PH2400 Quiz 4, Spring 2005

Show your work for full credit.

1. An electron moves in a cube whose sides have a length of 0.2 nm. Find the value for the energy of the first excited state (4 points).

\[ n_x = 1, \quad n_y = 1, \quad n_z = 1 \]

\[ E = \frac{\hbar^2}{8mL^2} \left( n_x^2 + n_y^2 + n_z^2 \right) \]

1st excited state: \( n_x = n_y = 1; \quad n_z = 2 \)

\[ E = \frac{\hbar^2}{8mL^2} (1 + 1 + 4) = \frac{6\hbar^2}{8mL^2} = 56.4 \text{ eV} \]

2. A particle of mass \( m \) moves in a two-dimensional box of sides \( L \). Find the energy of the first excited state (4 points) and give its degeneracy (2 points).

\[ \psi = A \sin(k_x x) \sin(k_y y) \quad ; \quad k_x = \frac{n_x \pi}{L} \quad ; \quad k_y = \frac{n_y \pi}{L} \]

\[ E = \frac{\hbar^2 \pi^2 (n_x^2 + n_y^2)}{2mL^2} \quad ; \quad E_o = \frac{\hbar^2 \pi^2}{2mL^2} \]

\[
\begin{array}{ccc}
\hline
\text{Ground state} & 1 & 1 & 2 \\
\text{1st excited} & 1 & 2 & 5 \rightarrow \text{doubly degenerate} \\
\text{2nd excited} & 2 & 1 & 5 \rightarrow \\
\hline
\end{array}
\]
