Bohr's Theory of Hydrogen Atom and Hydrogen Spectra

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Partners:	Whole class
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1 Objective

Conduct a research on the Bohr's Theory of Hydrogen Atom and Hydrogen Spectra 1.1:

1.1 Constants and Formulas that are needed for the following paper

Constants

$$c = 3x10^8 \frac{m}{s}$$

$$Me = 9.1x10^-31kg$$

$$e = 1.6x10^-19C$$

$$Ke = 9.0x10^9 \frac{nM^2}{C^2}$$

$$Hbar = 6.63x10^-34J$$

$$Hbar\frac{h}{2} = 1.05x10^-34J$$

Formulas

$$Fe = \frac{e^2Ke}{r^2}$$

$$KE = \frac{1}{2}mv^2$$

$$PE = \frac{keq1q2}{v} = -\frac{kEe^2}{r}$$

$$L = rmev = rp = nhbar$$

Fe=Fc

$$\frac{e^2Ke}{r^2} = \frac{mv^2}{r}$$

We multiply everything by

$$\frac{r}{2}$$

and get

$$\frac{e^2Ke}{2r} = \frac{mv^2}{2}$$

$$KE = \frac{1}{2}mv^2 = \frac{e^2Ke}{2r}$$

$$E = KE + PE = \frac{e^2Ke}{2r} - \frac{Kee^2}{r}$$

$$E = -\frac{e^2Ke}{2r}$$

$$Ln = KEn = Rn = En$$

$$L = nHbar$$

Which means the quantization of the angular momentum

$$rmev = nHbar$$

$$mev = \frac{n^2Hbar^2}{r^2}$$

$$KE = \frac{mev^2}{2} = \frac{n^2Hbar^2}{2mer^2}$$

$$KE = \frac{1}{2}mev^2 = \frac{e^2Ke}{2r}$$

Consequently we can equal them

$$KE = \frac{e^2ke}{2r} = \frac{n^2Hbar^2}{2mer^2} = KE$$

After all of this we will try to find R

$$Rn = \frac{n^2Hbar^2}{mer^2} = \frac{1}{e^2Ke} = \frac{n^2Hbar^2}{mee^2Ke} = n^2$$

$$Bohrradius = a0 = r = 53x10^-10m$$

$$r2 = 4a0$$

$$r3 = 9a0$$

$$En = -\frac{e^2Ke}{2rn}$$

$$En = -\frac{e^2Ke}{2n^2a0}$$

$$En = -\frac{e^2Ke}{n^2x2\frac{Hbar^2}{mee^2Ke}} = \frac{1}{n^2}\frac{-e^4Ke^2me}{2Hbar^2}$$

$$E1 = -2.18x10^-18Joules$$

$$En = \frac{E1}{n^2}$$

Delta Ehydrogen atom

$$E = Ef - Ef = \frac{E1}{m2} - \frac{E1}{n^2} = E1(\frac{1}{m^2} - \frac{1}{n^2})$$

$$2 - 1 = -2.8x10^-18(\frac{1}{1^2} - \frac{1}{2^2})$$

$$Ephoton = -2 - 1 = 1.63x10^-18J$$

$$E = hf = \frac{hc}{wavelength}$$

$$wavelength2{-}1 = \frac{hc}{E2-1} = \frac{1.99x10^-25}{1.6x10^-18} = 1.22x10^-7 = 1.22x10^-9m = 122nm$$

Hydrogen Spectra

$$Wavelengthn - m = \frac{hc}{DeltaEn-m} = \frac{hc}{E1(\frac{1}{m^2} - \frac{1}{n^2})} = \frac{91nm}{(\frac{1}{m^2} - \frac{1}{n^2})}$$

Emission Spectrum of Hydrogen When an electric current is passed through a glass tube that contains hydrogen gas at low pressure the tube gives off blue light. When this light is passed through a prism (as shown in the figure below), four narrow bands of bright light are observed against a black background.

Max Planck presented a theoretical explanation of the spectrum of radiation emitted by an object that glows when heated. He argued that the walls of a glowing solid could be imagined to contain a series of resonators that oscillated at different frequencies. These resonators gain energy in the form of heat from the walls of the object and lose energy in the form of electromagnetic radiation. The energy of these resonators at any moment is proportional to the frequency with which they oscillate.

To fit the observed spectrum, Planck had to assume that the energy of these oscillators could take on only a limited number of values. In other words, the spectrum of energies for these oscillators was no longer continuous. Because the number of values of the energy of these oscillators is limited, they are theoretically "countable." The energy of the oscillators in this system is therefore said to be quantized. Planck introduced the notion of quantization to explain how light was emitted.

Albert Einstein extended Planck's work to the light that had been emitted. At a time when everyone agreed that light was a wave (and therefore continuous), Einstein suggested that it behaved as if it was a stream of small bundles, or packets, of energy. In other words, light was also quantized. Einstein's model was based on two assumptions. First, he assumed that light was composed of photons, which are small, discrete bundles of energy. Second, he assumed that the energy of a photon is proportional to its frequency.

Visible light can be seen from 400nm till 700nm.

Lyman Series The series is named after its discoverer, Theodore Lyman, who discovered the spectral lines from 19061914. All the wavelengths in the Lyman series are in the ultraviolet band. n=2 - n=1

$$\frac{91}{\frac{1}{1}-\frac{1}{2}} = 91x\frac{4}{3} = 121nm$$

Balmer Series Named after Johann Balmer, who discovered the Balmer formula, an empirical equation to predict the Balmer series, in 1885. Balmer lines are historically referred to as "H-alpha", "H-beta", "H-gamma" and so on, where H is the element hydrogen. Four of the Balmer lines are in the technically "visible" part of the spectrum, with wavelengths longer than 400 nm and shorter than 700 nm. Parts of the Balmer series can be seen in the solar spectrum. H-alpha is an important line used in astronomy to detect the presence of hydrogen. n=3 - n=2

$$\frac{91}{\frac{1}{4}-\frac{1}{9}} = 91x\frac{36}{5} = 655nm$$

Which is known as Red orange

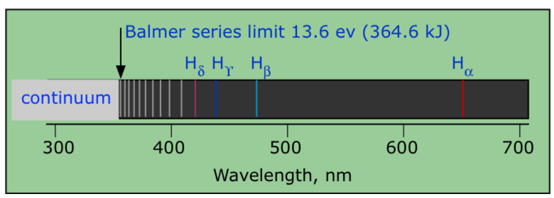
Paschen series Named after the German physicist Friedrich Paschen who first observed them in 1908. The Paschen lines all lie in the infrared band. This series overlaps with the next (Brackett) series, i.e. the shortest line in the Brackett series has a wavelength that falls among the Paschen series. All subsequent series overlap. n=4 - n=3

$$\frac{91}{\frac{1}{9}-\frac{1}{16}} = 91x\frac{144}{7} = 1872nm$$

References

Wikipedia, 2016, Physics: Hydrogen spectral series.

Purdue, 2016, Physics: Emission Spectrum of Hydrogen.


Balmer series limit 13.6 ev (364.6 kJ)
H_δ H_Υ H_β H_α
continuum
300 400 500 600 700
Wavelength, nm