Answer on the question #65947, Chemistry / Other

Question:

Discuss the origin of various spectral lines in the atomic spectrum of hydrogen. Draw a suitable diagram.

Answer:

If we put hydrogen gas in the ionization tube, after the electric flash we see intense pink light that, after a pass through the diffraction monochromator, shows a spectrum with a number of sharp lines. Atomic spectrum of hydrogen is the result of electron hops between different quantum energy levels.

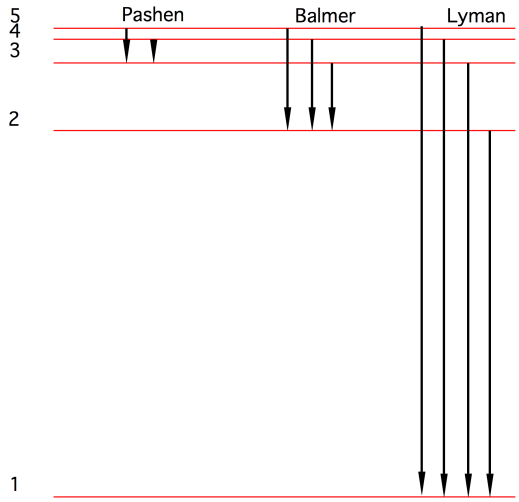

Figure 1. Energy diagram of electron levels in atom. First 5 levels are shown. The distance between the levels is scaled within the Bohr model.

Fig. 1 shows the energy diagram of electron levels in hydrogen atom (and all like-hydrogen atoms, with 1 electron orbiting the nucleus). The lines with arrows show the energy transitions, each transition being a line in the spectrum. As far as you see, energy levels are not equally distant. This is explained by Bohr model, where the energy of the electronic level is inversely proportional to the square of principal quantum number (i.e. 1, 2, 3, 4, 5 in the diagram). The longer the distance, the higher the energy of transition, so then higher the frequency of the photon emitted and lower its wavelength.

Depending on the lowest energy state, or the destination of transition, spectral lines and corresponding electron hops are divided into series: 1^{st} energy state as Lyman series, 2^{nd} as Balmer and 3^{rd} as Paschen, etc. Thus, Lyman series lines are the highest in energy (recall the distancing of energy levels), so situated in UV. Then, Balmer lines are in visible region and Paschen in IR (infra-red, even lower energy transitions). Lyman, Balmer and Paschen series are shown from the right to left on the diagram.

To calculate the distance between electronic levels, corresponding to wavelength of the transition, one can use Rydberg formula:

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_{final}^2} - \frac{1}{n_{init}^2}\right),$$

where λ is the wavelength, R is Rydberg's constant, Z is the charge of nucleus (atomic number).