ATOMIC STRUCTURE

✳ Electrical Nature of Matter:-

→ The electrical nature of matter is known from very early times from the experiments on the production of frictional electricity.

Ex.- (i) Comb dry hair.

(ii) When a **glass or ebonite rod** is rubbed **with silk or fur** and them brought **near an** inflated **balloon**, the balloon is attracted to rod.

→ This was further confirmed by '**Michael Faraday**' in **1830** when he showed that when electricity is passed through an electrolytic solution, a chemical reaction occurs at electrodes.

DISCOVERY OF ELECTRON (Study of Cathode Ray):-

→ **William Crookes in 1879** studied the conduction of electric current through gases at low pressure.

→ Long glass tube (about **60 cm long**).

→ Two Metallic electrods.

→ Stop cock, Vacuum pump.

→ This tube was known as '**Discharge tube**'.

● When a high electric discharge of about **10,000 volts** is applied between the electrodes, then-

(i) Pressure in tube is **1 atm, no current** flows between the electrodes because gases are poor conductor of electricity.

(ii) When pressure is **10^{-2} atm** (about 1mm to 10mm) **current starts flowing** and **coloured glow**.

(iii) When pressure is **reduced to 10^{-4} atm** the **glow disappears but current keeps on flowing**. The tube glows with a **faint greenish light**.

→ If a hole is made in anode and behind the anode coated with fluorescent material like **(Zns)** a bright spot is developed on the coating.

● This clearly shows that some **invisible rays** are emanating **from cathode**. These rays were called **Cathode Rays**.

PROPERTIES OF CATHODE:-

→ **J.J. Thomson (1897)** and other scientist found following properties.

(i) Cathode rays emerge **from the cathode** and move towards the **anode**.

(ii) Cathode rays **cast a shadow**, it means Cathode rays **travels in straight line**.

(iii) Cathode rays are made of **material particles** (paddle wheel starts moving).

(iv) These rays are deflected **towards the +ve plate** of electric field. This shows that cathode rays carry **-ve charge**.

(v) Cathode **rays ionise gases** through which they pass.

(vi) Cathode rays can **penetrate** through **thin metal foils**.

(vii) The characteristic properties of **cathode rays do not depend on the material** of the electrodes and also the nature of the gas taken in the discharge tube.

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→ **J.J. Thomsan** named these sub-atomic particles as **corpuscles** of negative electricity.

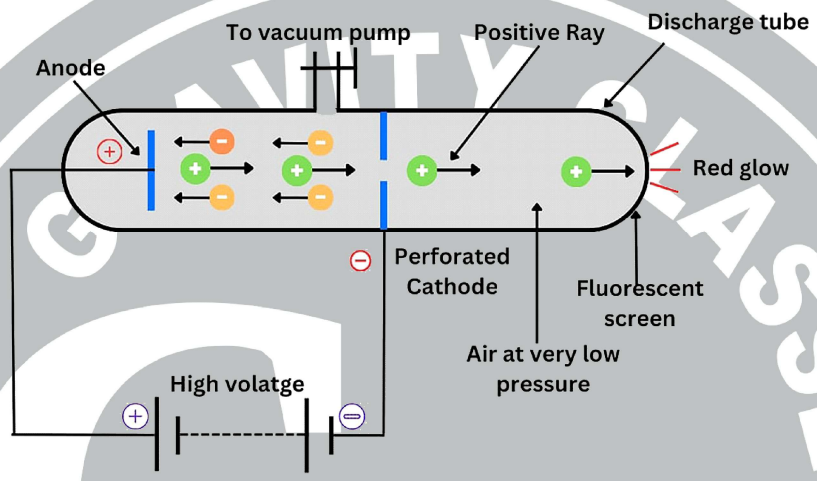
→ The name was later changed to electron (e^-) on the suggestion of '**G.J. Stoney**'.

→ **Change of electron** = 1.6×10^{-19} C. (Coulomb)

→ **Mass of electron** = 9.11×10^{-28} g.

Note:- Mass of electron is negligibly small and is approximately $\frac{1}{1840}$ **times** the mass of hydrogen atom.

DISCOVERY OF PROTON (ANODE RAYS):-



→ **Goldstein 1886** performed discharged tube experiment with perforated cathode. On **passing** high **electric charge** through the gas at **low pressure**, it was observed that some rays were coming from anode and passed through perforated cathode and produced green fluorescence on the opposite glass wall coated with **zinc sulphide**. These rays were called **Anode Ray** or **Canal Rays** or **+ve Rays**.

● Properties of Anode Rays:-

(i) Travels in **straight** lines.

(ii) Made up of **material particles**.

(iii) These particles are **+vely charged** gaseous ions.

(iv) +ve charge depends upon nature of the gas taken in discharge tube.

(v) The mass of these particles is found to be **nearly equal to the mass** of the atom of the gas.

● Lighest +vely charged particles is Hydrogen Gas.

Charge Particle Proton = $+1.6 \times 10^{-19}$ C.

Mass of Proton = 1.67×10^{-24} g.

Note:- The proton is a **Sub-atomic particles** of all atoms.

THOMSON MODEL OF ATOM:-

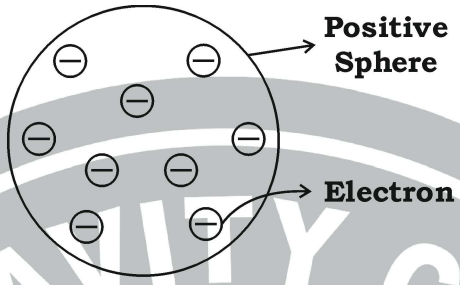
→ **J.J. Thomson** in 1904 proposed.

→ An atom is a uniform sphere of +ve electricity in which **electrons are embedded**.

→ The number of e^- embedded is such that the total negative charge on all the electrons is equal to the positive charge. So, the atom as a whole is electrically neutral.

It is also called **Plum-Pudding model**. It is also called **Watermelon Model**.

✳ Thomsons model assumes uniform distribution of mass and charge throughout the volume of the atom.



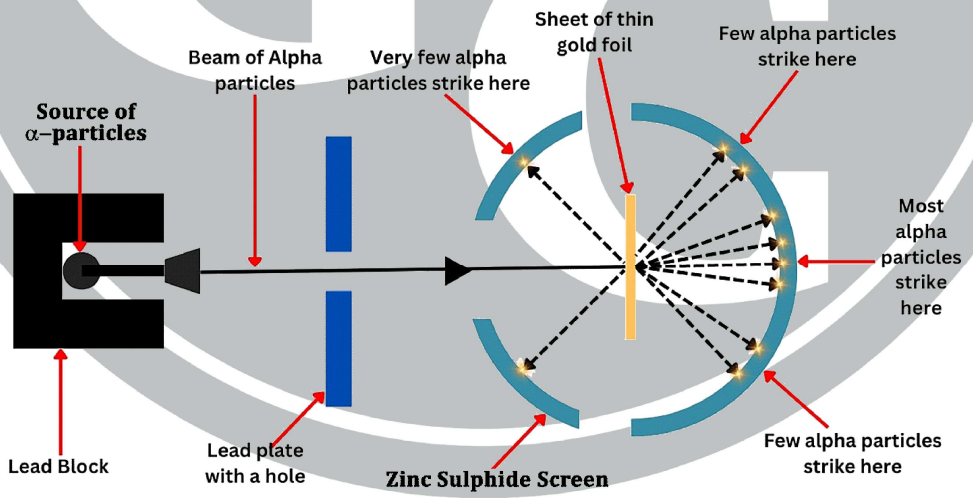
Thomson's Model of Atom

- **Drawback's of Thomson's Model:-**

→ It failed to explain the results of Rutherfords α – ray scattering experiment.

- **RUTHERFORD α - RAY SCATTERING EXPERIMENT:-**

→ British physicist **Ernest Rutherford** (**Father of Nuclear Physics**) in **1911** directed a narrow beam of alpha (α) particles at an extremely thin (0.00006 cm) gold foil in an evacuated chamber. α – particles are helium nuclei and each α – particles has a mass of 4u (4 times of proton) detected with the help of **circular fluorescent ZnS** screen, α – particles strikes the screen a **flash of green light** is seen.



Rutherford α – ray scattering experiment

 # Observation:-

(i) Most α – particles passed **undeviated**.

(ii) Some α – particles deflected **wider angle**.

(iii) Out of 20,000 traversed back their original path (i.e. 180°).

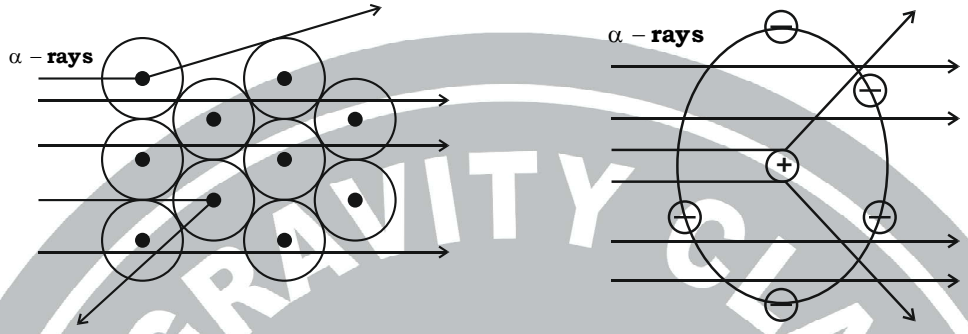
Conclusion:-

(i) Most of the space inside the atom is **empty**.

(ii) Some heavy and **positively charged body** inside the atom.

(iii) The heavy and +vely charged body inside the atom must be **very small** in volume.

✳ This **heavy, rigid and +vely charged body** located within the atom was called **Nucleus**.



Rutherfords Nuclear Model of Atom:-

→ From observation he proposed following model for an atom.

(i) An atom consists of a very small +vely charges centre called the **nucleus.**

(ii) The **entire mass** of the atom is contained in the **nucleus**. **+ve charge** on nucleus due to proton.

(iii) Equal number of e^- are **revolving** around the nucleus at extremely high speeds at greater distance from nucleus.

→ The **centrifugal force** arising from this circular motion balances the electrostatic force of attraction between nucleus and electrons.

✳ Rutherford's model is sometimes called **Planetary model of atom**. The path of electron around the nucleus is called its **orbit**.

Drawbacks of Rutherfords Model of Atom:-

(i) It falls to explain the stability of the atom. According to laws of physics e^- while moving around the nucleus will get **continuously accelerated** and a charged particle like e^- **when accelerated** should radiate energy. Because of **loss of energy the** e^- will slow down and **move closer and closer** to the **nucleus** with **each rotation** and finally would **spiral into the nucleus**.

✳ Collapsation is only 10^{-8} **second**.

(ii) He says nothing about the distribution of e^- around the nucleus.

● DISCOVERY NEUTRON:-

→ An atom is electrically neutral (i.e. $e^- = p^+$). But **mass of** e^- $\neq$ **mass of** p^+.

→ Rutherford in **1920**, suggested that mass of neutral particle in the nucleus is equal to that of proton mass.

→ Rutherford his prediction was proven true in 1932 by '**James Chadwick**'.

→ He discovered that when **Beryllium or boron** is **bombarded** by α – **particles** as **highly penetrating** radiation is **emitted**. It actually consist of new particle which carry no electrical charge (i.e. neutral) and have mass nearly equal to that of proton. These particles were called **neutrons**.

✳ The **mass of neutron** ≃ **1.674×10^{-27} kg**.

✳ **Neutron** is slightly **heavier than proton**.

✳ Protons and neutrons are present in the nucleus of the atom. They are collectively called **Nucleons**.

BOHR'S MODEL OF ATOM:-

→ Bohr's model of atom or Bohr's theory of atom, was developed by Nobel laureate **Niel's Bohr in 1913**. Overcome the drawback of Rutherfords model of atom.

● Postulates of Bohr's Theory:-

(i) Electrons revolve around the nucleus in circular orbits.

(ii) The e^- is allowed to revolve only in certain permissible orbits.

(iii) The allowed orbits are associated with a definite **fixed amount of energy**. Therefore, these orbits are called **stationary states** or **energy levels** or **shells**.

→ **Denoted** by letter K, L, M, N, O..... or 1, 2, 3, 4.

✳ Bohr was born in Copenhagen, Denmark. After doing his **Ph.D** he went to University of **Manchester** to **work with Rutherford**. He **got Nobel Prize** in **physics in 1922**.

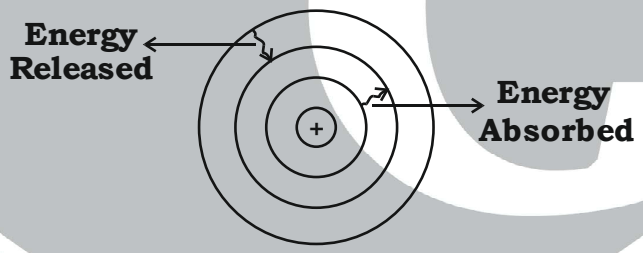
→ The K-orbit or the first orbit is nearest to the nucleus and has the lowest energy.

K < L < M < N < O .....

1 < 2 < 3 < 4 < 5 .....

(iv) The **energy** of an electron **remains constant** (in same orbit **don't radiate energy**) in a particular orbit.

(v) When an **e^- jumps** from **Lower energy/orbit to higher energy** level/orbit it **absorbs energy** but when it jumps from higher energy level/orbit to **lower** orbit **energy is emitted**.



Note:- When an electron makes a transition from one orbit to another, energy is lost or gained is definite discrete packets called **Quantum** or **Photon.**

ATOMIC NUMBER (Z):-

→ '**Antonius Van Den Brock**' was the first to suggest that the total units of +ve charge and the number of electrons in the atom of an element were equal to the ordinal number of the element in the periodic table starting with **Hydrogen** at 1 and **Uranium at 92**.

This **number** was called element no. or atomic no., symbolised by **Z**.

→ The number of unit +ve charge carried by the nucleus of an atom is called the **atomic number of the atom** (element).

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→ The atomic no. of an element is **equal to the number** of **proton** present in the nucleus of its atom.

→ Therefore atomic number (**z**) is also equal to the no. of e_s^- in the atom.

Atom number (z) = Number of unit +ve charge on **Nucleus**.

Atom number (z) = Number of **proton** in the Nucleus.

Atom number (z) = Number of **electron** in the atom.

Note:- '**Moseley**' concluded that **atom number (z)** is a fundamental property of the atom (or element). No two elements have the same **atomic number (Z)**.

Mass Number (A):-

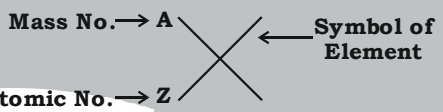
→ Nucleus has protons and neutrons. The total mass of the atom is equal to the sum total of the no. of protons and neutrons. This is called **mass number**.

Mass no. (A) = No. of Proton + No. of Neutrons.

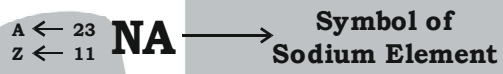
Mass no. (A) = Atomic no. (z) + No. of Neutrons.

$\therefore$ $\boxed{\text{No. of Neutrons} = \text{Mass no.(A)} - \text{Atom no.(Z)}}$

Symbolised



for ex:-



- **HOW ELECTRONS ARE DISTRIBUTED IN DIFFERENT ORBITS (SHELLS): Electronic Configuration.**

→ The distribution of these electrons in different energy level or orbits is called **electronic configuration** of the atom.

Bohr-Bury Scheme:-

→ **Bohr and Bury in 1921**, independently but simultaneously gave identical schemes for the distribution of electrons in various orbits or shells.

(i) The maximum no. of electrons that can be accommodated in an orbit or **shell is equal to ($2n^2$) rule**.

1^{st} shell (n = 1) or '**K**' **shell**.

Maximum no. of e^-s = $2n^2 = 2 \times 1^2 =$ **2**.

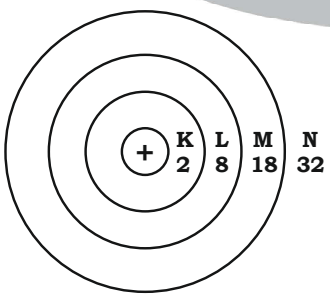
2^{nd} shell (n = 2) or '**L**' **shell**.

Maximum no. of e^-s = $2n^2 = 2 \times 2^2 =$ **8**.

3^{rd} shell (n = 3) or '**M**' **shell**.

Maximum no. of e^-s = $2n^2 = 2 \times 3^2 =$ **18**.

4th



(ii) the outermost orbitor shell can have a maximum of **8 electron (octet)** and the next inner to the **outermost (i.e. penultimate shell)** can have **18 e⁻s** (it permissible by **$2n^2$ rule**).

(iii) It is not necessary to get a shell completely filled before starting the filling of the next higher shell.

(iv) The outermost shell **can't hold more than 2e⁻** and the penultimate shell **can't hold more than 8** e⁻s unless the preceding inner shell is completely filled.

✳ The shells are filled in **stepwise manner**.

 # VALENCE ELECTRONS (V.E):-

→ The outermost shell of an atom is known as the **Valence Shell (V.S)** and the electrons present in the outermost shell are known as **Valence Elecrons**.

V.E and chemical properties of the element depend on the no. of Valence electrons and not the total no. of e⁻s present in an atom.

(i) An element in chemically **inert** if it has **8 e⁻s** in its outermost shell. Except **Helium (2e⁻s)** all other **noble gases have 8 electrons (octet)** in their valance shell and hence all noble gases are highly unreactive and rather chemically inert.

(ii) **1 e⁻** in V.shell are **very very reactive**.
ex.- Lithium (Li) (2, **1**)
Sodium (2, 8, **1**)

(iii) **7 e⁻s in** V.shell are also **very very reactive**.
ex.- Fluorine (2, **7**)
Chlorine (2, 8, **7**)

(iv) Having same no. of V.E show similar chemical properties.
ex.- Li (2, **1**), Na (2, 8, **1**), K (2, 8, 8, **1**)

(v) Element having less than 4 e_s^- in their V.shell are normally metal and are reactive '**H' (1) and 'He' (2) are exception**.

(vi) Elements having 4, 5, 6, 7 e⁻s in their V.shell are normally **non-metals**.
ex.- C, N, O, F, 4, 5, 6, 8, 7

● VALENCY AND VALENCE ELECTRONS:-

→ The no. of valence electrons of an **atom (element)** which actually take part in the chemical combination or bond formation with other element.

→ Valency of an element is equal to the no. of **Valence e⁻s** if their no. **is 4 or less**.
Ex.- Na (2, 8, 1) **1 Valence e⁻s and Valency is also 1**.

→ If no. of Valence e⁻s is more than 4, then the valency of the element is eight minus the no. of valence e⁻s.
Ex.- Cl (2, 8, 7) 7e⁻s is its Valence shell but its usual valency is **8 - 7 = 1**.

● Types of Valency:-

(i) By **loss or gain** of e⁻s **(electrovalency)**.
Formation of salt (sodium chloride).

ex.- $\underset{(2,8,1)}{Na} \longrightarrow \underset{(2,8)}{Na^+} + e^-$

$\underset{(2,8,7)}{Cl} + e^- \longrightarrow \underset{(2,8,8)}{Cl^-}$

→ The **two opposite** charged ions are held together or bonded together by **electrostatic force of attraction**.

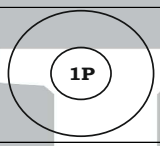
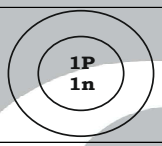
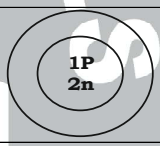
(ii) **By sharing of electrons (covalency)**.

ex.- Formation of **methane (CH_4)** molecule.

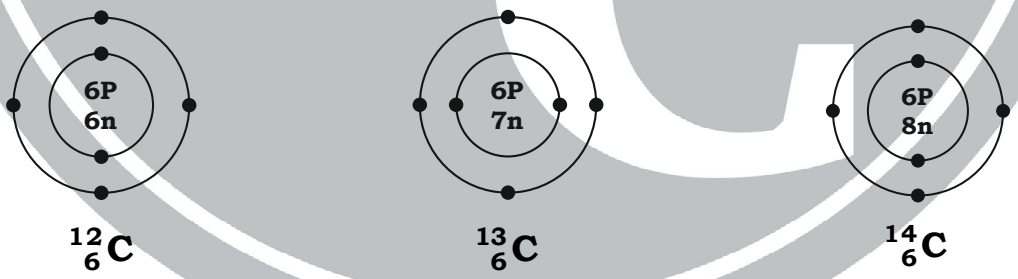
- **Isotope:-** Atoms of the same element which have same atomic no. but different mass no. are called **isotopes**.

→ Mass will be different due to different no. of Neutrons in their **Nuclei**.

ex.- **Hydrogen** has **three isotopes** having mass no. 1, 2 and 3 resp. but each of them has **same atom number** i.e. 1.

	Protium	**Deuterium**	**Tritium**
Symbol	${}_1^1H$	${}_1^2H$ or D	${}_1^3H$ or T
Number of Proton	1	1	1
Number of Neutron	0	1	2
			

→ **Carbon** has **3 isotopes** having mass no. 12, 13 and 14 but having the **same atomic number**. i.e. 6.



Isotopes of Carbon