Name: ___________________________ Partner(s): ___________________________

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Homework Questions for Investigation #10
EMISSION SPECTRUM OF ELEMENTAL GASES

Questions 1-6 refer specifically to the hydrogen spectrum and the data you acquired in Table 4.

1. The wavelengths of visible light lie in the range: 400 nm < λ < 700 nm. Calculate the range of energies (in eV) for photons of visible light.

2. Calculate the longest wavelength that occurs in the Lyman series. What are n_f and n_i for that transition? Calculate the energy of the photon for this transition. Would you expect to see any spectral lines of the Lyman series? If so which ones? If not, why not?

3. Calculate the shortest wavelength that occurs in the Paschen series. What are n_f and n_i for that transition? Calculate the energy of the photon for this transition. Would you expect to see any spectral lines of the Paschen series? If so which ones? If not, why not?

4. Do you think the hydrogen gas we used was excited to any states higher than the value of n_i you listed in Question 1? If not, what caused this upper limit on n_i? If the hydrogen was excited to higher states, why didn't you observe these lines?

5. Calculate the photon energies for each of the spectral lines you observed in the hydrogen spectrum. How do the energies of the photons emitted for the 4→3 and 3→2 transition relate to that of the 4→2 transition?

6. Calculate (in eV) the energies that correspond to the initial and final energy states of the hydrogen atom E_f and E_i for the blue line that you observed in the hydrogen spectrum.

7. In the Bohr model, the electron in the *n*th energy state moves in a circular orbit of radius r_n. Recall r_n was found by equating the classical Coulomb force to the centripetal force and employing the Bohr's quantization condition on the angular momentum. From that result, show the classical frequency of rotation for an electron in the nth energy state is given by:

$$f_n = \frac{me^4}{32\pi^3 \varepsilon_0^{\ 2} \hbar^3 n^3}$$

8. The energy of the photon emitted when an electron transitions from state $n + 1$ to state n is given by $hf = |E_n - E_{n+1}|$. Show that in the limit of large n, the frequency of the emitted photon approaches that of the classical frequency shown in the previous question. (This is an example of the *correspondence principle* which states that in the limit as $n \to \infty$, all quantum mechanical expressions approach the corresponding classical expressions.)