Histo...

Initial attempts to know composition of matter were made by Indian and Greek philosophers. Brief review of these attempts is given below :

- Indian philosopher **Maharishi Kanad** proposed that whole matter is made-up of very small particles named **parmanu** (param, anu *i. e.*, very small particle)
- Greek philosophers **Aristotle** and **Plato** believed that matter is infinitely divisible.
- **Lucretius** and **Democretius** proposed that their are very small indivisible particles which constitute the matter and they gave term atom (meaning indivisible) for these particles.

But these ideas were not accepted widely due to lack of experimental evidences.

First attempt in this regard used to explain experimental observations, law of conservation of mass and law of definite proportions was made by **John Dalton.** On the basis of his atomic theory, he also proposed law of multiple proportions.

Note

1. *Term atom was used by **Dalton** for the most fundamental particle of matter and its literal meaning "not divisible". (Gk. a = not, temnein = to cut).*
2. *An atom is the smallest bit of matter that can be identified as a substance and a molecule (made-up of atoms) is the smallest recognizable bit of substance.*
3. *Terms positive and negative charge were given by Benzamin Franklin.*

Dalton's Atomic Theory

The salient features of the theory are as given below :

(i) Matter is composed of extremely small particles called *atoms* (*i. e.*, indivisible particles).

(ii) Atoms of one element are same and of different elements are different.

(iii) Atom of each element has characteristics mass.

(iv) Atoms are indivisible *i. e.*, they can neither be destroyed nor created.

(v) Atom take part in chemical reaction.

(vi) Atoms of different elements combine in a definite ratio to form **compound atoms** (now called **molecules**), **in which relative number and kind of** atoms are constant.

...ments on Dalton's Atomic Theory

(a) It explained the law of conservation of mass and some other laws of chemical combinations like law of multiple proportions.

(b) It proposed that atoms is the smallest particle which take part in a chemical reaction. This statement is still used to define atom.

(c) It could not explain isotopes *i. e.*, why should atoms of same element differ in their masses *e. g.*, $_1H^1$, $_1H^2$ and $_1H^3$.

(d) It does not mention of atomic masses of elements.

(e) It does not explain why do atoms of same element combine with each other.

(f) The law of definite proportion fails if different isotopes are used.

ELECTRONIC CONCEPT OF ATOM

Electronic concept of atom came into existence to explain the observations like generation of frictional electricity and Faraday's laws of electrolysis. It was observed that when rod of glass or ebonite is rubbed with silk or fur, their surface get charged. On the basis of these observations, Faraday concluded that charge is discrete and this fundamental discrete unit of charge was named as **electron** (*e* = removed, lektron = amber) by **Stoney** and was considered as **atom of electricity.**

MODERN ATOMIC CONCEPTS

Developments after Dalton's model : After failure of Dalton's model and discovery of sub-atomic particles several developments have been made to describe structure of atom. The modern atomic concept is based on the following discoveries :

1. William Crookes (1879) and J.J. Thomson (1897)— Discovery of cathode rays and electron
2. Goldstein (1886)— Positive rays
3. Rutherford (1909)— Proton and nucleus
4. Mosley's experiment concept of atomic number (1913)
5. Bohr's model orbit and atomic spectra of H-atom (1913)
6. Chadwick (1932)— Discovery of neutron

These developments regarding structure of atom have been summarized in the Fig. 7.1 given ahead :

1. Discovery of Electron : Thomson's Cathode Rays Experiment

A. Experiment : Towards the end of nineteenth century **William Crookes** and **Julius Plucker** made studies on electric discharge through partially evacuated tubes (Fig. 7.2). A discharge tube (made of hard glass fitted with metal electrodes) was evacuated by vacuum pump and high voltage was applied across the electrodes. They observed that

(i) At normal pressure, the gas remains non-conducting, even at very high voltage. ($\approx 10{,}000\,V$)

(ii) When pressure is reduced (approximately upto $10^{-2} - 10^{-3}$ mm Hg), the gas becomes conducting and some rays are originated which cause certain materials including glass to fluoresce or give off light. *i. e.*, light is emitted by the residual gas in the discharge tube. The colour of light depends upon the nature of gas filled inside the tube.

(iii) On reducing the pressure further ($\approx 10^{-4}$ mm Hg), the glow faints and a green glow behind anode is observed. The gas again remains conducting.

B. Observation : On the basis of above observations, it was suggested that some radiation is originated there, because this radiation is originated at cathode, so term **'cathode ray'** was given for this radiation.

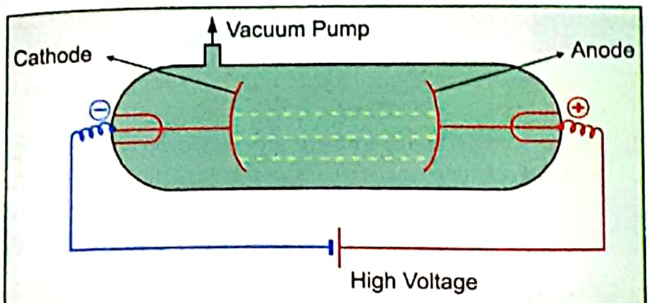

Fig. 7.2: Thomson's experiment : Cathode rays

Note

(i) Television picture tubes are cathode rays tubes and a television picture is the result of fluorescence from T.V. screen.

***(ii) Crooke's dark space:** In the discharge tube, when flow of current starts, a glow around cathode detaches from the surface of cathode and a space is left between glow and cathode, which is known as Crooke's dark space.*

Properties of Cathode Rays

1. Cathode rays are emitted at right angles to the surface of cathode and direction of emission does not depend upon the position of anode. They travel in **straight lines** (like ordinary light) normal to the cathode with speed of order 10^7 ms^{-1}. It is proved by sharp shadows, if any opaque solid object is placed in their path (Fig. 7.3).

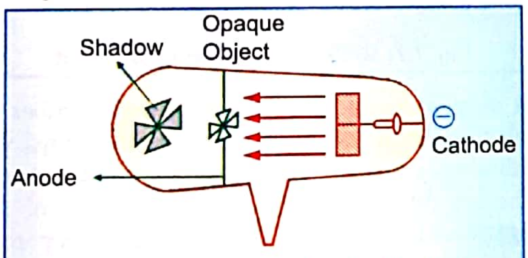

Fig. 7.3: Straight line path of cathode ray

2. The cathode rays are made-up of **particles** as they rotate a light frictionless paddle wheel (Fig. 7.4) placed in their path *i.e.*, they have momentum and thus, energy. Their speed is dependent on voltage applied. They produce heating effect also, which again proves that they are made- up of energetic particles.

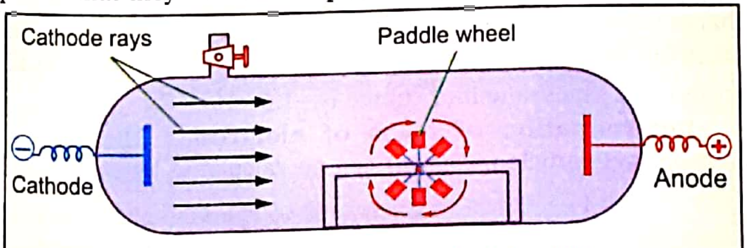

Fig. 7.4: Cathode rays are material particles

3. They contain negatively charged particles as they are attracted by positive electrode. They are deflected in both electric as well as in magnetic field.

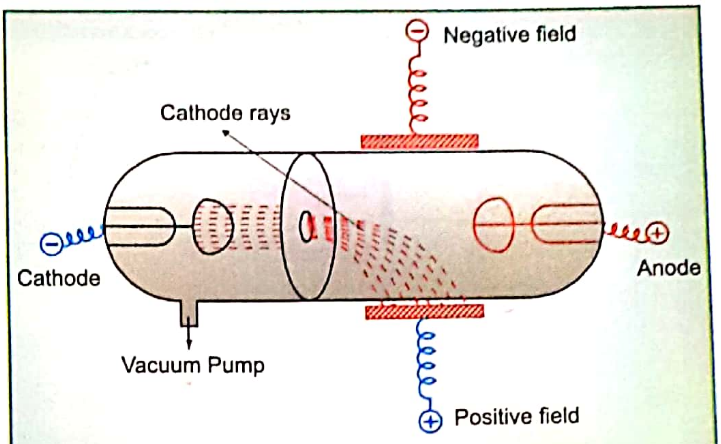

Fig. 7.5: Cathode rays are negatively charged

4. They are not formed in evacuated tube.

5. They affect the photographic plate and produce fluorescence.

6. They can ionise gases. Which again proves that they are charged.

7. The heavy metal plate exposed to cathode rays acquires a negative charge and X-rays are emitted (Mosley's exp.).

8. Their e/m value does not depend upon the gas taken in discharge tube.

C. Conclusion : Thomson concluded that cathode rays are made-up of stream of negatively charged particles and these particles are now named as **electron** (Term given by Stoney). All the observations revealed that electron is the fundamental particle of matter.

Explanation for the formation of cathode rays : The atoms or molecules present in the gas ionise under high potential difference and knock out electrons from cathode which constitute the cathode rays.

$$H \longrightarrow H^+ + e$$

$$O_2 \longrightarrow O_2^+ + e$$

Following observations also prove that electrons are fundamental particles :

(a) Many metal filaments emit electrons on strong heating. **(Thermionic emission)**

(b) All forms of matter emit electrons when they are exposed to X-rays.

(c) Radioactive substances decay β-particles, which are fast moving electrons.

(d) Alkali metals emit electrons on exposure to UV light **(Photoelectric effect)**

***e/m* value of cathode ray particle (electron) : Thomson's experiment :** Specific charge or charge– mass ratio (e/m) of cathode ray particle does not depend upon the nature of gas taken. To determine e/m value, Thomson made an experimer and determined its value to be $-1.76 \times 10^{11} C \cdot kg^{-1}$. The apparat used is shown in Fig. 7.6.