

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 nucleus 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

$$E = k + U = \frac{e^2}{8\pi\epsilon_0 r} - \frac{e^2}{4\pi\epsilon_0 r}$$

$$E = -\frac{e^2}{8\pi\epsilon_0 r}$$

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:

$$\bar{\nu} = R \left[\frac{1}{1^2} - \frac{1}{n^2} \right]; n = 2, 3, 4, \dots$$

- Lyman series:

$$\bar{\nu} = R \left[\frac{1}{2^2} - \frac{1}{n^2} \right]; n = 3, 4, 5, \dots$$

- Balmer series:

$$\bar{\nu} = R \left[\frac{1}{3^2} - \frac{1}{n^2} \right]; n = 4, 5, 6, \dots$$

- Paschen series:

$$\bar{\nu} = R \left[\frac{1}{4^2} - \frac{1}{n^2} \right]; n = 5, 6, 7, \dots$$

- Bracket series:

$$\bar{\nu} = R \left[\frac{1}{5^2} - \frac{1}{n^2} \right]; n = 6, 7, 8, \dots$$

- Pfund series:

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.,

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

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.

$$h\nu = E_2 - E_1$$

Where,

$E_1 \rightarrow$ Total energy of the electron in an inner stationary orbit

$E_2 \rightarrow$ Total energy of the electron in the outer stationary orbit

$\nu \rightarrow$ 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

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

$$n_i = 2, 3, 4 \dots$$

It lies in ultraviolet region.

- Balmer series

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

$$n_i = 3, 4, 5 \dots$$

It lies in the visible region.

- Paschen series

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

$$n_i = 4, 5, 6 \dots$$

It lies in the infra-red region.

- Brackett series

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

$$n_i = 5, 6, 7 \dots$$

It lies in the infra-red region.

- P fund series

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

$$n_i = 6, 7, 8 \dots$$

It lies in the far infra-red region.

The X rays are of two types:

- Characteristic X-rays: The intensity of the 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_β , the intensity of the X-rays varies gradually.