Homework 08 Name: ____________________

Problem 1 (10 points)
Selection rules: Assume that electric field in the form $\vec{E}(t) = E_o \cos(\omega t)\hat{\mathbf{z}}$ acts on a hydrogen atom (here $\hat{\mathbf{z}}$ is the unit vector along z direction). Recall, that $\hat{\mathbf{H}}_1(t) = e\vec{E}(t) \cdot \vec{r}$ and find probabilities to transfer to either of 4 degenerate sublevels of $n = 2$ energy level from the ground level as a function of time. Hint: start with calculation $\langle f | \hat{\mathbf{H}}_1 | i \rangle$. Do not go beyond 1st order perturbation treatment.

Problem 2 (10 points)
No external time dependent fields. The hydrogen atom at the initial time is occupying $|n = 2, l = 0, m = 0\rangle$. How long does it take to build up probability of transition to the ground level to be 0.5? Hint: the previous problem should help.
(In reality it is not that long since there are other mechanism for population transfer, i.e. change of probability of being in the given state).

Problem 3 (10 points)
Consider two level atom under perturbation where

$$\hat{\mathbf{H}}_{1_{ab}} = \hat{\mathbf{H}}_{1_{ba}} = \frac{\alpha}{\sqrt{\pi}\tau} e^{-(t/\tau)^2} \tag{1}$$

$$\hat{\mathbf{H}}_{1_{aa}} = \hat{\mathbf{H}}_{1_{bb}} = 0 \tag{2}$$

- At the initial time $t_i = -\infty$ the $c_a = 1, c_b = 0$, what is the probability to find the system at state $|b\rangle$ at time $t = \infty$?
- Same question at the limit $\tau \to 0$ resulting in $\hat{\mathbf{H}}_{1_{ab}} = \alpha\delta(t)$
- Same question in adiabatic regime $\omega_0\tau \gg 1$