Exam #4

Collin Heist

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1 Question 1

The particle is most likely to transition to the fourth state (this optimally interacts with the perturbation), and the purturbation of this eigenenergy is the highest (see below):

$$\epsilon_1^1 =< \phi_1|H_P|\phi_1 >= \int_{3.25}^{4.25} (\sqrt{\frac{2}{10}} sin(\frac{\pi x}{10}))^2 dx = 0.169553 \text{ meV}$$

$$\epsilon_2^1 =< \phi_2|H_P|\phi_2 >= \int_{3.25}^{4.25} (\sqrt{\frac{2}{10}} sin(\frac{2\pi x}{10}))^2 dx = 0.1 \text{ meV}$$

$$\epsilon_3^1 =< \phi_3|H_P|\phi_3 >= \int_{3.25}^{4.25} (\sqrt{\frac{2}{10}} sin(\frac{3\pi x}{10}))^2 dx = 0.0393024 \text{ meV}$$

$$\epsilon_4^1 =< \phi_4|H_P|\phi_4 >= \int_{3.25}^{4.25} (\sqrt{\frac{2}{10}} sin(\frac{4\pi x}{10}))^2 dx = 0.175683 \text{ meV}$$

The required energy for this transition would be:

$$\Delta E = \epsilon_4 - \epsilon_1 = 60 - 3.75 = 56.25 \text{ meV}$$

$$E = hf \rightarrow 56.25 \cdot 10^{-3} \text{ eV} = 4.135 \cdot 10^{-15} \text{ eV/s} \cdot f$$

$$f = 1.36 \cdot 10^{13} Hz$$

2 Question 2

Since $\hat{a}^+\hat{a} = \hat{n}$, and $\hat{n}\phi_3 = \epsilon_3$, the expectation of Ψ is:

$$E_3 = (n + \frac{1}{2})E_{ref} = \frac{7 \cdot E_{ref}}{2} = 0.035 \text{ eV}$$

3 Question 3

The green's function can be used here as the perturbation can be treated as a forcing function with an oscillating frequency (ω_L), whose eigenvalues are γ_n or ϵ_n.

4 Question 4

4.1 Part a

Fermi's Golden Rule is the formula that gives a *transition rate* for some particle in a given eigenstate to a different eigenstate due to some perturbation on the space containing the particle.

4.2 Part b

For a system with degenerate eigenstates, the *good* states are states who, once perturbed, return to their original eigenstate once that perturbation is removed. In particular, because the states are degenerate, the values for α and β must be such that this *good* state is a unique linear combination of some unperturbed eigenstates.