CHEM 4450

Problem Set 2

25 Points

(Some of the problems here are revisits of the ones from before with some more information (hints) that should help get you started.)

1. Transform the Planck radiation formula for energy density from a function of wavelength (λ) into a function of frequency (υ). (Don't forget the dλ term in the formula, it is really important!) (You will use the relationship c=$\lambda\upsilon$.)
2. Now that you have the distribution in terms of frequency, show that the total energy density of blackbody radiation is given by the Stefan-Boltzman Law:
$$U = \frac{8\pi^5 k^4}{15h^3c^3}T^4$$
$$To\ do\ this, you\ will\ need:$$
$$\int_0^\infty \frac{x^3}{e^x - 1}dx = \frac{\pi^4}{15}$$
3. The normalized wavefunctions of a particle confined to move on a circle (think benzene pi-structure) are:
$$\psi(\phi) = (\frac{1}{2\pi})^{\frac{1}{2}}e^{-im\phi}\ where\ m = 0, \pm1, \pm2, \dots and\ 0 \leq \phi \leq 2\pi$$
Determine the expectation value for ϕ.

4. Evaluate the commutator [$[\hat{H}, \widehat{p_x}]$ if V(x) = ½ $k_f x^2$.
5. Calculate the energy separation in eV, and kJ/mol of a particle in a box of length 1.0 nm between the levels of (a) n=1 and n=2, (b) n=2 and n=3, (c) n=8 and n=9.
6. Now repeat the problem above given the length of the box increases to 3.0nm.
7. Calculate the expectation value of $\hat{p}$ and $\hat{p}^2$ for a particle in the the state n=2 in a one-dimensional square well potential.
8. What are the most probable locations of a particle in a (1D) box of length L in the n=4 state?