Chemistry Worksheet NAME: ______________________________

**The Hydrogen Atom and the Lyman series** Block: _________

**Answer each question in the space required. Show all work. Pay attention to significant figures and units.**

1. Hydrogen is the simplest atom in the universe, thus it is the most commonly used example for delving into the quantum world. The energy levels of hydrogen can be calculated using the principle quantum number, *n*, in the equation $E_n = -13.6 \text{ eV } (1/n^2)$, for $n = 1, 2, 3, 4 \ldots \infty$. Recall that eV stands for the energy unit called the *electron volt*, which relates to joules (J) by the following conversion: $1 \text{ eV} = 1.602 \times 10^{-19}$ J.

   a. What is the value of principle quantum number, *n*, for the *ground state* of hydrogen?

   b. Calculate the energy (in eV and in joules) for the *ground state* of hydrogen.

   c. Calculate the energy, $E_n$, for the *first four excited states* of the hydrogen atom.

   d. Is the third excited state higher or lower in energy than the ground state? Justify your answer in one or two sentences.

   e. The *ionization energy* of hydrogen is defined as the *minimum* energy required to excite an electron from the ground state to a state where the electron is separated from the nucleus (the proton). From your answers above, what is the ionization energy for hydrogen? Justify your answer in one or two sentences.

   f. How much energy would be required to ionize an entire mole of hydrogen atoms?

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2. In the previous problem you calculated the lowest five energy states (called energy levels) for the hydrogen atom. The <u>Lyman</u> series results from excited state hydrogen atoms transiting to the ground state by emitting electromagnetic radiation.

    a. In total, how many spectral lines will result if a sample of hydrogen is excited into the fourth excited state? (Hint: draw a small energy level diagram and use arrows to represent transitions from higher to lower energy states.)

    b. How many of the lines from the previous answer belong to the Lyman series?

    c. Calculate the energy for each of the lines in the Lyman series that you identified in the last answer. (Recall that the energy of the light emitted represents the *difference* between two energy states of the atom.)

    d. Calculate the wavelength from the energy for each of the lines in part c.

    e. In what region of the spectrum would you find these spectral lines? Use the box across the bottom of the page to create a spectrum for the Lyman lines from part d. Be sure to write in a wavelength scale!

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