Rydberg formula

Under suitable conditions, an atom emits light with certain wavelengths; this only depends on the identity of the atom. For example, the hydrogen atom emits light with certain wavelengths, while the helium atom emits light with certain other wavelengths (that differ from the hydrogen atom's), and so on.

In the late 19th century, the Swedish physicist Rydberg found out that for a given kind of atom, the inverse of the wavelength of the light emitted can be expressed as the difference of two arbitrarily chosen numbers from a set of numbers that only depend on the identity of the atom. For example, if the set of numbers is the following:

$$A_1, A_2, A_3, A_4, A_5, A_6, \tag{1}$$

Then, the inverse of wavelengths emitted must be $A_i - A_j$, where i and j are natural numbers. In the case of hydrogen, A_i is given by the following:

$$A_i = \frac{R}{i^2} \tag{2}$$

where R is called the "Rydberg constant." Therefore, λ, the wavelength of the light emitted from hydrogen, can be expressed as follows:

$$\frac{1}{\lambda} = \frac{R}{i^2} - \frac{R}{j^2} \tag{3}$$

So, a natural question one may ask is "why can the inverse of wavelengths always be expressed as a difference of two terms?" The correct explanation came in 1913 from Niels Bohr. He argued that in an atom, the electrons move around only certain orbits, which in turn correspond to specific energies. When an electron changes its orbit, the energy of the atom changes by the difference between the energies of the atom before the change of the orbit and after the change of the orbit. As energy is conserved, the atom emits light when an electron falls into an orbit with lower energy and the energy of the emitted light is given by this difference. As the atom can have only certain values of energy as its electrons have certain orbits, we conclude that the energy of emitted light is given by the difference of two terms, namely two possible energies an atom can have. As the energy of light is inversely proportional to wavelength (Remember that Planck's relation says that $E = hf$. f, the frequency is inversely proportional to wavelength, as it is given by the speed of light divided by the wavelength.), we conclude that the inverse of wavelength must be proportional to the difference of two energies an atom can have. Summarizing, we can conclude that the inverse of wavelength can be always expressed as a difference of two terms.

Summary

- The electrons move around only certain orbits that correspond to specific energies. When an electron changes its orbit, a photon is emitted, and its energy corresponds to the difference between the energies of the orbit before the change and after the change. Applying Planck's relation $E = hf$, and using the fact that the frequency is inversely proportional to wavelength, the inverse of the wavelength of the light emitted can be expressed as the difference of two arbitrarily chosen numbers from a set of numbers that only depend on the identity of the atom.