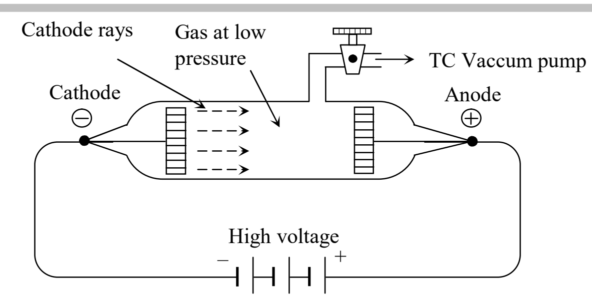
Composition of atom.

The works of J.J. Thomson and Ernst Rutherford actually laid the foundation of the modern picture of the atom. It is now believed that the atom consists of several sub-atomic particles like electron, proton, neutron, positron, neutrino, meson etc. Out of these particles, the electron, proton and the neutron are called fundamental subatomic particles and others are non-fundamental particles.

Electron (–1eo)

(1) It was discovered by J.J. Thomson (1897) and is negatively charged particle. Electron is a component particle of cathode rays.

(2) Cathode rays were discovered by William Crooke's & J.J. Thomson (1880) using a cylindrical hard glass tube fitted with two metallic electrodes. The tube has a side tube with a stop cock. This tube was known as discharge tube. They passed electricity (10,000V) through a discharge tube at very low pressure (10^{-2} to $10^{-3}\ mm\ Hg)$. Blue rays were emerged from the cathode. These rays were termed as Cathode rays.



Discharge tube experiment for production of cathode rays

(3) Properties of Cathode rays

(I) Cathode rays travel in straight line.

(ii) Cathode rays produce mechanical effect, as they can rotate the wheel placed in their path.

(iii) Cathode rays consist of negatively charged particles known as electron.

(iv) Cathode rays travel with high speed approaching that of light (ranging between 10^{-9} to 10^{-11} cm/sec)

(v) Cathode rays can cause fluorescence.

(vi) Cathode rays heat the object on which they fall due to transfer of kinetic energy to the Object.

(vii) When cathode rays fall on solids such as $Cu, X-$ rays are produced.

(viii) Cathode rays possess ionizing power i.e., they ionize the gas through which they pass.

(ix) The cathode rays produce scintillation the photographic plates.

(x) They can penetrate through thin metallic sheets.

(xi) The nature of these rays does not depend upon the nature of gas or the cathode material used in discharge tube.

(xii) The e/m (charge to mass ratio) for cathode rays was found to be the same as that for an e^{-} $(-1.76 \times 10^{8}$ coloumb per gm). Thus, the cathode rays are a stream of electrons.

Note: When the gas pressure in the discharge tube is 1 atmosphere no electric current flows through the tube. This is because the gases are poor conductor of electricity.

The television picture tube is a cathode ray tube in which a picture is produced due to fluorescence on the television screen coated with suitable material. Similarly, fluorescent light tubes are also cathode rays tubes coated inside with suitable materials which produce visible light on being hit with cathode rays.

(4) R.S. Mullikan measured the charge on an electron by oil drop experiment. The charge on each electron is $-1.602 \times 10^{-19} C$.

(5) Name of electron was suggested by J.S. Stoney. The specific charge (e/m) on electron was first determined by J.J. Thomson.

(6) Rest mass of electron is $9.1 \times 10^{-28} gm = 0.000549\ amu = 1/1837$ of the mass of hydrogen atom.

(7) According to Einstein's theory of relativity, mass of electron in motion is, m'

$$= \frac{\text{Rest mass of electron(m)}}{\sqrt{[1-(u/c)^2]}}$$

Where u = velocity of electron, c= velocity of light.

When u=c than mass of moving electron =∞.

(8) Molar mass of electron = Mass of electron × Avogadro number = 5.483×10^{-4}.

(9) 1.1$\times 10^{27}$ electrons =1gram.

(10) 1 mole electron = 0.5483 mili gram.

(11) Energy of free electron is ≈ 0. The minus sign on the electron in an orbit, represents attraction between the positively charged nucleus and negatively charged electron.

(12) Electron is universal component of matter and takes part in chemical combinations.

(13) The physical and chemical properties of an element depend upon the distribution of electrons in outer shells.

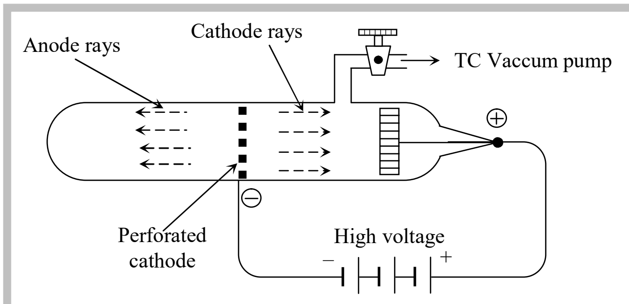
(14) The radius of electron is $4.28 \times 10^{-12}\, cm$.

(15) The density of the electron is = $2.17 \times 10^{-17}\, g/mL$.

Proton (1H1, H+, P)

(1) Proton was discovered by Goldstein and is positively charged particle. It is a component particle of anode rays.

(2) Goldstein (1886) used perforated cathode in the discharge tube and repeated Thomson's experiment and observed the formation of anode rays. These rays also termed as positive or canal rays.



Perforated tube experiment for production of anode rays

(3) Properties of anode rays

(I) Anode rays travel in straight line.

(ii) Anode rays are material particles.

(iii) Anode rays are positively charged.

(iv) Anode rays may get deflected by external magnetic field.

(v) Anode rays also affect the photographic plate.

(vi) The e/m ratio of these rays is smaller than that of electrons.

(vii) Unlike cathode rays, their e/m value is dependent upon the nature of the gas taken in the tube. It is maximum when gas present in the tube is hydrogen.

(viii) These rays produce flashes of light on ZnS screen.

(4) Charge on proton = 1.602×10^{-19} coulombs = $4.80 \times 10^{-10}\, e.s.u.$

(5) Mass of proton = Mass of hydrogen atom= $1.00728\ amu = 1.673 \times 10^{-24}\ gram = 1837$ of the mass of electron.

(6) Molar mass of proton = mass of proton $\times$ Avogadro number $= 1.008$ (approx.).

(7) Proton is ionized hydrogen atom (H^+) i.e., hydrogen atom minus electron is proton.

(8) Proton is present in the nucleus of the atom and its number is equal to the number of electron.

(9) Mass of 1 mole of protons is $\approx$1.007 gram.

(10) Charge on 1 mole of protons is $\approx$ 96500 coulombs.

(11) The volume of a proton (volume = $\frac{4}{3}\pi r^3$) is $\approx$ $1.5 \times 10^{-38}\ cm^3$.

(12) Specific charge of a proton is 9.58×10^4 Coulomb/gram.

Neutron (on1, N)

(1) Neutron was discovered by James Chadwick (1932) according to the following nuclear reaction,

$$_4Be^9 + _2He^4 \rightarrow _6C^{12} + _on^1 \text{ or } _5B^{11} + _2He^4 \rightarrow _7N^{14} + _on^1$$

(2) The reason for the late discovery of neutron was its neutral nature.

(3) Neutron is slightly heavier (0.18%) than proton.

(4) Mass of neutron = 1.675×10^{-24} *gram* = 1.675×10^{-27} *kg* = 1.00899 *amu* $\approx$ mass of hydrogen atom.

(5) Specific charge of a neutron is zero.

(6) Density = 1.5×10^{-14} *gram/c.c.*

(7) 1 mole of neutrons is $\approx$ 1.008 gram.

(8) Neutron is heaviest among all the fundamental particles present in an atom.

(9) Neutron is an unstable particle. It decays as follows:

$$\underset{\text{neutron}}{_0n^1} \longrightarrow \underset{\text{proton}}{_1H^1} + \underset{\text{electron}}{_{-1}e^0} + \underset{\text{anti nutrino}}{_0\nu^0}$$

(10) Neutron is fundamental particle of all the atomic nucleus, except hydrogen or protium.

Comparison of mass, charge and specific charge of electron, proton and neutron

Name of constant	Unit	Electron(e–)	Proton(p+)	Neutron(n)
Mass (m)	amu	0.000546	1.00728	1.00899
	kg	9.109 × 10–31	1.673 × 10–27	1.675 × 10–24
	Relative	1/1837	1	1
Charge(e)	Coulomb (C)	– 1.602 × 10–19	+1.602 × 10–19	Zero
	esu	– 4.8 × 10–10	+4.8 × 10–10	Zero

	Relative	– 1	+1	Zero
Specific charge (e/m)	C/g	1.76 × 108	9.58 × 104	Zero

• The atomic mass unit (amu) is 1/12 of the mass of an individual atom of $_6C^{12}$, i.e. $1.660 \times 10^{-27}\,kg$.

Other non-fundamental particles

Particle	Symbol	Nature	Charge esu ×10–10	Mass (amu)	Discovered by
Positron	$e^+, {}_1e^0, \beta^+$	+	+ 4.8029	0.0005486	Anderson (1932)
Neutrino	ν	0	0	< 0.00002	Pauli (1933) and Fermi (1934)
Anti-proton	p^-	–	– 4.8029	1.00787	Chamberlain Sugri (1956) and Weighland (1955)
Positive mu meson	μ^+	+	+ 4.8029	0.1152	Yukawa (1935)
Negative mu meson	μ^-	–	– 4.8029	0.1152	Anderson (1937)
Positive pi meson	π^+	+	+ 4.8029	0.1514	Powell (1947)
Negative pi meson	π^-	–	– 4.8029	0.1514	
Neutral pi meson	π^0	0	0	0.1454	