Atomic Models

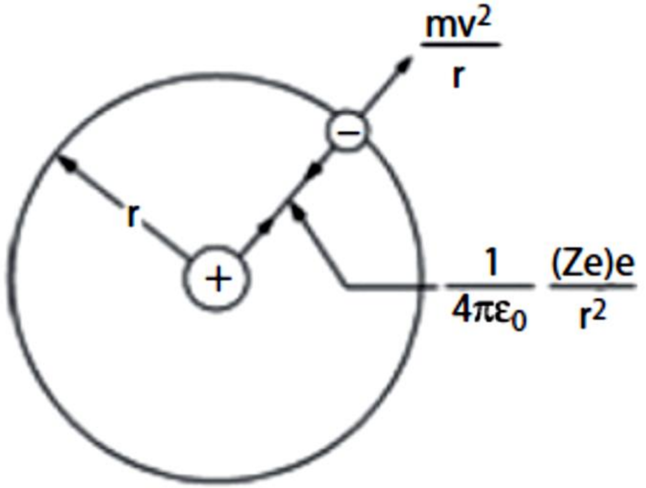
- The history of development of atomic models may be enumerated as under:

1. Thomson’s plum pudding atomic model
2. Rutherford’s nuclear atomic model
3. Bohr’s quantum atomic model
4. Sommerfeld’s relativistic atomic model
5. Wave mechanical or de Broglie’s atomic model, or modern concept of atomic model

Atomic Models

➢ Bohr’s Quantum Atomic Model:

- Bohr conceived-off a new atomic model employing the principles of *quantum theory* suggested by Planck.
- This model provided adequate explanation for stability of the atom.
- The model also accounted for the origin of spectral lines in the hydrogen atom.



Balance forces keeps the electron in orbital motion

Atomic Models

➢ **Bohr's Quantum Atomic Model:**

- He proposed new ideas which are now known as Bohr's postulates. These are:
- i. Electrons revolve in non-radiating stationary orbits.
- Centripetal force provided by Coulomb's force of attraction between the electron and the nucleus keeps the electron in orbital motion, Fig. 1.

Thus

$$\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_0}\frac{(Ze)(e)}{r^2} \qquad (2.1)$$

where, Z = atomic number of nucleus,
m = mass of the electron,
v = velocity of electron in the orbit,
r = radius of the orbit,
e =charge of electron.

Atomic Models

- **Bohr's Quantum Atomic Model:**

ii. Angular momentum of the moving electron is an integral multiple of h/2∏ where *h* is *Planck's constant .* Thus

$$mvr = \frac{nh}{2\pi} \qquad (2.2)$$

- where, *n* = 1, 2, 3, . . . ∞, and is called *principal quantum number.*

iii. The electron does not radiate energy while moving in stationary orbit.

- Energy is emitted when the electron falls from higher energy orbit to lower energy orbit.
- If the electron jumps-up to higher energy orbit from lower energy orbit, absorption of energy takes place.
- The energy absorbed or emitted is expressed by Bohr's frequency condition given as
- $\Delta E = Ef - Ei = hf$ (2.3)

where *f* is the frequency of emitted radiation, E_i and E_f are the energies of initial and final orbits respectively.

Atomic Models

- **Radii of Orbits, Velocity and Frequency of Electrons**

- **Radius of *n*th orbit.** The radius of *n*th stationary orbit is, given as

$$r_n = \frac{n^2 \epsilon_0 h^2}{\pi m Z e^2} \tag{2.4}$$

- **Velocity of *n*th orbit.** Velocity of *n*th orbit electrons is determined by

$$v_n = \frac{Ze^2}{2n \epsilon_0 h} \tag{2.5}$$

- **Frequency of *n*th orbit.** The orbital frequency of an electron in *n*th orbit is given as

$$f_n = \frac{v_n}{2\pi r} \tag{2.6}$$

- Substituting the values of r_n and v_n from Eqs. 2.4 and 2.5 in Eq. 2.6, we get

$$f_n = \frac{mZ^2 e^4}{4 \epsilon_0^2 n^3 h^3} \tag{2.7}$$

Atomic Models

- **Radii of Orbits, Velocity and Frequency of Electrons**
- As ε_o, *h, m* and *e* are constants, hence for Z = 1, Eq. 2.4 shows that r_n proportional to n^2
- Thus for n = 1, 2, 3, 4, ...; the radii of orbits are proportional to 1_2, 2_2, 3_2, 4_2, ... *i.e.* in the ratio of 1 : 4 : 9 : 16, ..., etc.

Conclusions. Equation 2.5 reveals $v_n \propto \frac{1}{n}$ It means that

- v the velocity of electrons in outer orbits is lower than those in the inner orbits.

Similarly Eq. 2.7 interprets that $f_n \propto \frac{1}{n^3}$. Therefore

- orbital frequency of electrons, for $Z = 1$, is in the ratio of $\frac{1}{1^3} : \frac{1}{2^3} : \frac{1}{3^3} : \frac{1}{4^3} : \ldots$ etc.