Bohr model worksheet

Assume a model of an electron in orbit about a massive nucleus with charge +e. The electron has a charge -e

(1) Write down the force of attraction between the nucleus and the electron from Coulomb's law. This force will be a central force.

(2) Write down the form of the centripetal force from Newton's law.

(3) Multiply the top and the bottom of this expression by mr^2.

(4) Identify L=rp=mvr and write (3) in terms of L

(5) Equate (1) and (4) since these are the predominate forces acting in the atom.

(6) Solve (5) for the radius of orbit in terms of L.

(7) Apply Bohr's quantization condition where $L=nh/2\pi$ to find a new expression for r.

(8) Find the smallest radius and equate this to the constant a_0. Also, write ke^2 in terms of a_0.

(9) Write r in terms of a_0 and write ke^2 in terms of L, m and a_0 using (6).

(10) Use Bohr's quantization condition to find v in terms of r and m and from (9) in terms of a_0, n and m.

(11) Find the total K from $(1/2)mv^2$.

(12) Find the total U at a particular r. Write U in terms of $(h/2\pi)$, m and a_0 using (5).

(13) Use your results from (11) and (12) to find the total energy of the electron.

(14) Provide a value for the ionization energy E_0 of the electron from (13). Then write E in terms of n and E_0.

(15) According to Bohr, a photon will be emitted as the result of a transition between two energy levels. For the case of the final state being n=2, we will have the visible spectrum of the atom resulting (if the atom is hydrogen). Calculate the energy of transition between a level with n>2 to the level n=2.

(16) Using E=hf, write (14) in terms of inverse wavelength.

(17) Compute your result to the Balmer series and thus provide a value for the Rydberg constant R.

(18) Determine an expression for the fine structure constant $\alpha=v_1/c$ (which is equal to 1/137).