CLASS 9 SCIENCE

CHAPTER 8: JOURNEY INSIDE THE ATOM

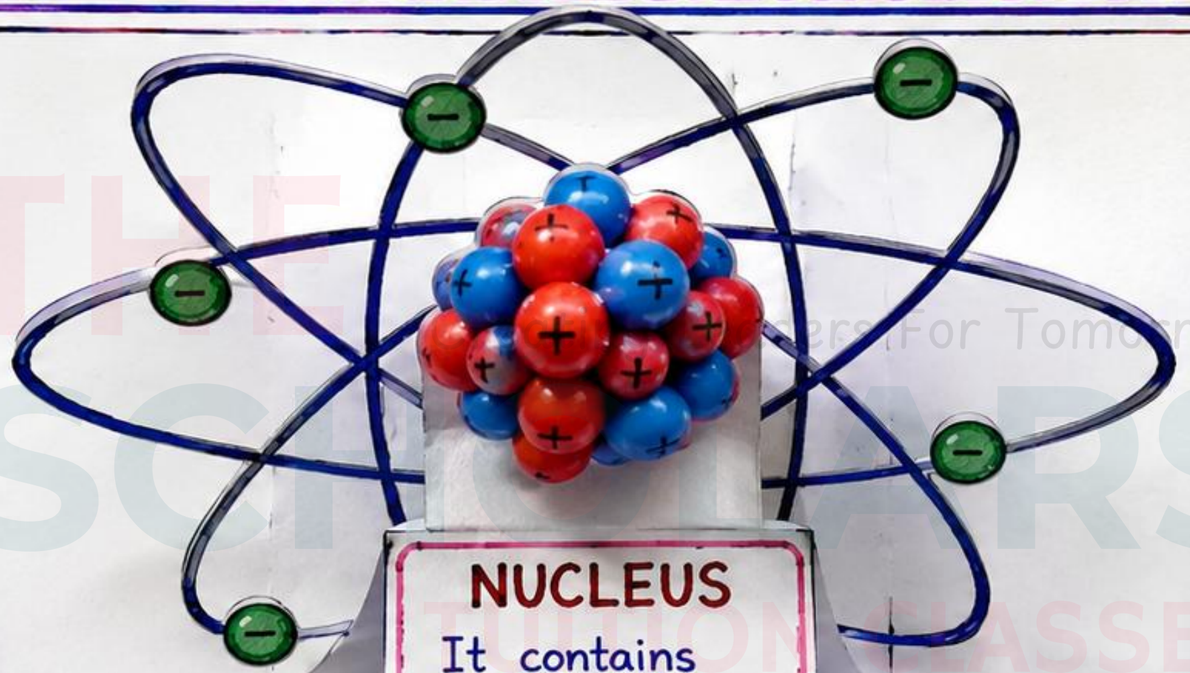
SINCE 1971 ROSEMARY CAREER ACADEMY

ATOMS

Atoms are the building blocks of matter.

PROTONS

Protons are positively charged particles present in the nucleus.



NUCLEUS

It contains protons (+) and neutrons (n)

NEUTRONS

Neutrons are neutral particles present in the nucleus.

ELECTRONS

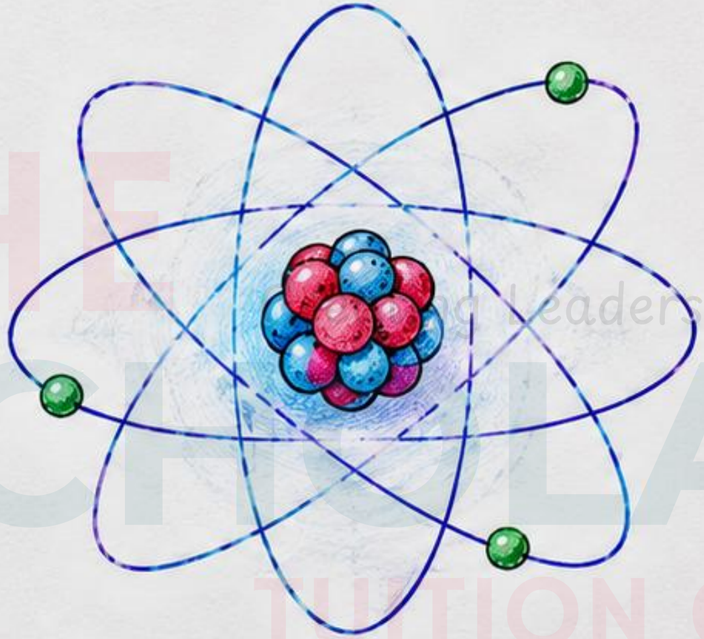
Electrons are negatively charged particles that revolve around the nucleus in fixed paths (shells).

The atom has a tiny, dense nucleus at the center.
Electrons revolve around the nucleus in fixed paths.

1. Introduction to Atom

SINCE 1971
ROSEMARY CAREER ACADEMY

- Everything around us is made of matter.
- Matter consists of tiny particles called atoms.
- Atoms are the basic building blocks of matter.



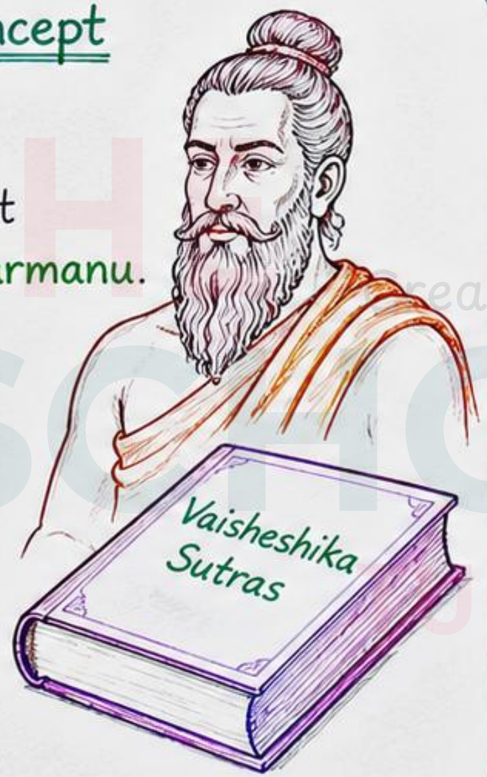
Scientists wanted to know:

- Are atoms divisible?
- What is inside an atom?
- How are particles arranged inside an atom?

2. Development of Atomic Theory

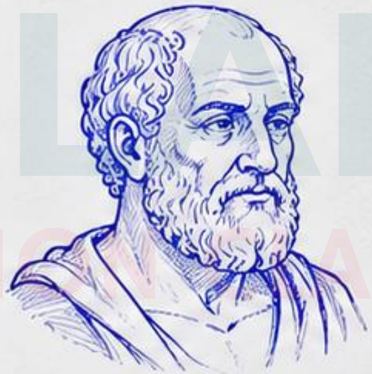
Ancient Indian Concept

- ★ Acharya Kanada
- ★ Proposed the idea of smallest indivisible particles called Parmanu.
- ★ Parmanus combine to form larger particles.
- ★ Ideas recorded in Vaisheshika Sutras.



Greek Philosophers

- ★ Leucippus and Democritus
- ★ Called smallest particles Atomos.
- ★ Meaning of atomos = indivisible.



Leucippus

Democritus

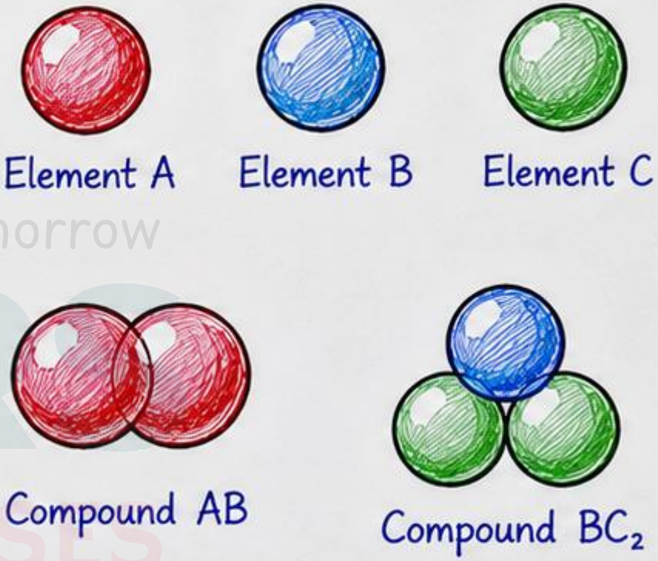
Limitation

- ★ These ideas were philosophical and not based on experiments.

3. Dalton's Atomic Theory (1808)

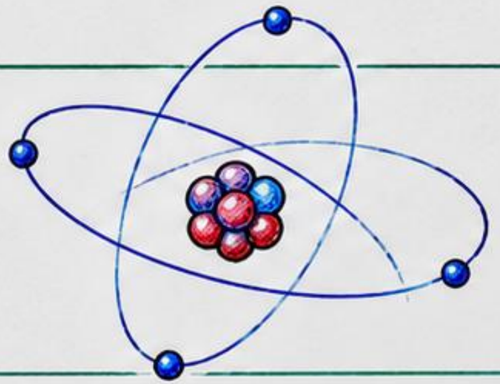
John Dalton proposed:

- ★ Matter is made of atoms.
- ★ Atoms are indivisible.
- ★ Atoms of same element are identical.
- ★ Atoms of different elements are different.
- ★ Atoms combine to form compounds.



Importance

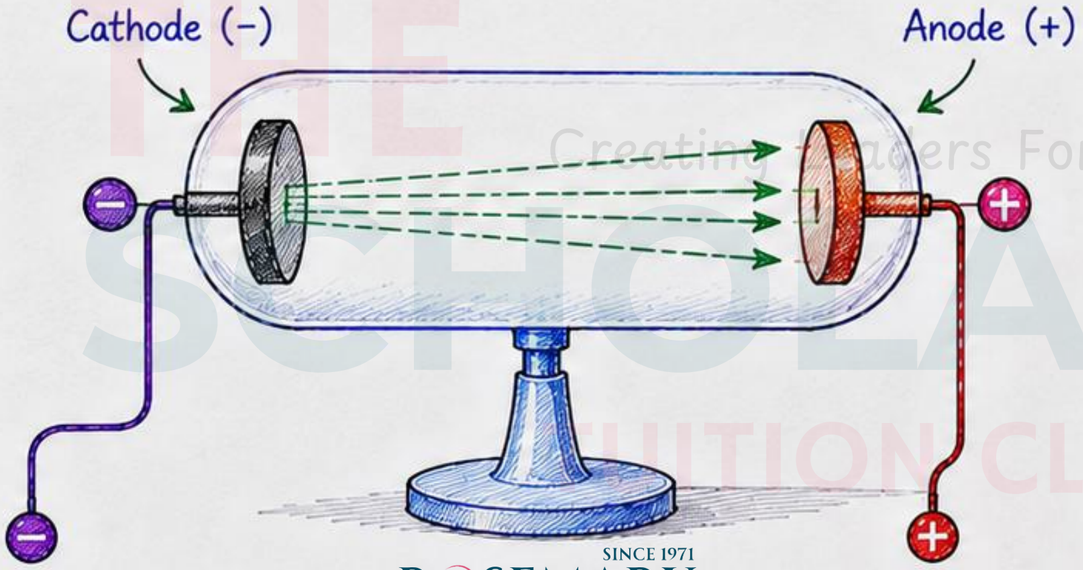
- ★ First scientific atomic theory.
- ★ Foundation of modern atomic structure.



4. Discovery of Electron

J.J. Thomson (1897)

Cathode Ray Experiment



Observations:

- ★ Cathode rays travel from cathode to anode.
- ★ Rays are negatively charged particles.

Conclusion:

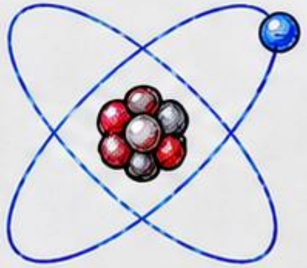
- ★ Atoms contain tiny negatively charged particles called electrons.

Charge on Electron

- Relative charge = −1
- Actual charge = -1.602×10^{-19} C

Importance

- ★ Electron became the first discovered subatomic particle.

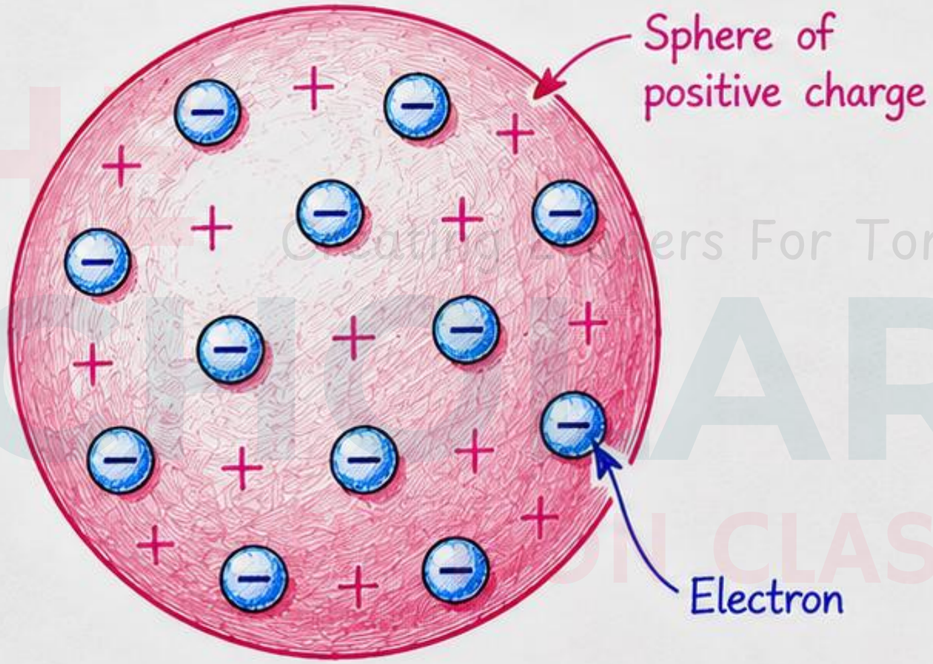


5. Thomson's Atomic Model

Plum Pudding Model

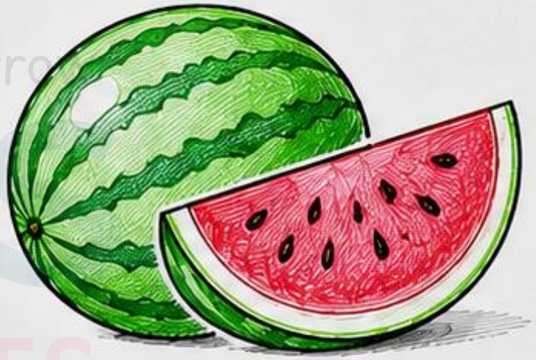
Main Points

- ★ Atom is a sphere of positive charge.
- ★ Electrons are embedded throughout the sphere.
- ★ Total positive charge = Total negative charge.
- ★ Atom remains electrically neutral.



Example

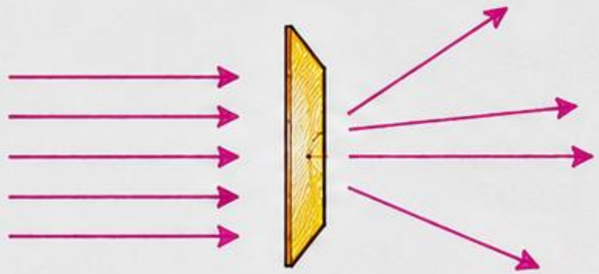
Watermelon Model:



- Red pulp → Positive charge
- Seeds → Electrons

Limitation

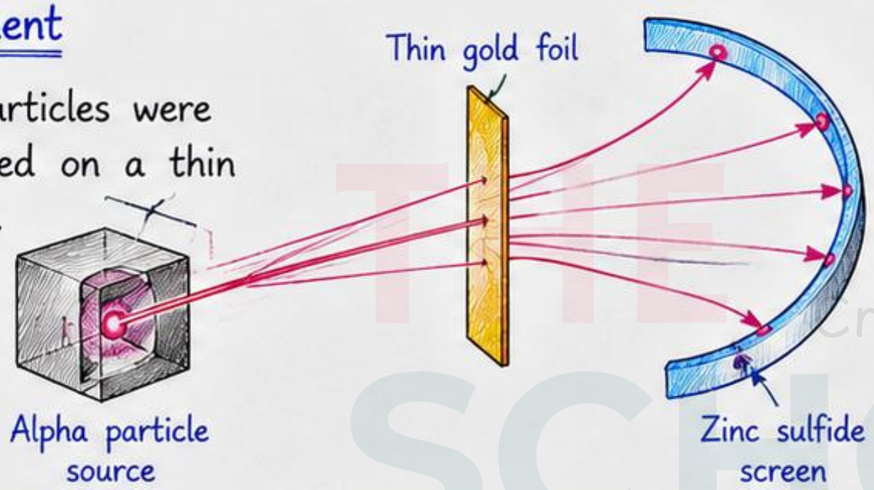
- ★ Could not explain Rutherford's Gold Foil Experiment.



6. Rutherford's Gold Foil Experiment

Experiment

★ Alpha particles were bombarded on a thin gold foil.



Conclusions

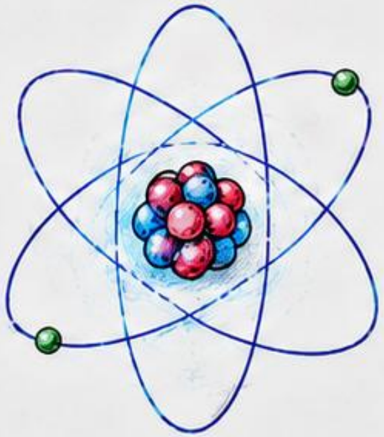
★ Most of atom is empty space.

★ Positive charge concentrated at centre.

★ Centre called nucleus.

★ Nucleus contains most mass of atom.

★ Electrons revolve around nucleus.

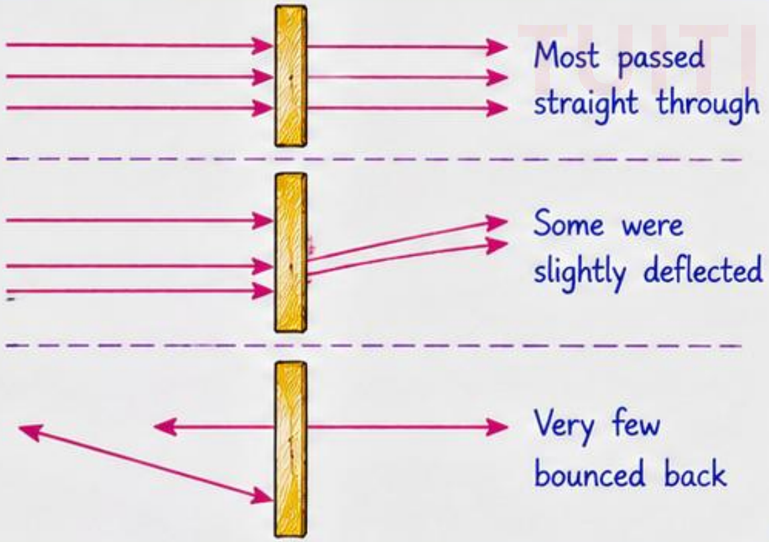


Observations

★ Most α-particles passed straight through.

★ Some were slightly deflected.

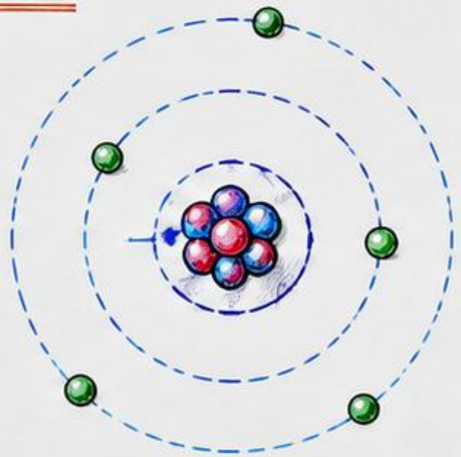
★ Very few bounced back.



Rutherford's Planetary Model

★ Nucleus at centre.

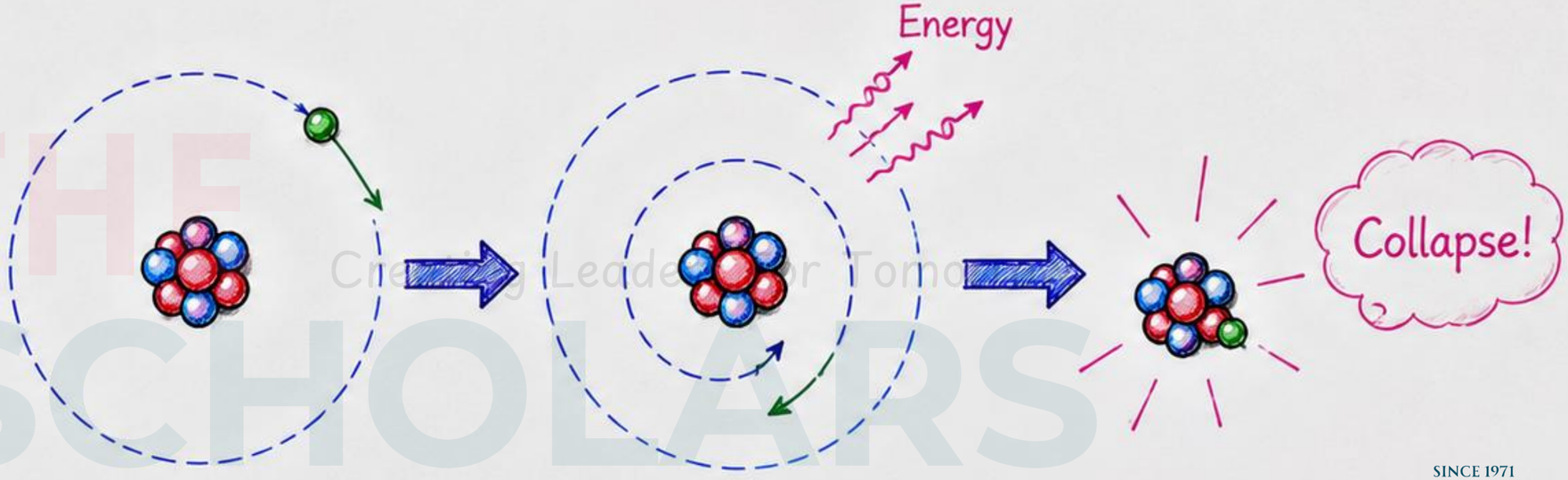
★ Electrons revolve around nucleus like planets around Sun.



7. Limitations of Rutherford Model

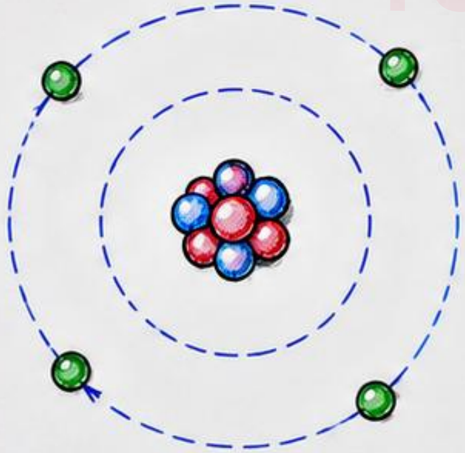
According to physics:

- Moving electrons should lose energy.
- They should spiral into nucleus.
- Atom should collapse.



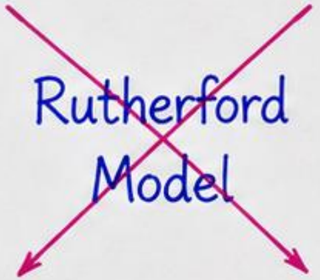
Problem

- Atoms are stable.



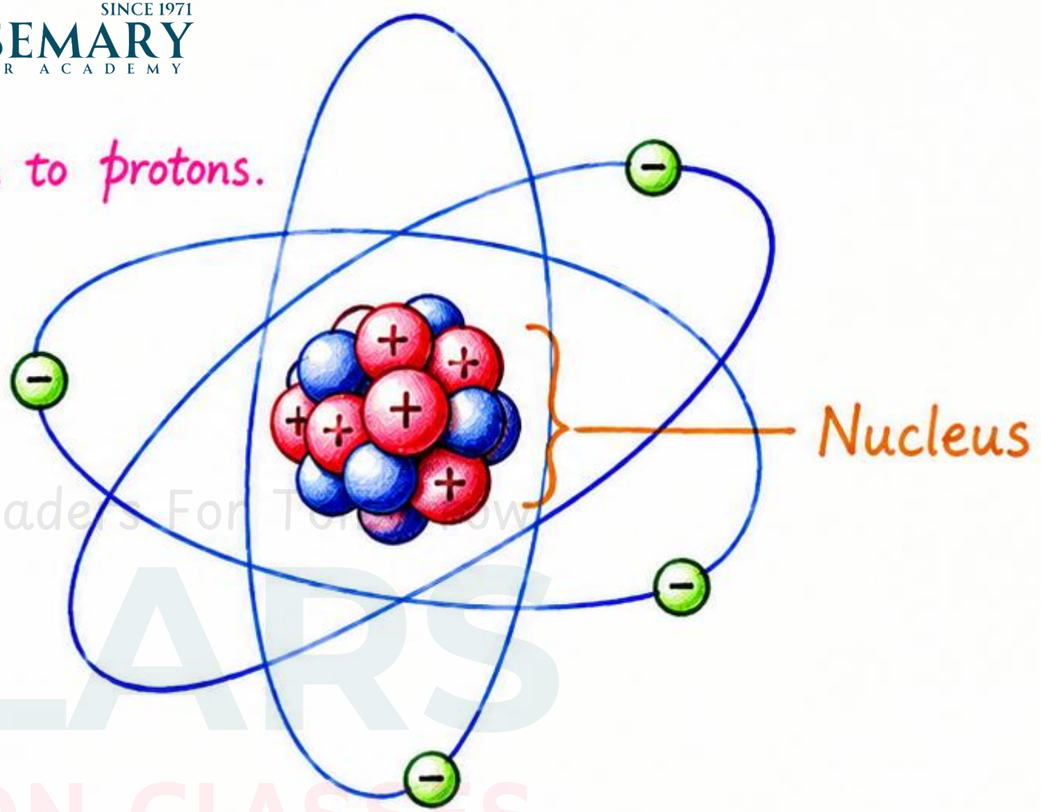
Therefore

- Rutherford model could not explain atomic stability.



8. Discovery of Proton

Rutherford → Positive charge of nucleus is due to protons.



Proton

Property	Value
Symbol	p^+
Charge	+1
Location	Nucleus

Neutral Atom

Number of Protons = Number of Electrons

→ Therefore atoms are electrically neutral.

Example:

- Helium = 2p + 2e
- Sodium = 11p + 11e

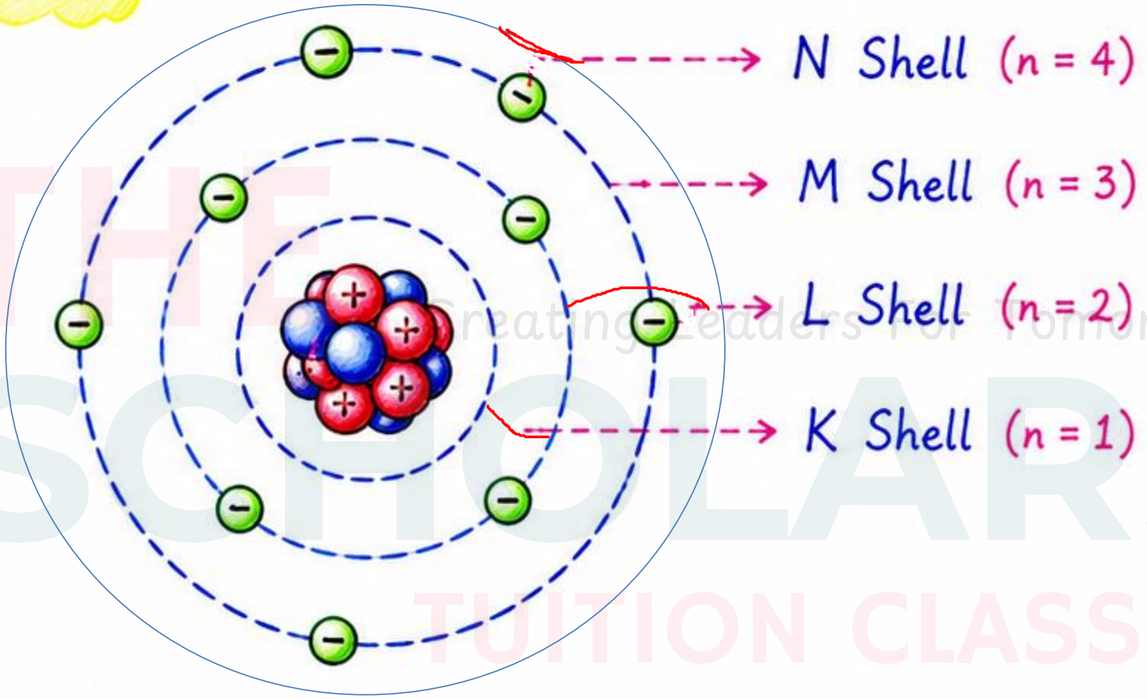
9. Bohr's Atomic Model (1913)

Niels Bohr's Postulates

Fixed Energy Levels

Electrons revolve in fixed paths called:

- ☆ Shells
- ☆ Orbits
- ☆ Energy Levels



Shell Names

Shell	n Value
K	1
L	2
M	3
N	4

Important Points

- ☑ Electrons do not lose energy in these shells.
- ☑ Energy increases away from nucleus.
- ☑ Electrons jump between shells by absorbing or releasing energy.

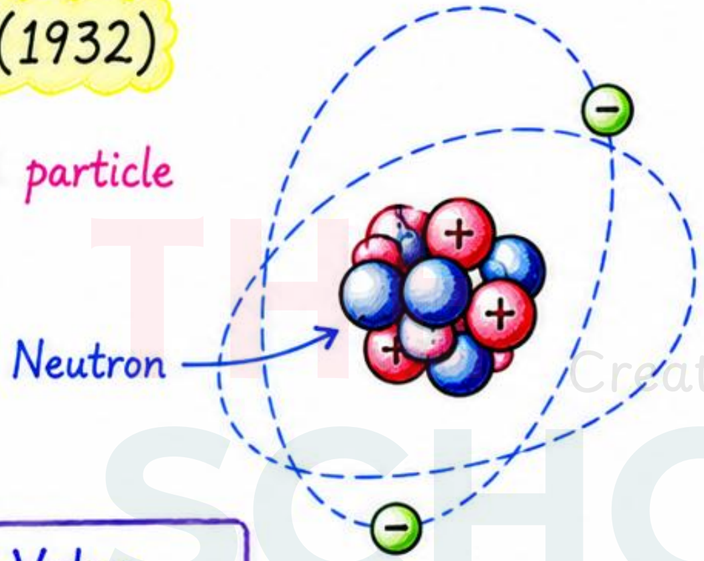
Achievement

→ Successfully explained stability of atom.

10. Discovery of Neutron

James Chadwick (1932)

→ Discovered a neutral particle called neutron.



Neutron

Property	Value
Symbol	n^0
Charge	0
Location	Nucleus

Importance

→ Explained extra mass of atoms.

11. Subatomic Particles

Particle	Symbol	Charge	Location
Electron	e^-	-1	Outside nucleus
Proton	p^+	+1	Nucleus
Neutron	n^0	0	Nucleus

12. Atomic Number (Z)

Definition → Number of protons in nucleus.

Formula

$$Z = \text{Number of Protons}$$

Important Facts

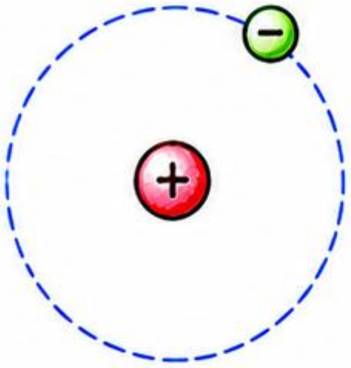
- ☆ Identifies element.
- ☆ In neutral atom:

$$\text{Number of Protons} = \text{Number of Electrons}$$

Example:

Hydrogen:

- ☑ Proton = 1
- ☑ Electron = 1
- ☑ Atomic Number = 1



13. Mass Number (A)

Definition → Total number of protons and neutrons.

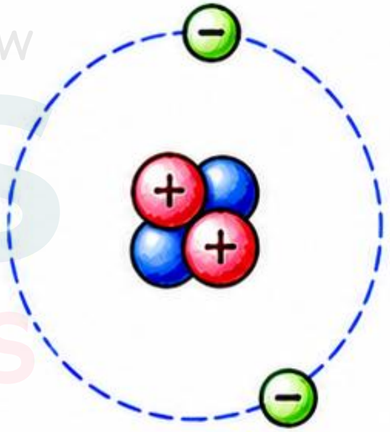
Formula

$$A = \text{Protons} + \text{Neutrons}$$

Example

Helium:

- ☑ Protons = 2
- ☑ Neutrons = 2
- ☑ Mass Number = 4



Relationship

$$\text{Neutrons} = A - Z$$

14. Electronic Configuration

Bohr-Bury Rules

Rule 1

Maximum electrons in shell

$$2n^2$$

Rule 2

Outermost shell can have maximum 8 electrons.

Rule 3

Filling order:

$$K \rightarrow L \rightarrow M \rightarrow N$$

Capacity of Shells

Shell	Maximum Electrons
K	2
L	8
M	18
N	32

15. Electronic Configurations (Most Important)

Element	Atomic No.	Electronic Configuration	Element	Atomic No.	Electronic Configuration
H	1	1	Na	11	2,8,1
He	2	2	Mg	12	2,8,2
Li	3	2,1	Al	13	2,8,3
Be	4	2,2	Si	14	2,8,4
B	5	2,3	P	15	2,8,5
C	6	2,4	S	16	2,8,6
N	7	2,5	Cl	17	2,8,7
O	8	2,6	Ar	18	2,8,8
F	9	2,7			
Ne	10	2,8			

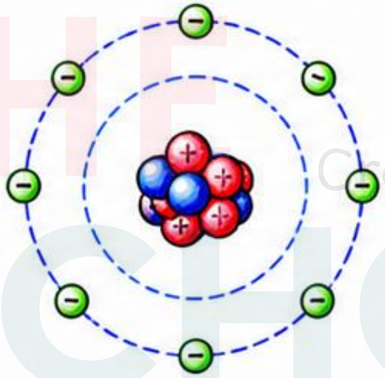
16. Valency

SINCE 1971
ROSEMARY
CAREER ACADEMY

Definition → Combining capacity of an atom.

Valence Electrons

→ Electrons present in outermost shell.



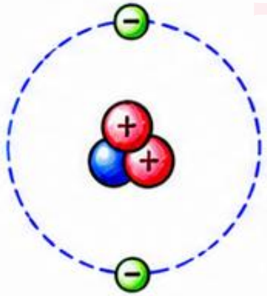
Octet
(8 electrons)

Octet Rule

Stable atoms generally have:

☆ 8 electrons in outermost shell

☆ Helium has stable duet
(2 electrons)



Helium
Duet
(2 electrons)

Shortcut

Valence Electrons	Valency
1	1
2	2
3	3
4	4
5	3
6	2
7	1
8	0

17. Isotopes

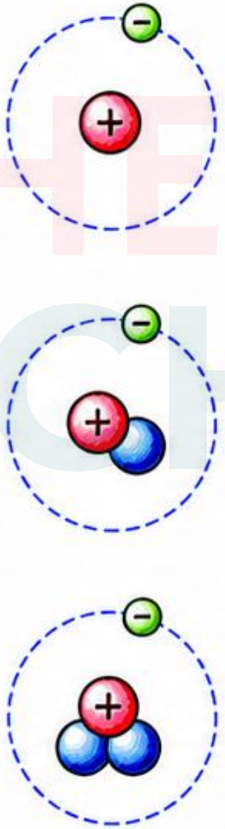
SINCE 1971 ROSEMARY CAREER ACADEMY

Definition → Atoms of same element having:

- ☆ Same atomic number
- ☆ Different mass numbers

Example Hydrogen Isotopes

Isotope	Symbol
Protium	$^{1}_{1}H$
Deuterium	$^{2}_{1}H$
Tritium	$^{3}_{1}H$



Characteristics

- ☆ Same chemical properties
- ☆ Different physical properties

Uses

- → U-235 → Nuclear fuel
- → Co-60 → Cancer treatment
- → I-131 → Thyroid treatment
- → C-14 → Carbon dating

18. Isobars

Definition → Atoms of different elements having:

- ☆ Same mass number
- ☆ Different atomic numbers

Example

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

Same mass number (40)
Different atomic numbers (18, 19, 20)

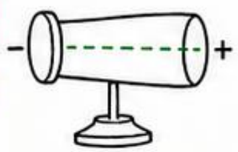
JOURNEY INSIDE THE ATOM

ATOMIC THEORY

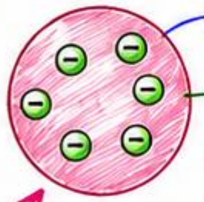
- Acharya Kanada (Parmanu) → Smallest indivisible particles
- Democritus & Leucippus → "Atomos" = Indivisible
- John Dalton (1808 Theory) → Matter made of atoms → First scientific atomic theory

DISCOVERY OF ELECTRON

J.J. Thomson → Cathode Ray Experiment → Discovery of Electron (e^-) → Charge = Negative (-1)



THOMSON'S ATOMIC MODEL (Plum Pudding Model)



- Positive sphere throughout atom
- Electrons embedded inside atom

→ Atom Neutral → Limitation → Could not explain Gold Foil Experiment

RUTHERFORD GOLD FOIL EXPERIMENT

α-particles + Gold Foil

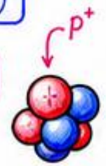
- Most passed straight
- Few deflected
- Very few bounced back

→ Conclusions

- Most atom empty space
- Positive charge at centre
- Dense nucleus at centre → Planetary Model

DISCOVERY OF PROTON (Rutherford)

Proton (p^+) → Positive charge (+1) → Present in nucleus

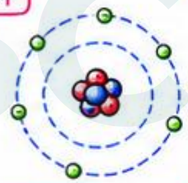


BOHR'S ATOMIC MODEL

Electrons move in fixed shells

K	L	M	N
n=1	n=2	n=3	n=4

- → Fixed energy levels
- → No energy loss in orbit
- → Explains stability of atom



DISCOVERY OF NEUTRON

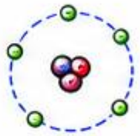
James Chadwick (1932) → Neutron (n^0) → Charge = 0 → Present in nucleus

SUBATOMIC PARTICLES

Electron (e^-)	Proton (p^+)	Neutron (n^0)
Charge = -1	Charge = +1	Charge = 0
Outside nucleus	Nucleus	Nucleus

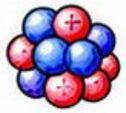
ATOMIC NUMBER (Z)

Number of Protons → Z = Number of Protons → In neutral atom: Number of Electrons = Number of Protons



MASS NUMBER (A)

Total Nucleons in Nucleus → A = Protons + Neutrons → Neutrons = A − Z

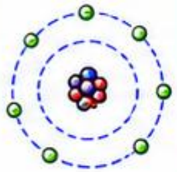


ELECTRONIC CONFIGURATION

Bohr-Bury Rules → Maximum Electrons = $2n^2$

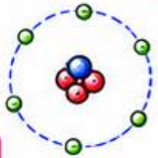
K	L	M	N
2	8	18	32

→ Filling Order → K → L → M → N



VALENCY

Combining Capacity → Valence Electrons → Octet Rule ($8e^-$) → Gain / Lose / Share electrons → To become stable



ISOTOPES

Same Atomic Number (Z) → Different Mass Number (A)

Example:

- ^1H (Protium)
- ^2H (Deuterium)
- ^3H (Tritium)

→ Same chemical properties / Different physical properties

Uses:

- U-235 → Nuclear fuel
- Co-60 → Cancer treatment
- I-131 → Thyroid treatment
- C-14 → Carbon dating

ISOBARS

Same Mass Number (A) → Different Atomic Number (Z)

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

EVOLUTION OF ATOMIC MODELS

Dalton → Thomson → Rutherford → Bohr → Modern Quantum Mechanical Model

CHAPTER FORMULAS

- ☆ Atomic Number (Z) = Number of Protons
- ☆ Mass Number (A) = Protons + Neutrons
- ☆ Neutrons = A − Z
- ☆ Maximum Electrons in Shell = $2n^2$
- ☆ For Neutral Atom: Electrons = Protons
- ☆ Valency = Electrons Lost / Gained / Shared