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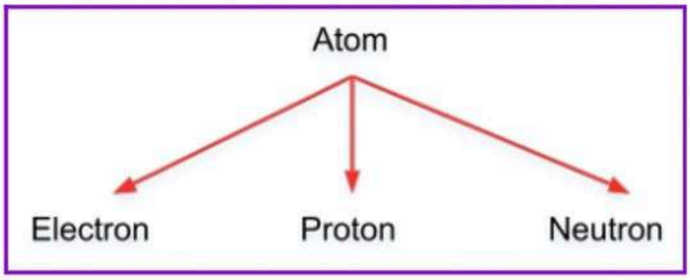
Structure of Atom

Atoms and molecules are the fundamental building block of matter.



Discovery of electrons (Cathode ray - JJ Thomson)

J. J. Thomson, in 1897, discovered negatively charged particles emitted by the cathode towards the anode in a cathode ray experiment. These are negatively charged.

Charge on electron = -1.6×10^{-19} Coulomb
Mass of electron = 9.1×10^{-31} kg

Discovery of Protons (Anode rays - E. Goldstein)

Ernest Goldstein, in 1886, discovered that with a different condition in the same chamber, anode emitted positively charged particles known as Canal rays or later named as Protons.

Charge on electron = 1.6×10^{-19} Coulomb
Mass of electron = 1.6726×10^{-27} kg.

Discovery of Neutrons (J. Chadwick)

J. Chadwick bombarded lighter elements like lithium, boron, etc. with alpha particles and observed emission of new particles having zero charge but having mass equal to that of proton.
These particles are called 'Neutron' i.e. neutral particle of the atom.

Neutrons are absent in Protium isotope of hydrogen Atom.

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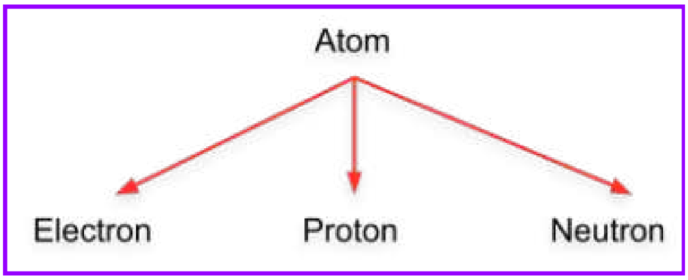
Structure of Atom

Atoms are the building blocks of matter and the smallest unit of matter.



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"Rubbing two objects together creates electrical charge."

Drawback of Dalton's Theory: *it stated atoms were indivisible, but discovery of electrons and protons inside atoms disproved this, highlighting a limitation.*

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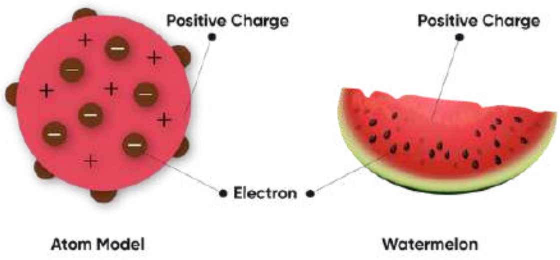
Thomson Model of an atom : Thomson's atomic model compared atoms to a Christmas pudding or watermelon.

In Thomson's model:

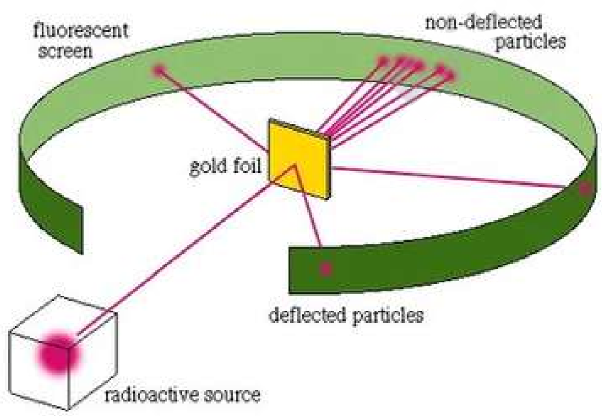


- Atoms consist of a positively charged sphere, like the red edible part of the watermelon
- Electrons are embedded within this sphere, similar to currants in a pudding or seeds in a watermelon.
- Negative and positive charges are equal, making the atom electrically neutral.
- Despite explaining electrical neutrality, Thomson's model couldn't account for some experimental results.

Rutherford's atomic model In his famous "Alpha ray scattering Experiment", Rutherford bombarded alpha rays upon thin gold foil.

Observations:

- He selected a gold foil because he wanted as thin a layer as possible. This gold foil was about 1000 atoms thick.
- Alpha (α)-particles are helium ions with a double charge and a mass of 4 u, giving them significant energy. Initially, it was anticipated that these particles would be deflected by sub-atomic particles within gold atoms. However, due to their greater mass compared to protons, large deflections were not expected.



Conclusions:

- Most of the space inside is empty because alpha particles passed through the gold foil.
- Very few particles deflected indicating positive charge occupies very little space in an atom.
- As a very small fraction of particles were reflected by an angle of 180 degrees, it indicates positive charges were concentrated in small volume within the atoms.

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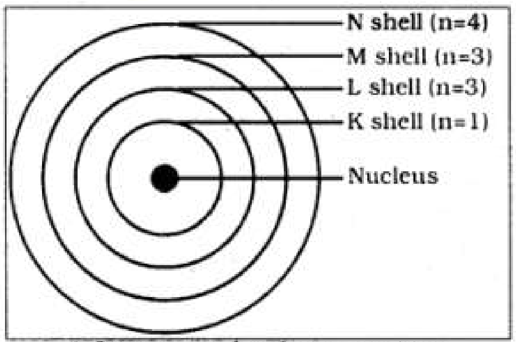
Rutherford's nuclear model of an atom

- There is a positively charged center in an atom called the nucleus and the nucleus resides almost all the mass of an atom.
- Electrons revolve around the nucleus in well-defined orbits.
- The size of the nucleus is very small compared to that of atoms.

Drawbacks of the Rutherford model

Orbital Revolution will not be stable as particles in a circular orbit would undergo acceleration and during this particles may radiate energy leading to loss of energy and finally they fall into the nucleus of the atom.

Bohr's model of the atom



A few energy levels in an atom

Neutron:

- In 1932, **J. Chadwick** discovered the neutron.
- **Neutrons** have **no charge** and a **mass nearly equal to that of a proton**.
- Neutrons are present in the nucleus of all atoms **except hydrogen**.
- Represented as '**n**'.
- The mass of an atom is the sum of the masses of its protons and neutrons.

It says that:

- Only certain special orbits known as discrete orbits of electrons are allowed inside the atom.
- While revolving in discrete orbits, the electrons do not radiate energy.
- Energy is emitted or absorbed by an atom only when an electron moves from one orbit to another.

Electron distribution in different orbits:

Electrons are distributed into different orbits as suggested by Bohr & Bury.

Rules for writing the number of electrons in different energy levels:

- The maximum number of electrons present in a shell is given by the formula $2n^2$.
- Here 'n' is the orbit number or energy level.
- The maximum number of electrons that can be present in the outermost orbit is 8.

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- Electrons are not accommodated in a given shell unless the inner shells are filled with electrons.

Valency

- Total electrons present in the outermost shell of an atom are known as the valence electrons and we also know that the total number of electrons can not be more than 8.
- Valency gives the combining capacity of an atom so if the outermost shell has 8 electrons the combining capacity or valency is zero.

Combining capacity

- The tendency of an atom to react with another atom of the same or different element to form a molecule.
- It is to attend a filled outermost shell i.e., 8 electrons, and achieve a stable octet.
- The number of electrons gained, lost, or shared from the outermost shell gives directly the combining capacity of that element.
- *When the number of electrons is less in the outermost shell, then the valency is written as 1,2,3,4.*
- *If the number of electrons is close to 8 i.e., 5,6,7,8, then the valency is determined in the opposite direction (like valency is 1 for 7 electrons and 0 for 8 electrons).*

Name of Element	Symbol	Atomic Number	Number of Protons	Number of Neutrons	Number of Electrons	Distribution of Electrons K	L	M	N	Valency
Hydrogen	H	1	1	-	1	1	-	-	-	1
Helium	He	2	2	2	2	2	-	-	-	0
Lithium	Li	3	3	4	3	2	1	-	-	1
Beryllium	Be	4	4	5	4	2	2	-	-	2
Boron	B	5	5	6	5	2	3	-	-	3
Carbon	C	6	6	6	6	2	4	-	-	4
Nitrogen	N	7	7	7	7	2	5	-	-	3
Oxygen	O	8	8	8	8	2	6	-	-	2
Fluorine	F	9	9	10	9	2	7	-	-	1
Neon	Ne	10	10	10	10	2	8	-	-	0
Sodium	Na	11	11	12	11	2	8	1	-	1
Magnesium	Mg	12	12	12	12	2	8	2	-	2
Aluminium	Al	13	13	14	13	2	8	3	-	3
Silicon	Si	14	14	14	14	2	8	4	-	4
Phosphorus	P	15	15	16	15	2	8	5	-	3,5
Sulphur	S	16	16	16	16	2	8	6	-	2
Chlorine	Cl	17	17	18	17	2	8	7	-	1
Argon	Ar	18	18	22	18	2	8	8		0

Atomic number = no. of protons = no. of electrons

Atomic number(Z)

The *number of protons* in an atom is called the atomic number.

For Hydrogen, Z = 1

Carbon, Z = 6

Atomic mass(M)

The sum of *protons and neutrons* in an atom is called the mass number.

Applications of isotopes:

(i) An isotope of uranium is used as a fuel in nuclear reactors.

(ii) An isotope of cobalt is used in the treatment of cancer.

(iii) An isotope of iodine is used in the treatment of goitre.

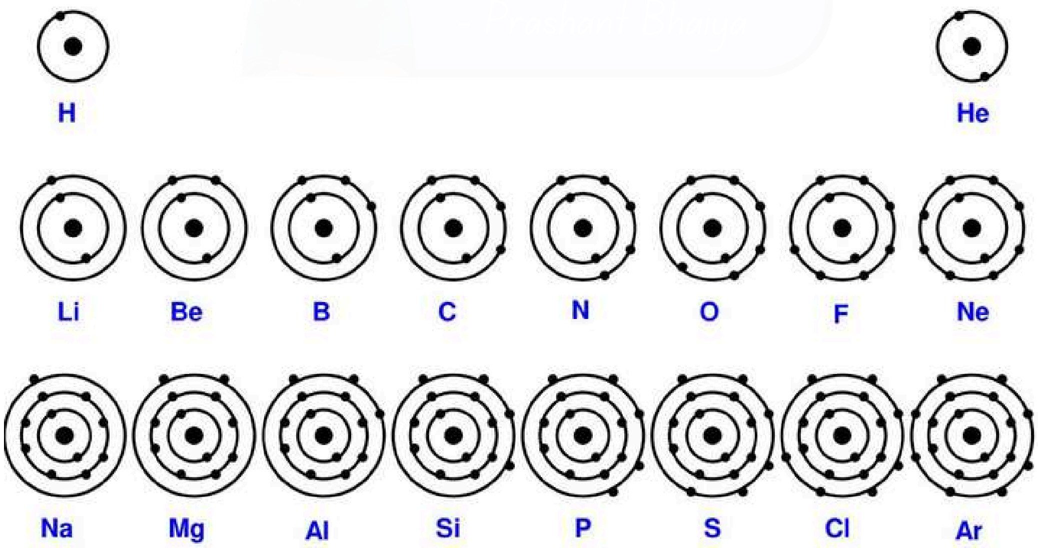
Isotopes

- Atoms of the same element with different numbers of neutrons.
- Have the same atomic number but different mass numbers.
- *Three atomic species protium, deuterium, and tritium have the same atomic number as 1 but their mass number are 1,2,3 respectively.*

Isobars

Different elements have the same atomic mass but different atomic numbers.

Like Calcium with Z = 20 and Argon with Z = 18 have the same mass number 40



Schematic atomic structure of the first eighteen elements