PROBLEM 1 – 15 points

A hypothetical single-electron atom has energy levels given by $E_n = -(72\text{ eV})\frac{1}{n^2}$, where n is an integer, $n = 1, 2, 3, \ldots$.

[3 points] (a) What are the energies of the first three levels?

$$E_1 = -\frac{72\text{ eV}}{1^2} = -72\text{ eV}; \qquad E_2 = -\frac{72\text{ eV}}{2^2} = -18\text{ eV}; \qquad E_3 = -\frac{72\text{ eV}}{3^2} = -8\text{ eV}$$

[3 points] (b) While the atom is in the ground state, it is observed that light shining on the atom never gets absorbed if the frequency of the light is below a certain value f_0. Explain why it is impossible for light below this frequency to be absorbed by the atom.

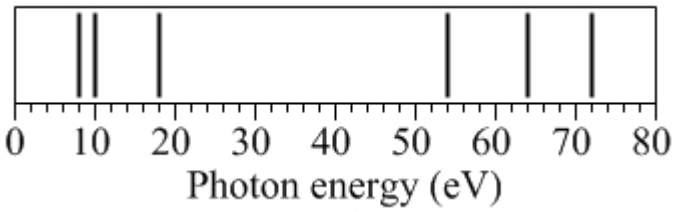
If the atom is in the ground state, the next level available for the electron is the E_2 level. To be excited to that level, the atom must absorb a photon with an energy equal to the energy difference between the E_2 and E_1 levels. If the photon has less energy than this, it will not be absorbed by the atom, because that energy cannot cause an electron transition to a higher level. Thus, there is a minimum photon energy that the atom can absorb. Because photon energy is proportional to frequency, there is a corresponding minimum energy.

[3 points] (c) What is the value of f_0 from part (b)? You may leave your answer in terms of fundamental constant(s).

The difference between the E_2 and E_1 levels is 54 eV. This is the minimum photon energy, which is hf_0. Thus,

$f_0 = \frac{54\text{ eV}}{h}$**, where h has units of eV s.**

[6 points] (d) Which of the following lines will appear in the emission spectrum of this atom, assuming the emission is associated with electrons that are initially in one of the first three energy levels? Indicate which of these lines will appear, and which will not appear, in the space below. The six lines are at energies of 8 eV, 10 eV, 18 eV, 54 eV, 64 eV, and 72 eV.



The photons have energies equal to the energy differences between the levels.

Lines that will appear in the spectrum	Lines that will not appear in the spectrum
10 eV, 54 eV, 64 eV	**8 eV, 18 eV, 72 eV**

10 eV = -8 eV – (-18 eV), etc.