ARJUNA NEET BATCH

Structure of Atom

LECTURE - 3

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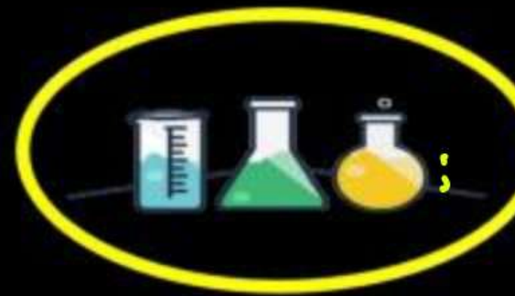
Objective of today's class

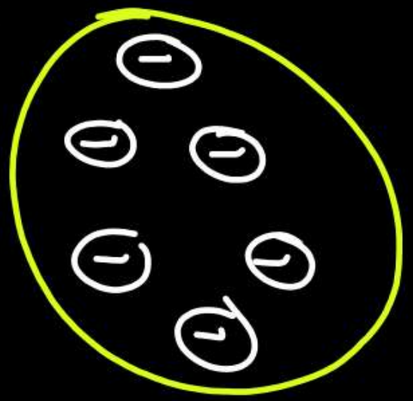
RUTHERFORD'S NUCLEAR MODEL OF ATOM



THOMSON Model of Atom

J.J. Thomson in 1898, proposed a model of atom which looked more or less like plum pudding or raisin pudding.

He assumed atom to be a spherical body in which electrons are unevenly distributed in a sphere having positive charge which balance the electron's charge. It is called Plum Pudding model.



Important Feature of This Model: The mass of the atom is assumed to be uniformly distributed over whole atom.

Failure: It failed after Rutherford's α-scattering experiment, which proved atom to be quite different.

→ Failed to Explain the Stability of Atom.

Representation of atom

Atomic number (Z)

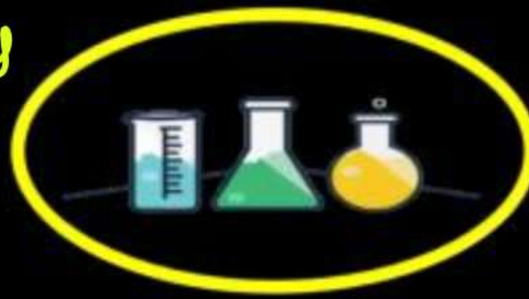
The number of unit positive charge on the nucleus of an atom of the element is called atomic number

- Atomic number = Number of protons
  = Number of electrons in an atom

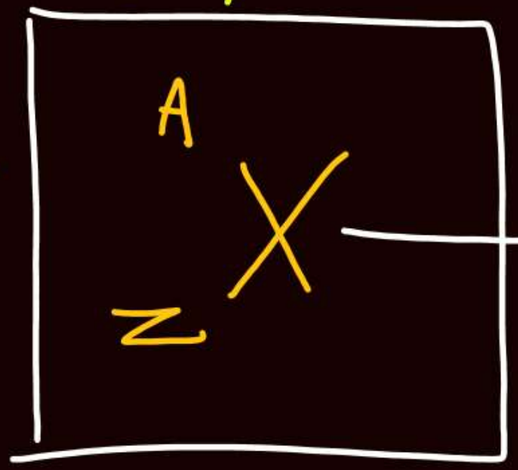
- **Mass number (A)**
- The number of protons and neutrons in the nucleus is called mass number of the atom.

Mass number (A) = Number of protons + Number of neutons

Neutrons



⇒ Representation of Atoms.



⇒ Symbol of Element

No. of neutrons
⇒ A − Z
⇒ 12 − 6 ⇒ 6

⇒ A → Atomic mass ⇒ No. of neutrons + No. of protons

⇒ Z → Atomic Number
→ Number of electrons
→ Number of protons

$^{12}_{6}C$

Atomic Number → 6
no. of e⊖ → 6
no. of proton → 6
Atomic mass → 12

Q. Calculate No. of $e^{\ominus}$, protons and Neutrons ?

① $^{14}_{7}N$
$e^- \rightarrow 7$
$p \rightarrow 7$
$n \rightarrow 7$

② $^{13}_{6}C$
$e^- \rightarrow 6$
$p \rightarrow 6$
$n \rightarrow 7$

③ $^{23}_{11}Na$
$e^- \rightarrow 11$
$p \rightarrow 11$
$n \rightarrow 12$

④ $^{1}_{1}H$
$e^- \rightarrow 1$
$p \rightarrow 1$
$n \rightarrow 0$

⑤ $^{4}_{2}He$
$e^- - 2$
$p - 2$
$n \rightarrow 2$

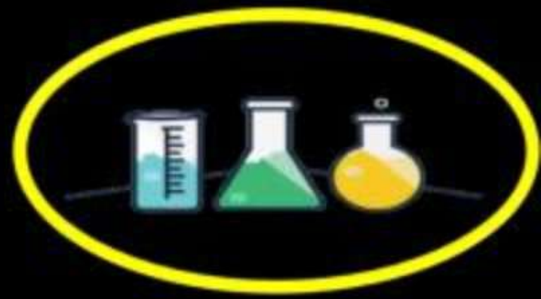
Isotopes :- Atoms of same element having same Atomic number but different Atomic mass.

Eg :-

$^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$

Isobars :- Species having same Atomic mass but different Atomic Number.

$^{40}_{18}Ar$ $^{40}_{19}K$ $^{40}_{20}Ca$



Isotones :- Species having Same no. of Neutrons

Eg. $^{14}_{6}C$ $^{15}_{7}N$

neutron ⇒ 8

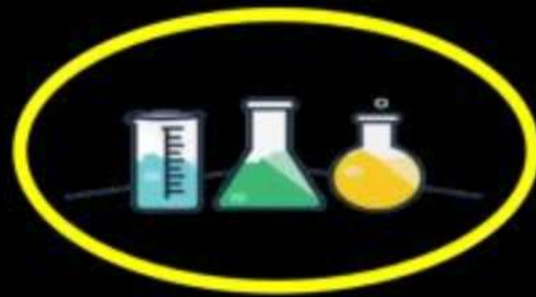
neutron = 8

Isosters :- Species having Same no. of atoms and $e^{\ominus}$s

Eg N_2 CO

⇒ 2 Atoms ⇒ 2 Atoms

⇒ 14 $e^{\ominus}$s ⇒ 14 $e^{\ominus}$



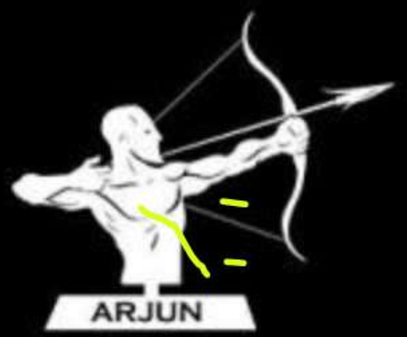
Isodiaphers :- Species having Same isotopic Excess

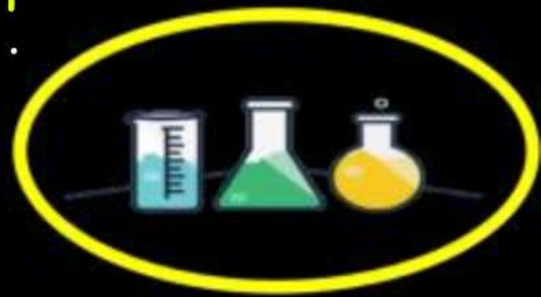
$A-2Z$ or $n-p$ → Same

A → Atomic mass
Z → Atomic no
n → neutrons
p → protons

Isoelectronic :- Species having Similar no. of $e^{\ominus}$.

Note → All Isosters are Isoelectronic but All Isoelectronic species are not Isosters.





Identification Relation:-

(1) $^{16}_{8}O$ $^{17}_{8}O$ $^{18}_{8}O$ → Isotopes

(2) $^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$ → Isotopes

(3) $^{40}_{18}Ar$ $^{40}_{19}K$ $^{40}_{20}Ca$ → Isobars

(4) $^{3}_{1}H$ $^{4}_{2}He$ → Isotones

(5) $^{14}_{6}C$ $^{15}_{7}N$ $^{16}_{8}O$ →

(6) N_2 CO → Isosters

(7) N_2O CO → ✗

O = 22 ✓

3) Borazene, Benzene → Isosters, Isoelectronic

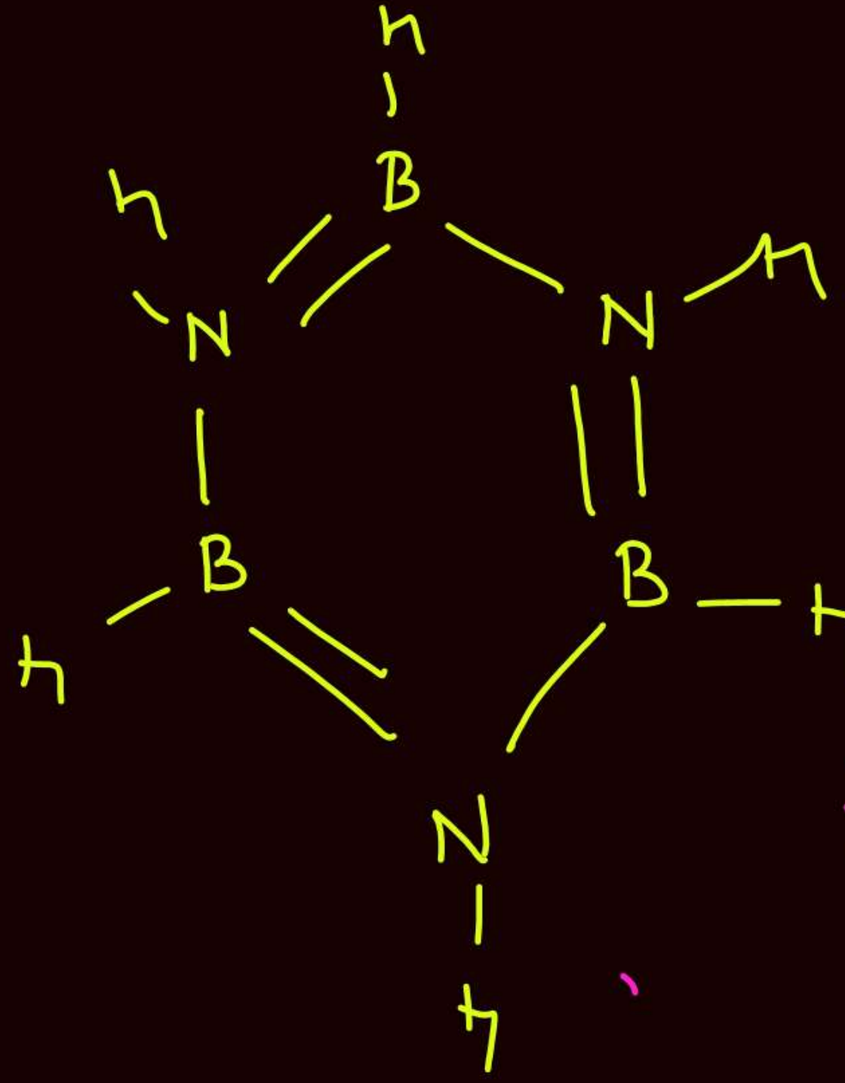
$(B_3N_3H_6)$ (Inorganic benzene) (C_6H_6)

9) $^{238}_{92}U$ $^{234}_{90}Th$ → Isodiaphers

Isoelectronic (10) Na^{+} Mg^{+2}

Na^{+} → 10e⁻ Mg^{+2} → 10e⁻

$B_3N_3H_6$



(9) $^{238}_{92}U$ $\quad$ $^{234}_{90}Th$

no. of neutrons $\Rightarrow A-Z$

$U \Rightarrow 238 - 92 = 146$

$Th \Rightarrow 234 - 90 = 144$

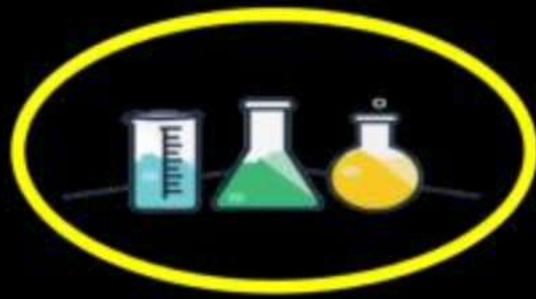
$\rightarrow n-p \Rightarrow 146 - 92 = 54$

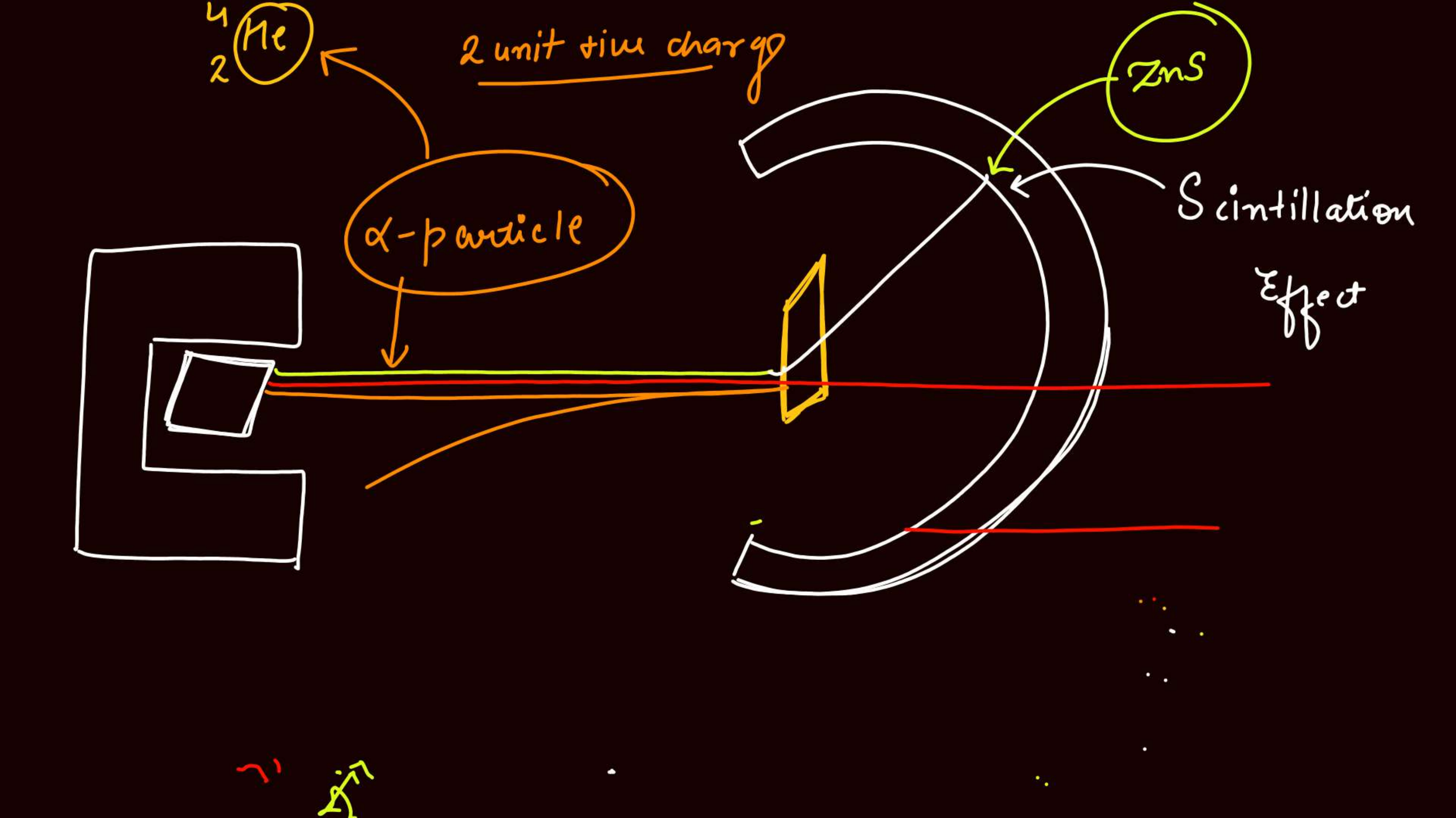
$\Rightarrow 144 - 90 = 54$

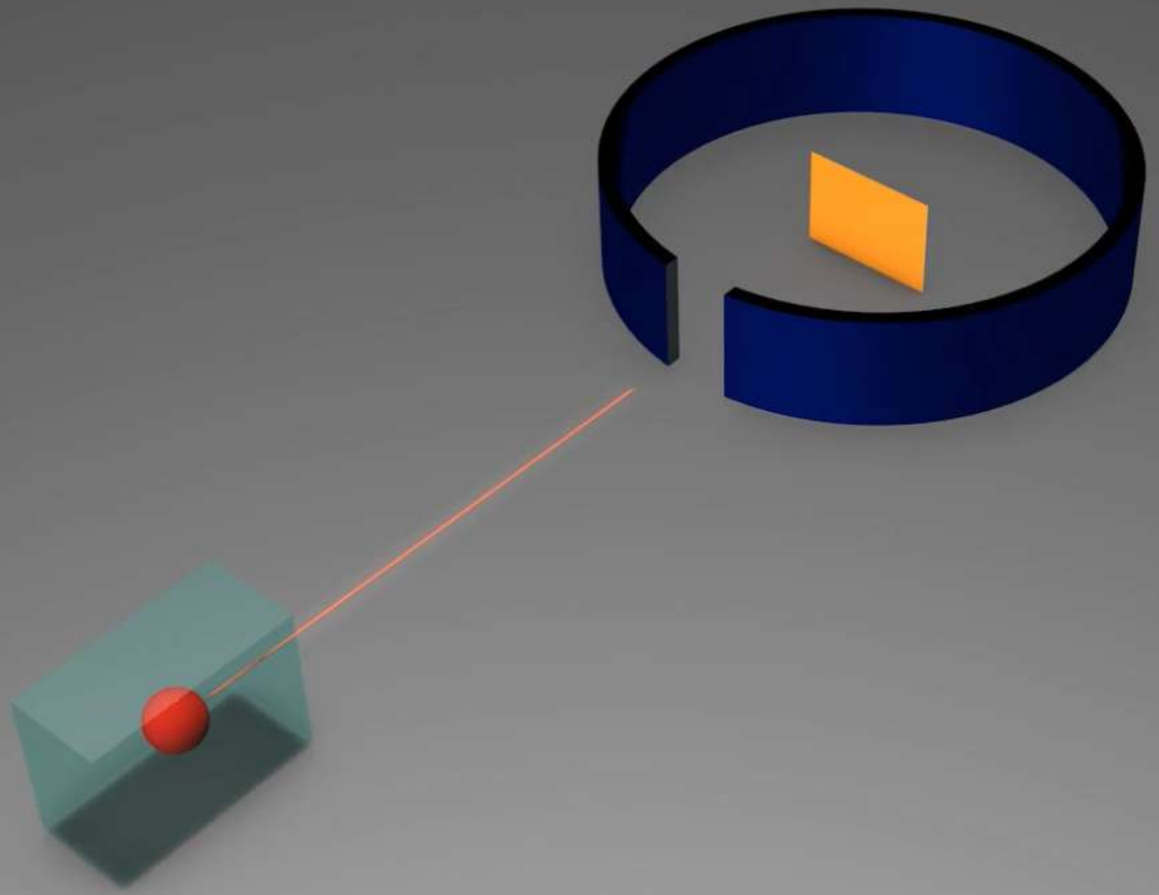
RUTHERFORD'S NUCLEAR MODEL OF ATOM

α-scattering Experiment : Rutherford allowed a narrow beam of α-particles to fall on .... Very thin gold foil. This foil had circular fluorescent zinc sulphide screen around it. The α-particles emits ..... by radioactive substance are dipositive helium ions (He^{++}) having a mass of 4 units and 2 units of positive charge.

A tiny flash of light was produced at the point where α-particles stuck.

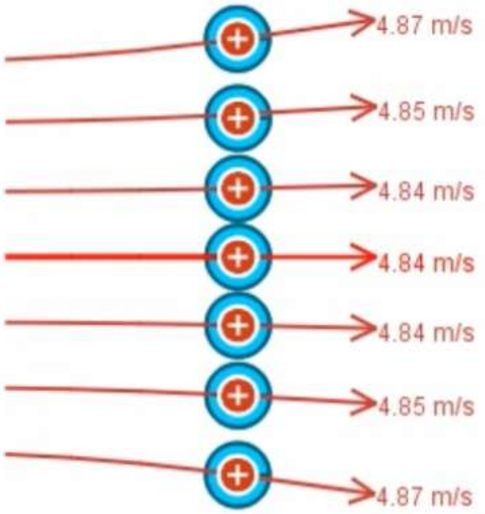



^4_2He
2 unit +ive charge
ZnS
α-particle
Scintillation
Effect



The observation and conclusions made from the experiment by Rutherford are as following :

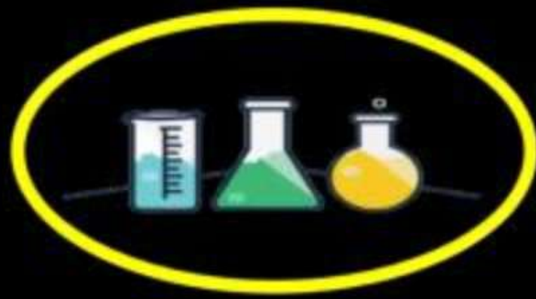
	Observation	Conclusion
	Most of the α- particles passed through the foil without any deflection.	Presence of large empty space in the atom.
	Few α- particles were deflected by small angles.	Positive charge is concentrated at a very small region and not uniformly distributed in whole atom. (If not then large number of α- particles would have been deflected by experiencing the enormous repulsive force from positive charge of the atom.)
	Very few α- particles (1 out of 20,000 particles) rebounded completely i.e., deflected at ~ 180°.	Positively charged core is known as nucleus.



Fixed Nucleus

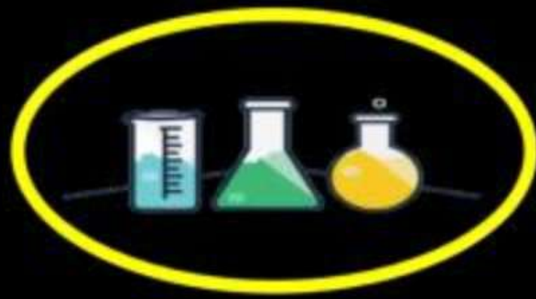
RUTHERFORD'S MODEL:-

- α-scattering Experiment :
- Discovery of Nucleus



Main features RUTHERFORD'S MODEL:-

- **Nucleus :** In an atom, the mass and positive charge is centrally located in extremely small region called nucleus.
- ⇒ The volume of nucleus is negligible as compared to the total volume of the atom. As the radius of atom is about 10^{-10} m and the radius of nucleus is 10^{-15} m.
- Both protons and neutrons present in the nucleus are collectively called nucleons.



- **Extra-nuclear part:** The nucleus is surrounded by revolving electrons.
- Rutherford's model of atom resembles the solar system in which the nucleus plays the role the electrons of revolving planets.

Density of nucleus = 2.3×10^{17} kg/m^3

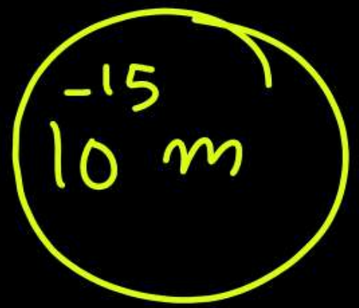
Range

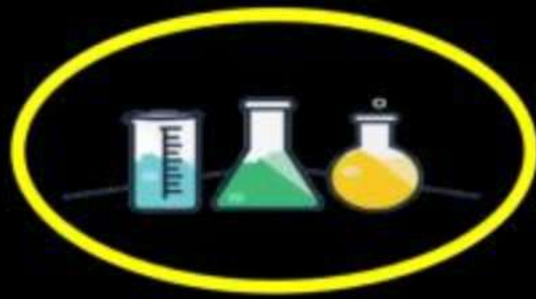
⇒ Approx. size of Nucleus = 1.5×10^{-13} cm -------- 6.5×10^{-13} cm

= 1.5 fermi ------- 6.5 fermi

Approx. size (radius) of Nucleus = 10^{-13} cm = 10^{-15} m

Approx. size (radius) of atom = 10^{-8} cm = 10^{-10} m





Radius of nucleus = 10^{-5} Radius of atom

Fraction size of total atom = Volume of nucleus /Volume of atom

$$= \frac{\frac{4}{3}\pi r^3}{\frac{4}{3}\pi r^3} = \frac{(10^{-13})^3}{(10^{-8})^3} = 10^{-15}\ m^3$$

$\Rightarrow$

Reason for revolution of $e^{\ominus}$ around timely charged nucleus is for balancing of centripetal force and electrostatic force.

$\frac{mv^2}{r} = \frac{Kq_1q_2}{r^2}$ elect. Force/ centripetal force balance centri figal force.

Other Types of Rays:-

1. **X-Rays:** → X-rays are high Energy Electromagnetic Radiations which are not deflected by the Electric and Magnetic fields.

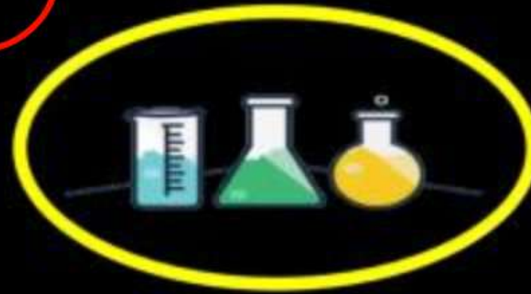
2. **Radioactivity**

(i) **Alpha (α) rays :** → α-rays Consists of α-particles carrying two units of positive charge and four units atomic mass $\left({}^{4}_{2}He\right)$

(ii) **Beta (β) rays :** → Consists of -ive charge particles similar to $e^{\ominus}$s

(iii) **Gamma (γ) rays :**

↳ These rays do not consists of particles. These are neutral Electromagnetic Radiation



Penetration

Power →

thanks
for watching