**Exercise No. 1:**

1. What is the ionization energy of the hydrogen atom? (This refers to the minimum energy required to ionize the atom).

2. What is the minimum kinetic energy of an electron capable of causing, by collision, the excitation of an atom from its ground state to its first excited level?

3. The previously excited hydrogen atom returns to the ground state, emitting a spectral line. What is the wavelength *λ*2,1​of the emitted line?

4. The Balmer series is defined as the set of spectral lines corresponding to transitions from energy levels En​ to ​ E2 (where *n*>2). Derive the numerical relation giving the wavelength *λn*,2​ of the Balmer series lines as a function of *n*.

5. What is the longest wavelength in the Balmer series?

**Exercise No. 2:**

Let us consider the hydrogen atom: an electron with charge −e orbits around a proton with charge +e, and the electron's motion is uniform and circular. Knowing that the angular momentum is quantized: L= nℏ with n=1,2,3,…

**I/** **1.** The hydrogen atom is initially in its ground state. It absorbs an energy of **10.2 eV**. To which energy level does its electron transit?

**2.** The hydrogen atom is in its ground state. It absorbs a photon of wavelength **λ₁**, then emits a photon of wavelength **λ₂**. After this emission, on which energy level is the

electron located? Given: **λ₁ = 97.28 nm** and **λ₂ = 1879 nm**.

**3.** The hydrogen atom is currently in the **n = 3** level.  
**a.** Illustrate on a diagram the different possible emission transitions from this level.  
**b.** Complete the following table by calculating the different wavelengths corresponding to these emissions, identify the series to which they belong, and determine the region of the electromagnetic spectrum they fall into.

|  |  |  |  |
| --- | --- | --- | --- |
| **Transition n → m** | **λ (wavelength)** | **Name of the series** | **Spectral region** |
|  |  |  |  |

**II/** Compare the spectrum of the hydrogen atom to that of **Li²⁺**, identifying the similarities and differences. Are these differences observed at long or short distances?

**Exercise No. 3:**

We propose to study some characteristics of muonium, which is a light isotope of the hydrogen atom. To form muonium, the proton in the hydrogen atom is replaced by a particle with charge +e and mass mμ​=207me​.

1) Calculate the Rydberg constant for muonium.

2) Calculate the radius of the first Bohr orbit as well as the electron's velocity on this orbit.

3) Calculate the wavelengths of the visible spectral lines in the Balmer series.

**Exercise No. 4:**

Consider a bound system consisting of a particle with charge e (e<0) and mass M=1836m (where M and m are the masses of a proton and an electron, respectively) orbiting around a proton.

1) Calculate the Rydberg constant for this system.

2) Calculate the energies of the system when it is in the states n=1 and n=2. What are the wavelengths required to ionize this system when it is in the states n=1 and n=2, respectively?

3) Calculate the wavelength Lα​ corresponding to the transition from n=2 to n=1.