Atoms

Rutherford's model of atom:

- Most of the mass of the atom and all its positive charge are concentrated in a tiny nucleus, and the electrons revolve around this nucleus.

- **Limitations**
  - It predicts that atoms are unstable because the accelerated electrons revolving around the nucelus must spiral into the nucleus. This contradicts the stability of matter.
  - It could not explain the characteristic line spectra of atoms of different elements.

- Total energy of electron in hydrogen atom

$$E = k + U = \frac{e^2}{8\pi\varepsilon_0 r} - \frac{e^2}{4\pi\varepsilon_0 r}$$

$$\boxed{E = -\frac{e^2}{8\pi\varepsilon_0 r}}$$

Origin of Spectral Lines:

- The atomic hydrogen emits a line spectrum consisting of various series. The frequency of any line in a series can be expressed as a difference of two terms:
- Lyman series: $\bar{\nu} = R\left[\frac{1}{1^2} - \frac{1}{n^2}\right];\ n = 2, 3, 4, \ldots$
- Balmer series: $\bar{\nu} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right];\ n = 3, 4, 5, \ldots$
- Paschen series: $\bar{\nu} = R\left[\frac{1}{3^2} - \frac{1}{n^2}\right];\ n = 4, 5, 6, \ldots$

- Bracket series: $\bar{\nu} = R\left[\frac{1}{4^2} - \frac{1}{n^2}\right]; n = 5, 6, 7, \ldots$
- Pfund series: $\bar{\nu} = R\left[\frac{1}{5^2} - \frac{1}{n^2}\right]; n = 6, 7, 8, \ldots$

Bohr model of hydrogen atom

- In a hydrogen atom, electrons can revolve only in certain discrete, non-radiating orbits—called stationary orbits—for which the total angular momentum of the revolving electrons is an integral multiple of , $\frac{h}{2\pi}$ i.e.,

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

Where, n is any positive integer, 1, 2, 3 …

- The emission/absorption of energy occurs only when an electron jumps from one of its specified non-radiating orbit to another.

$$\boxed{h\nu = E_2 - E_1}$$

Where,

E_1 → Total energy of the electron in an inner stationary orbit

E_2 → Total energy of the electron in the outer stationary orbit

ν → Frequency of radiation emitted

- When an electron in a hydrogen atom jumps from the higher energy level to the lower energy level, the difference of energies of the two energy levels is emitted as a radiation of a particular wavelength.

The different spectral series are as follows:

- Lyman series

$$\frac{1}{\lambda} = R_H \left(\frac{1}{1^2} - \frac{1}{n_i^2} \right)$$

$n_i = 2, 3, 4 \ldots$

It lies in ultraviolet region.

- Balmer series

$$\frac{1}{\lambda} = R_H \left(\frac{1}{2^2} - \frac{1}{n_i^2} \right)$$

$n_i = 3, 4, 5 \ldots$

It lies in the visible region.

- Paschen series

$$\frac{1}{\lambda} = R_H \left(\frac{1}{3^2} - \frac{1}{n_i^2} \right)$$

$n_i = 4, 5, 6 \ldots$

It lies in the infra-red region.

- Brackett series

$$\frac{1}{\lambda} = R_H \left(\frac{1}{4^2} - \frac{1}{n_i^2} \right)$$

$n_i = 5, 6, 7 \ldots$

It lies in the infra-red region.

- P fund series

$$\frac{1}{\lambda} = R_H\left(\frac{1}{5^2} - \frac{1}{n_i^2}\right)$$

$n_i = 6, 7, 8 \ldots$

It lies in the far infra-red region.

The X rays are of two types:

- Characteristic X-rays: The intensity of these X-rays is very high at certain sharply defined frequencies.
- Continuous X-rays: At all the wavelengths other than those corresponding to K_α and $K_{\beta,}$ the intensity of these X-rays varies gradually.