Bohr's theory of hydrogen atom.

Radius of hydrogen atom.

In a hydrogen atom, an electron having charge - e revolves round the nucleus having charge +e in a circular orbit of radius r.

The force of attraction between the nucleus and the electron is

$$F = \frac{1}{4\pi\varepsilon_0}\frac{e\,e}{r^2} = \frac{e^2}{4\pi\varepsilon_0 r^2} \quad \text{.......................(1)}$$

This force provides the centripetal force for the orbiting energy

i. e. $$\frac{e^2}{4\pi\varepsilon_0 r^2} = \frac{m v^2}{r} \quad \text{...............................(2)}$$

$$m v^2 = \frac{e^2}{4\pi\varepsilon_0 r} \quad \text{.. .... (3)}$$

According to Bohr's second postulate, $m v r = \frac{nh}{2\pi}$

$$\therefore v = \frac{nh}{2\pi m r} \quad ....(4)$$

$$\therefore r = \frac{\varepsilon_0 n^2 h^2}{\pi e^2 m} \quad ....(5) \quad \text{where} \quad n = 1,2,3..........$$

Bohr's radius

The radius of the innermost orbit (1st orbit) in hydrogen atom is called Bohr's radius.

If n = 1 in (5) $\quad r_0 = \frac{\varepsilon_0 h^2}{\pi m e^2} = 0.53\overset{0}{A}$

Energy of electron in the Hydrogen atom.

The Kinetic Energy of revolving electron is $KE = \frac{1}{2} m v^2 .... (6)$

Substuting for mv^2 fom (3), $KE = \frac{e^2}{8\pi\varepsilon_0 r} \quad ....(7)$

Potential Energy of electrons is $PE = -\frac{e^2}{4\pi\varepsilon_0 r} \quad ....(8)$

Now total energy, TE = KE + PE

i.e. $E = \frac{e^2}{8\pi\varepsilon_0 r} + \frac{-e^2}{4\pi\varepsilon_0 r} \qquad \therefore E = \frac{-e^2}{8\pi\varepsilon_0 r} \quad ....(9)$

Substuting for r from (5); Energy of electron in hydrogen orbit, $E = \frac{-me^4}{8\varepsilon_0^2 n^2 h^2} \quad ....(10)$

Substuting the values of m, e, ε_0 and h then $E = \frac{-13.6}{n^2}$ eV

Energy levels

Ground state (E_1)

It is the lowest energystate in which the electron revolve in the orbit of smallest radius. For ground state,