ATOMIC STRUCTURE

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4. The Bohr Atom
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THE BOHR ATOM

The first successful theory was put forward by Niels Bohr in 1913.

Although it was suggested a decade before de Broglie but it was based on matter waves.

Let us examine the wave behavior of an electron in orbit around a H nucleaus.

The de Broglie wavelength of this electron…

$$\lambda = \frac{h}{m\upsilon}$$

$$\upsilon = \frac{e}{\sqrt{4\pi\varepsilon_o mr}}$$

$$\lambda = \frac{h}{e}\sqrt{\frac{4\pi\varepsilon_o r}{m}}$$

THE BOHR ATOM

Previously we found…

$$E = -\frac{e^2}{8\pi\varepsilon_o r}$$

Since E = 13.6 eV, the calculated r for the H atom is $r = 5.3 \times 10^{-11}$ m:

Then the de Broglie wavelength is

$$\lambda = \frac{h}{e}\sqrt{\frac{4\pi\varepsilon_o r}{m}} = \frac{6.6\times10^{-34}}{1.6\times10^{-19}}\sqrt{\frac{(4\pi)(8.85\times10^{-12})(5.3\times10^{-11})}{9.1\times10^{-31}}} = 33\times10^{-11} m$$

It was found that $\lambda = 2\pi r$

→*The orbit of the electron in H atom corresponds to one complete electron wave joined on itself!*

THE BOHR ATOM

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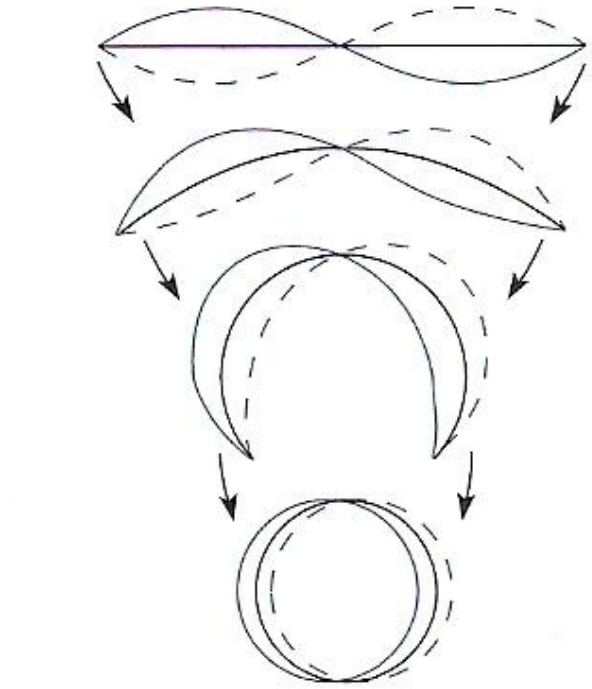
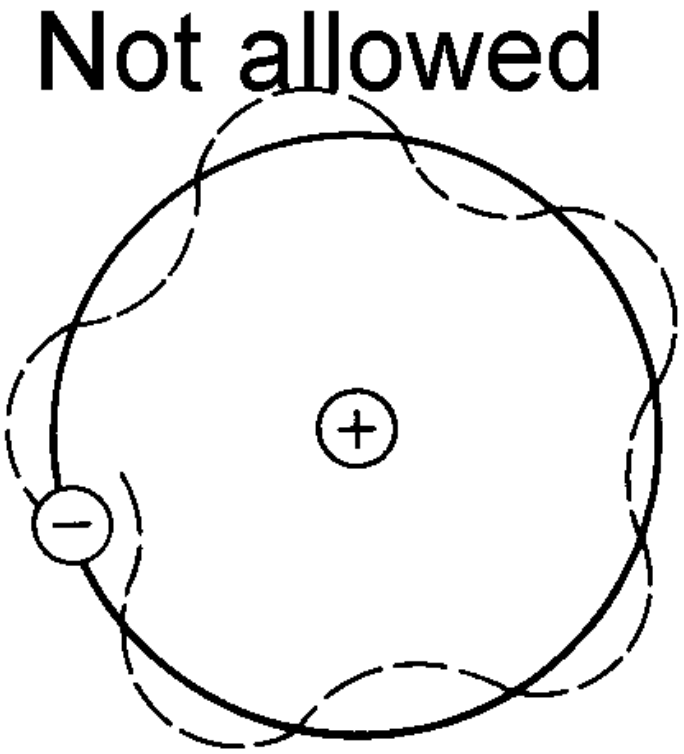
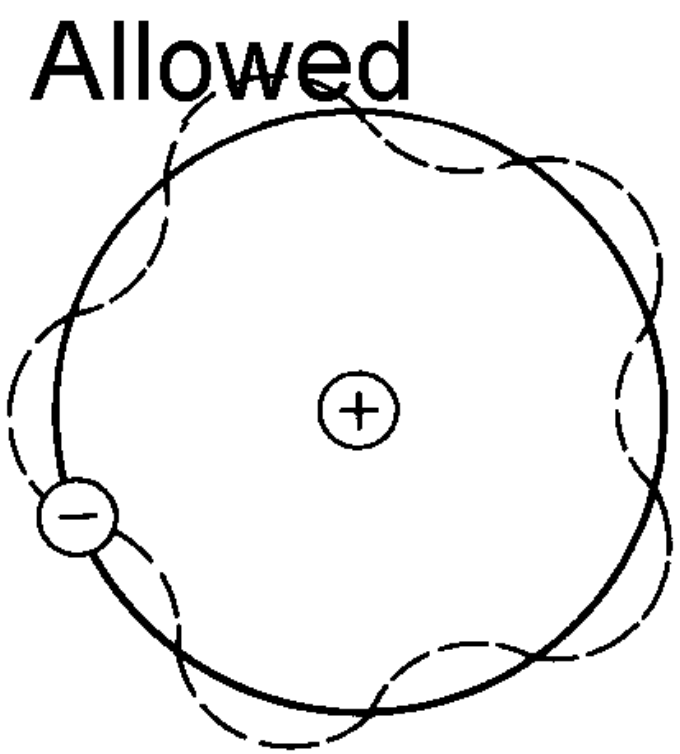


THE BOHR ATOM



Destructive interference



Constructive interference

THE BOHR ATOM

Higher vibration ….

Let us watch the animation…

In each case a whole number of wavelengths fit into the circumference of the loop.

THE BOHR ATOM

An electron can circle a nucleus only if its orbit contains an integral number of de Broglie wavelengths.

The condition for orbit stability..

$$n\lambda = 2\pi\, r_n \quad , \quad n = 1,2,3,\ldots$$

Where n is called the **quantum number**...

Substituting for λ... $\lambda = \frac{h}{e}\sqrt{\frac{4\pi\varepsilon_o r}{m}}$ $r_n = \frac{n^2 h^2 \varepsilon_o}{\pi m e^2} \quad , \quad n = 1,2,3,\ldots$

The radius of the innermost orbit is called Bohr radius of the H atom and given the symbol a_o $a_o = r_1 = 5.292\times10^{-11} m$

Other radii are given in term of a_o by ... $r_n = n^2 a_o$

THE BOHR ATOM

Remember…

Electron waves in the atom.