5.73

Quiz 15

1.

$$E_n^{(0)} = H_{nn}^{(0)} \qquad E_n^{(1)} = H_{nn}^{(1)}$$

$$E_n^{(2)} = \sum_k{}' \frac{\left|H_{nk}^{(1)}\right|^2}{E_n^{(0)} - E_k^{(0)}} \qquad \psi_n = \psi_n^{(0)} + \sum_k{}' \frac{H_{nk}^{(1)}}{E_n^{(0)} - E_k^{(0)}} \psi_k^{(0)}$$

$$\mathbf{H}^{(0)} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 100 & 0 \\ 0 & 0 & 110 \end{pmatrix} \qquad \mathbf{H}^{(1)} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & -1 & 0 \end{pmatrix}$$

$$A = \begin{pmatrix} 0 & 10 & -2 \\ 10 & 0 & 0 \\ -2 & 0 & 0 \end{pmatrix}$$

A. Use perturbation theory to find the three energy levels of **H**

$$E_n = E_n^{(0)} + E_n^{(1)} + E_n^{(2)} \text{ for } n = 1, 2, 3.$$

$E_1 =$

$E_2 =$

$E_3 =$

B. Use first-order perturbation theory to calculate the wavefunctions, Ψ_n, that correspond to each of three energy levels in Part A.

$\Psi_1 = \Psi_1^{(0)} +$ _____ $\Psi_2^{(0)} +$ _____ $\Psi_3^{(0)}$

$\Psi_2 = \Psi_2^{(0)} +$ _____ $\Psi_1^{(0)} +$ _____ $\Psi_3^{(0)}$

$\Psi_3 = \Psi_3^{(0)} +$ _____ $\Psi_1^{(0)} +$ _____ $\Psi_2^{(0)}$

C. **A** is the "transition moment" operator. There are, in principle, 3 possible transitions between three eigen-levels. If you number your energy levels in order of increasing energy (1 is lowest, 3 is highest), calculate the transition moment, $\langle \psi_i | A | \psi_j \rangle$, for *at least one* of the following three transitions:

(i) $1 \rightarrow 2$

(ii) $1 \rightarrow 3$

(iii) $2 \rightarrow 3$.

5.73 Quantum Mechanics I
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