- **Characteristics of the Anode Rays**—Travel in straight lines : They cast a shadow of the objects placed in their way.
- Produce mechanical effect. A paddle wheel placed in their path starts rotating.
- Rays are positively charged.
- Anode rays are deflected towards the negative plate of an electric field.
- The smallest and lightest positive ion was obtained by using hydrogen gas and was called proton.

  The mass of each of this particle,

$$m = \frac{e}{e/m} = \frac{1.6 \times 10^{-19}}{9.58 \times 10^{4}} = 1.67 \times 10^{-24}\ \text{g}$$

  This mass is nearly the same as that of the hydrogen atom.
- **Discovery of Neutron**—Chadwick worked day and night to prove the neutron theory, studying the beryllium radiation with an ionisation counter and a cloud chamber. It is a neutral particle with mass equal to 1.67493×10^{-27} kg. They are present in nucleus.

$$_4Be^9 + {}_2He^4 \longrightarrow {}_6C^{12} + {}_0n^1$$

  α-particle → Neutron
- **Atomic Models**—In the early 1900's many scientists had turned their attention to investigating the structure of the atom.
- Proposed about 1900 by Lord Kelvin and strongly supported by Sir Joseph John Thomson.
- In 1898 Thomson suggested a model of the atom as a sphere of positive matter in which electrons are positioned by electrostatic forces.
- The electrons are embedded into the sphere of positive matter.
- It is also called plum pudding, raisin pudding or watermelon model.

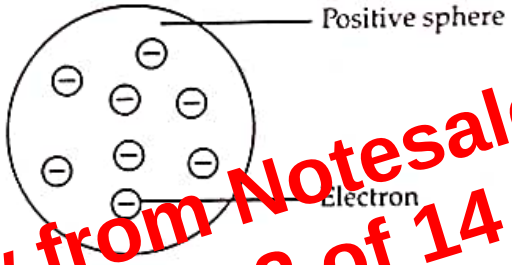

Fig. Thomson Model of Atom

- **Limitations of Thomson Model**—It could not explain the result of the scattering experiment performed by Rutherford.
- It did not have any experimental evidence in its support.
- **Rutherford's Nuclear Model of Atom**—Rutherford bombarded high energy α-particles from radioactive source on thin foil of gold metal.
- The thin gold foil had a circular fluorescent ZnS screen around it.
- Whenever an α-particle strike the screen, a tiny flash of light was produced at that point.
- **Conclusion Made by Rutherford**—
  - Most of the space is empty because most of the α-particles passed through the foil undeflected.
  - The positive charge has to be concentrated in a very small volume that repelled and deflected few positively charged α-particles.
  - This portion of the atom was called nucleus.
  - The centre is dense and hard, *i.e.*, the total mass of the atom lies at the centre of the atom.
  - Due to which α-particles bounced back to their original path.
- **Atomic Number**—It is equal to number of protons present in the nucleus, *i.e.*, It is denoted by (Z).
- **Mass Number** – It is equal to as total number of nucleons, i.e., protons and neutrons in the nucleus. It is denoted by (A).
- Mass Number of an element = Number of Protons + Number of Neutrons.
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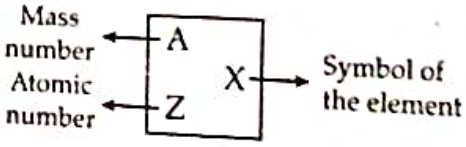

TOPIC-3 Dual Nature, Heisenberg's Principle and Quantum Mechanical Model

Quick Review—

➢ **Towards Quantum Mechanical Model of the Atoms**—To overcome the shortcoming of the Bohr's model, attempts were made to develop a more suitable and general model for an atom. Two important developments which contributed significantly in the formulation of a new model were :

(i) Dual Nature of matter

(ii) Heisenberg uncertainty principle.

➢ **Dual Behaviour of Matter**—Einstein has suggested that light can behave as a wave as well as like a particle. *i.e.*, it has dual character.

In 1924, de-Broglie suggested that matter and hence electron like radiations, has a dual character – wave and particle.

According to de-Broglie

"All material particles in motion possess wave characterstics".

According to de-Broglie, the wavelength associated with a particle of mass m, moving with velocity v is given by the relation,

$$\lambda = \frac{h}{mv} = \frac{h}{p}$$

h = Planck's constant

v = Velocity

($p = mv$) is momentum of the particles.

➢ **Significance of de-Broglie equation**

Although the dual nature of matter is applicable to all materials objects but it is significant for microscopic bodies only.

In case of ordinary objects, the wavelength are so short that wave properties cannot be detected.

➢ **Heisenberg's Uncertainity Principle**

Heisenberg's uncertainity principle states that

It is not possible to measure simultaneously both the position and momentun (or velocity) of a microscopic particle, with absolute accuracy.

Mathematically, this law may be expressed as :

$$\Delta x \times \Delta p \geq \frac{h}{4\pi}$$

$$\Delta x . m\Delta V \geq \frac{h}{4\pi}$$

or

$$\Delta x \times \Delta V \geq \frac{h}{4\pi m}$$

where,

Δx = uncertainty in position

Δp = uncertainty in momentum.

ΔV = uncertainty in velocity.

➢ **Quantum Mechanical Model of Atom and Concept of Atomic Model—**

Quantum Mechanical Model of Atom : Quantum mechanics was developed independently by **Heisenburg** and **Schrodinger.**

Schrodinger equations is $\hat{H}\psi = E\psi$ where $\hat{H}$ is a mathematical operator called **Hamiltonian,** E is the total energy of the system and ψ is the wave function.

Important Features of the Quatum Mechanical Model of Atom

1. The energy of the electrons in atoms is quantized.
2. The existence of quantized electronic energy level is a direct result of the wave like properties of electrons