- Third postulates: (2)

When an electron jumps from higher energy level to lower energy level, the energy difference is radiated in the form of ~~electromagnetic~~ frequency(f)

i.e. $E_2 - E_1 = hf$

where E_2 = energy of the outer orbit

E_1 = energy of the inner orbit

So loss of energy is not continuous. This is called quantisation of energy.

Bohr's Theory of the Hydrogen atom:

Let us consider an electron of mass (m) and charge (e) moving around a nucleus having charge (ze) in an orbit of the radius (r).

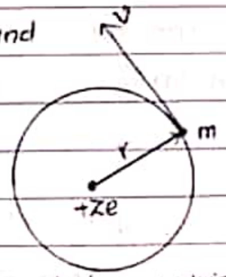

fig: electron revolving around a nucleus

The force of attraction between the nucleus and the electron is given by Coulomb's law,

$$F_e = \frac{(ze)\cdot(e)}{4\pi\epsilon_0 r^2} \longrightarrow (1)$$

where ϵ_0 = permitivity of free space

z = atomic number of the atom

This force is provided by centripetal force, F_c

$$F_c = \frac{mv^2}{r} \longrightarrow (2)$$

From equations (1) and (2), we get

$$\frac{1}{4\pi\epsilon_0}\frac{ze^2}{r^2} = \frac{mv^2}{r}$$

$$\text{or, } mv^2 = \frac{1}{4\pi\epsilon_0}\frac{ze^2}{r} \longrightarrow (3)$$

(i) Radius of orbit of electron:

According to the basic postulates of Bohr's atomic model,

$$mvr = \frac{nh}{2\pi}$$

$$\text{or, } v = \frac{nh}{2\pi mr} \qquad (4)$$

Substituting this value of v in eq^n (3), we get,

$$m\left(\frac{nh}{2\pi mr}\right)^2 = \frac{1}{4\pi\epsilon_0}\frac{ze^2}{r}$$

$$r = 4\pi\epsilon_0 \frac{n^2h^2}{4\pi^2 mze^2} \qquad (2)$$

$r = \epsilon_0 n^2h^2$ (3)

$$r = \frac{\epsilon_0 n^2 h^2}{\pi m Z e^2} \quad (3)$$

∴ Radius of the nth orbit is given as,

$$r_n = n^2 \frac{\epsilon_0 h^2}{\pi m Z e^2}$$

$$\boxed{r_n = n^2 r_1} \longrightarrow (5)$$

where, $r_1 = \frac{\epsilon_0 h^2}{\pi m Z e^2}$

$= 0.53 \times 10^{-10} m = 0.53 A°$

$\epsilon_0 = 8.85 \times 10^{-12} Fm^{-1}$
$h = 6.62 \times 10^{-34} Js$
$m = 9.1 \times 10^{-31} kg$
$e = 1.6 \times 10^{-19} C$
$Z = 1$ for H-atom

We have, $n = 1, 2, 3, 4 \ldots\ldots$

So the radius of the first orbit of hydrogen atom is $0.53 \times 10^{-10} m$.

Similarly, $r_2 = 2^2 \times 0.53 \times 10^{-10}$

$= 2.12 \times 10^{-10} m.$

(ii) orbital velocity of an electron:

From equation (3), we can write,

$$v^2 = \frac{1}{4\pi\epsilon_0} \frac{Ze^2}{mr} \longrightarrow (6)$$

Now dividing eqn (6) by (4), we get,

$$\frac{v^2}{v} = \frac{\frac{1}{4\pi\epsilon_0}\frac{Ze^2}{mr}}{\frac{nh}{2\pi m r}}$$

$$v = \frac{1}{4\pi\epsilon_0} \frac{2\pi Z e^2}{nh}$$

$$v = \frac{Ze^2}{2\epsilon_0 nh}$$

For nth orbit, $v_n = \frac{Ze^2}{2\epsilon_0 nh}$

$$\therefore \boxed{v_n \propto \frac{1}{n}} \longrightarrow (7)$$

This shows that the orbital velocity of the electron varies inversely to the number of orbit of the electrons.

(iii) Energy of electrons:

(a) Kinetic energy (KE):

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(4)

Electron gains KE due to the motion of the electron. If v is the velocity of electr
then $KE = \frac{1}{2}mv^2$