Physical Chemistry II
Problem Set 2

1. A 378W red laser (700nm) is turned on for 1 nsec. How many photons does it emit? How many mols of photons is this?

2. Compute the energy per mole of photons with the following wavelengths:
a) 200 nm (UV)
b) 1cm (microwave)

3. The work function for metallic francium is 3.84eV. Compute the KE and speed of an electron hit by a photon of wavelength 170 pm. What if the wavelength of the photon is 170 µm?

4. Compute the energy of the H-atom emission line for the transition of an electron from the n = 1 shell to the n = 3 shell. Express your answer in units of wavenumbers and Joules. Also compute the wavelength and frequency of the emitted photon.

5. A 1.0g ball bearing rolls 1 cm along the floor at 1 cm/s. Compute the wavelength of the ball bearing.

6. If $\hat{A} = \frac{d}{dx}$ and $\psi = \cos(x^2 + 1)$ compute $\hat{A}\psi$. Is $\psi$ and eigenfunction of $\hat{A}$?

Same question but now $\hat{A} = \frac{d^2}{dx^2} + 3x \frac{d}{dx}$ and $\psi = 4x^3$

7. A wave function for a certain particle is given as $N\psi = Ne^{ikx}$. Give a symbolic expression for N (the normalization constant) in terms of an integral. x ranges from minus infinity to infinity.

8. The ground state harmonic oscillator wave function is given as:

$$\psi(x) = \left(\frac{2a}{\pi}\right)^{1/4} \exp\left(-ax^2\right)$$

Where x can range from minus infinity to infinity. Set up the integrals:
a. $\langle \hat{x} \rangle$
b. $\langle \hat{x}^2 \rangle$
c. $\langle \hat{p} \rangle$
d. $\langle \hat{p}^2 \rangle$
e. $\langle \hat{t} \rangle$
f. $\langle \hat{V} \rangle$
g. $E$