangle$.

b) Show $|n_1 n_2 \cdots\rangle = \cdots \frac{(a_2^\dagger)^{n_2}}{\sqrt{n_2!}} \frac{(a_1^\dagger)^{n_1}}{\sqrt{n_1!}} |0_1, 0_2 \cdots\rangle$

is normalized.

2a) Evaluate $\langle n_k | \vec{E} | n_k \rangle$.

b) How do nonzero electric fields arise?

3) $H_1 = \frac{e}{mc} \vec{p} \cdot \vec{A}$ $\quad H_2 = \frac{e^2}{2mc^2} A^2$

Estimate the laser power such that $H_1 \sim H_2$.

4) Derive the following expression for the $2p \to 1s$ transition in a hydrogenic atom.

$$T = \left(\frac{2}{3}\right)^8 \frac{mc^2}{\hbar} \propto (Z\alpha)^4$$

For H, show $\tau_{2p} = 1.596$ nsec. (Experimental result is 1.600 ± 0.004 nsec.)

5) Derive the expression for absorption rate given by (5.63)

6) Thomson Cross section $\frac{d\sigma}{d\Omega} = \frac{r_e^2}{2}(1 + \cos^2\theta)$

Integrate $\frac{d\sigma}{d\Omega}$ to get the total cross section + evaluate it.