A series of experiments by scientists resulted in the discovery of an atom's structure.
According to ***Dalton*****, atoms are indivisible**. Later on, one of the first indications is that atoms are not indivisible since there are smaller particles inside an atom.
According to ***Thomson***, atoms are indivisible, but they **contain at least one subatomic particle**, the **electron**.
According to **E. Goldstein**, gas discharge contains new radiations known as canal rays. The rays had a **positive charge**. Canal rays helped the discovery of another subatomic particle. The charge of this subatomic particle was the exact opposite of the charge of the electron.
What are subatomic particles?
The particles that build an atom are called subatomic particles.

Charged Particles in Matter

1. Whenever we rub two objects together, they become electrically charged. This is because atoms contain charged particles in them. Therefore, atoms can be divided further into particles i.e proton, electron and neutron.
   Protons were discovered by Ernest Rutherford, in his famous gold foil experiment.
   Electrons were discovered by J.J. Thomson, in his cathode ray tube experiment.
   Neutrons were discovered by James Chadwick.

Name	Location	Charge (C)	Unit Charge	Mass (amu)	Mass (g)
electron	outside nucleus	-1.602×10^{-19}	1−	0.00055	0.00091×10^{-24}
proton	nucleus	1.602×10^{-19}	1+	1.00727	1.67262×10^{-24}
neutron	nucleus	0	0	1.00866	1.67493×10^{-24}

2. Atoms consist of protons and electrons in a balanced proportion.
3. Protons exist in the interiors of the atom and electrons exist in the exteriors of the atom. Therefore, electrons can be removed from an atom.

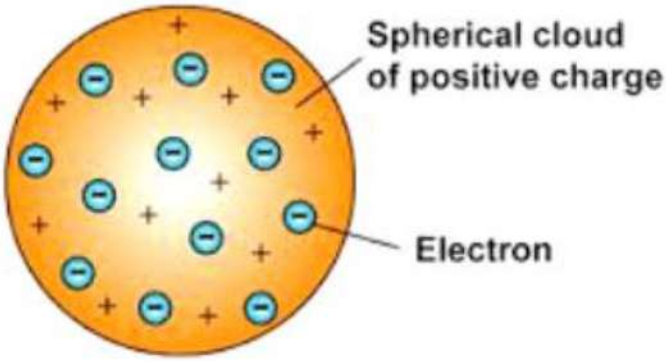
Failure of Dalton's Atomic Theory

The postulates of the atomic theory by John Dalton
1. The matter is made up of tiny particles called **Atoms** that cannot be divided.
2. Atoms are never formed or destroyed during a chemical reaction.
3. Atoms of an element exhibit same nature. They have the same size, mass, and character.
4. Atoms of different elements exhibit variant nature. They do not have same characteristics.
5. Atoms form compounds by combining in a ratio of whole numbers.
6. A compound contains a constant number and kinds of atoms

Dalton suggested that atoms can neither be created nor destroyed and are indivisible. But the discovery of electrons and protons in atoms ***lead to failure of this aspect of Dalton's theory.***

Thomson's Model of an Atom

1. According to J.J. Thomson, the structure of an atom can be compared to Christmas pudding where electrons are present inside a positive sphere.



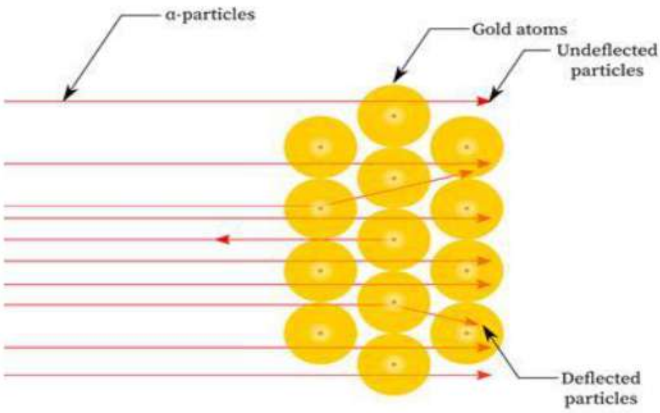
2. An atom is composed of a positively charged sphere in which electrons are embedded.
3. Atom is neutral as the positive and negative charged are equal in proportion.
4. ***The discovery of two fundamental particles (electrons and protons) inside the atom, led to the failure of this aspect of Dalton's atomic theory***.

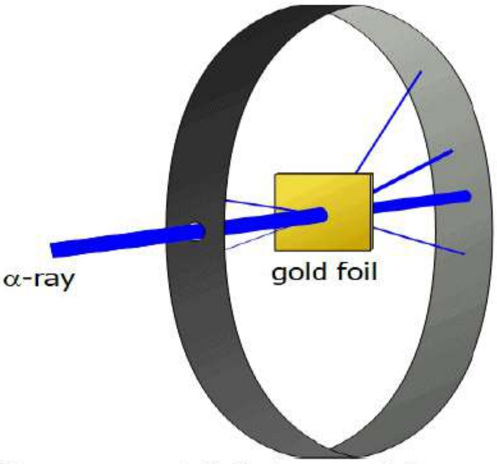
Rutherford's Model of an Atom

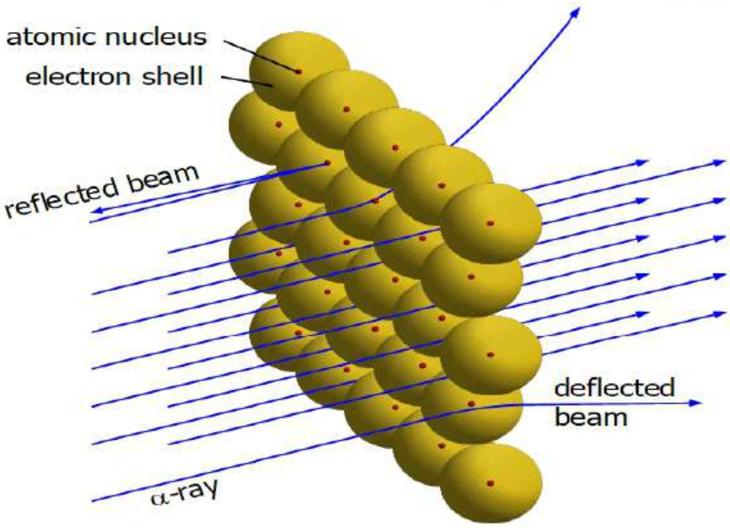
Rutherford designed an experiment to discover the structure of atom

In this experiment:

1. He selected a gold foil because he wanted as thin a layer as possible. This gold foil was about 1000 atoms thick.
2. α- particles are doubly – charged helium ions. Since they have a mass of 4 u, the fast – moving α–particles have a considerable amount of energy.







3. It was expected that α- particles would be deflected by the sub – atomic particles in the gold atoms. Since the α – particles were much heavier than the protons, he did not expect to see large deflections.

α – particle scattering experiment unexpected results

1. Most of the fast moving a particles passed straight through the gold foil.
2. Some of the α – particles were deflected by the foil by small angles.
3. Surprisingly one out of every 12000 particles appeared to rebound.

In the words of Rutherford, "This result was almost as incredible as if you fire a 15 – inch shell at a piece of tissue paper and it comes back and hits you".

Rutherford concluded from the α – particle scattering experiment that

1. Most of the space inside the atom is empty because most of the α – particles passed through the gold foil without getting deflected.
2. Very few particles were deflected from their path, indicating that the positive charge of the atom occupies very little space.
3. A very small fraction of α-particles were deflected by 180º, indicating that all the positive charge and mass of the gold atom were concentrated in a very small volume within the atom.

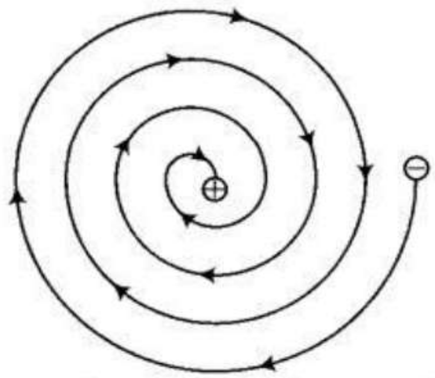
From the data he also calculated that the radius of the nucleus is about 10^5 times less than the radius of the atom.

Rutherford experiment of nuclear model of an atom, which had the following features:

1. There is a positively charged center in an atom called the nucleus. Nearly all the mass of an atom resides in the nucleus.
2. The electrons revolve around the nucleus in circular paths.
3. The size of the nucleus is very small as compared to the size of the atom.

Drawbacks of Rutherford's model of the atom

1. The revolution of the electron in a circular orbit is not expected to be stable.
2. Any particle in a circular orbit would undergo acceleration.
3. During acceleration, charged particles would radiate energy.
4. The revolving electron would lose energy and finally fall into the nucleus.



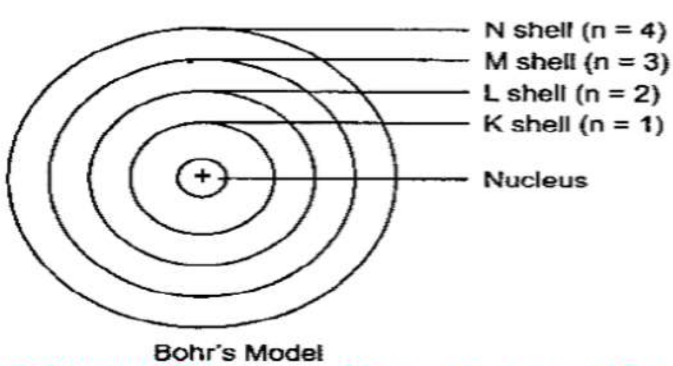
Continuous loss of energy by a revolving electron

If this were so, the atom should be highly unstable and hence matter would not exist in the form that. Atoms are quite stable.

Bohr's Model of an Atom

Neils Bohr put forward the following postulates about the model of an atom:

1. Only certain special orbits known as discrete orbits of electrons, are allowed inside the atom.
2. While revolving in discrete orbits the electrons do not radiate energy.
3. These orbits are also called as **Energy Levels**.
4. These orbits or shells are represented by the letters K, L, M, N,… or the numbers, n = 1,2,3,4, ….



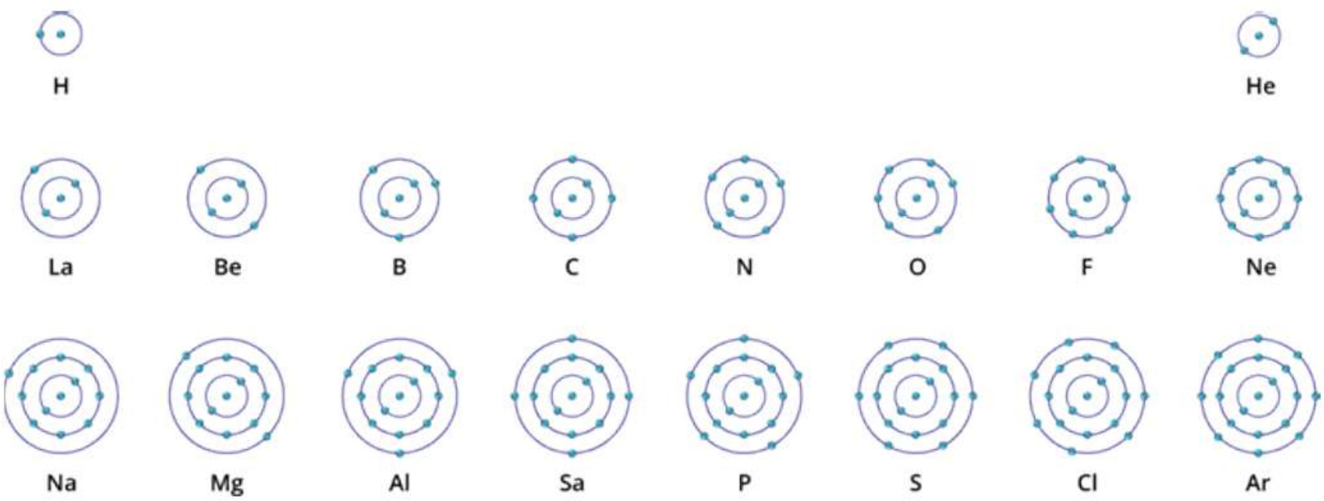
Bohr's Model

According to Bohr, the energy of the **shell is proportional to its size**. The greater the size, the greater the energy. Since the **first shell is the smallest, it has the lowest energy**, and it gets **filled first**.

Hence, the energy level or size of the shells are given by:

$$K < L < M < N$$

The atomic structure of the first eighteen elements is shown schematically.



NEUTRONS

1. In 1932, J. Chadwick discovered another sub atomic particle which had no charge and a mass nearly equal to that of a proton.
2. Neutrons are present in the nucleus of all atoms , except hydrogen.
3. A neutron is represented as 'n'.
4. The sum of the masses of protons and neutrons present in the nucleus

Therefore, we can conclude that atom consists of three types of particles -

Electrons	which carry a negative charge
Protons	which carry a positive charge
Neutrons	they are neutral

How are Electrons Distributed in Different Orbits (Shells)?

The distribution of electrons into different orbits of an atom was ***suggested by Bohr and Bury.***

Rules are followed for writing the number of electrons in different energy levels or shells:

The maximum number of electrons present in a shell is ***given by the formula $2n^2$.*** where ' n ' is the orbit.
First orbit or K – shell will be = $2 \times 1^2 = 2$.
Second orbit or L – shell will be = $2 \times 2^2 = 8$.
Third orbit or M – shell will be = $2 \times 3^2 = 18$.
Fourth orbit or N – shell will be = $2 \times 4^2 = 32$, and so on.

NOTE:

1. The maximum number of electrons that can be accommodated in the outermost orbit is 8.
2. Electrons are not accommodated in a given shell, unless the inner shells are filled.

VALENCY AND VALENCE ELECTRONS

1. **Valency or valence refers to an atom's ability to accept or donate a pair of electrons to form a chemical compound.** The valency of an element is equal to the number of valence electrons if their number is 4 or less.
2. The valency of **noble gases or inert gases is zero since there are no free electrons in the valence shell**, and the elements are already in a stable state.
   For example, Na (2, 8, 1) has 1 valence electron and therefore, valency of sodium is 1. Similarly, carbon (2, 4) shows a valency of 4

ELECTRONIC CONCEPT OF VALENCY

It is a well – known fact that noble gases like Helium (He) Neon (Ne) , Argon (Ar) , Krypton (Kr) and Xenon (Xe) are rather chemically inert . Except helium, which has 2 electrons in its valence shell, atoms of all noble gases have 8 electrons (octet) in their outermost shell or the valence shell. This shows that the octet configuration is very stable.
Octet Rule: Every system in nature tries to have the state of maximum stability. Therefore, reactive atoms (or elements) undergo chemical combination or bond formation in order to acquire octet configuration in their valence shell. This is called octet rule.

TYPES OF VALENCY

The combining atoms of the elements try to acquire the nearest inert gas stable configuration mainly in two ways:
By loss or gain (transfer) of electrons between the combining atoms (electro-valency).

ATOMIC NUMBER

1. It is the number of protons of an atom, It is denoted by Z.
2. All atoms of an element have the same atomic number, Z.
3. The atomic number is defined as the total number of protons present in the nucleus of an atom.

MASS NUMBER

"The mass number is defined as the sum of the total number of protons and neutrons present in the nucleus of an atom".

1. It is denoted by A
2. Mass of an atom is practically due to protons and neutrons alone.
3. These are present in the nucleus of an atom.
4. Protons and neutrons are also called nucleons.
5. The mass of an atom resides in its nucleus.

For example, mass of carbon is 12 u because it has 6 protons and 6 neutrons, 6 u + 6 u = 12 u .

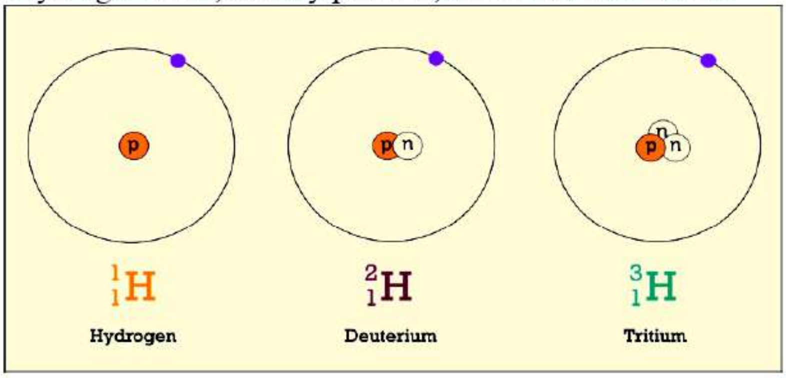
NOTE: The atomic number (**Z**), mass number (**A**) and symbol of an element are written as follows in atomic notation:

$$^{A}_{Z}X$$

Where, **X** is the symbol of element.
A = Protons + Neutrons
Z = Protons or electrons

ISOTOPES

1. Isotopes are defined as the atoms of the same elements, having the same atomic number but different mass numbers.
2. Three isotopes of hydrogen atom, namely protium, deuterium and tritium.



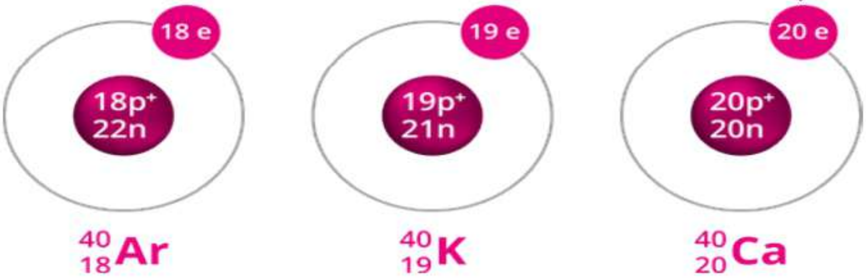
3. The chemical properties of isotopes are similar but their physical properties are different.
4. If an element has no isotopes, then the mass of its atom would be the same as the sum of protons and neutrons in it.

Applications

1. An isotope of uranium is used as a fuel in nuclear reactors.
2. An isotope of cobalt is used in the treatment of cancer.
3. An isotope of iodine is used in the treatment of goitre.

ISOBARS

Atoms of different elements with different atomic numbers and same mass number, are known as isobars.

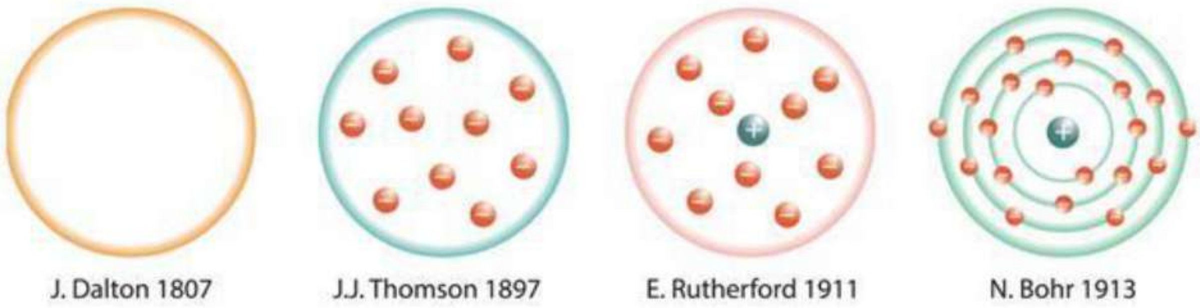


Difference between Isotopes and Isobars:

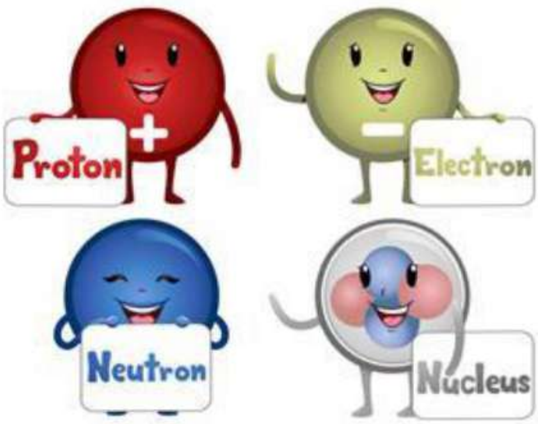
Isotope	Isobar
Same atomic numbers but a **different mass number**.	**Different atomic numbers** but the **same mass number**.
The chemical properties are **identical**.	The chemical properties are **different**.
Physical properties differ from one another.	The **physical properties are the same**.
The number of **protons** and **electrons** are the **same**, but the number of **neutrons differs**.	The number of **protons**, **electrons** and **neutrons differs**.
Examples: $^{35}_{17}Cl$, $^{37}_{17}Cl$	Examples: $^{24}_{11}Na$, $^{24}_{12}Mg$

Points to remember:

- The structure of an atom has been proposed by various scientists, as shown below:



- The **sub-atomic particles** of an atom are:



- The shells or energy levels of an atom are represented by **K**, **L**, **M**, **N**, etc.
- The **combining capacity** of an atom is called valency.
- **Atomic number = Number of protons** in the nucleus
- Nucleons are **protons and neutrons** in the nucleus.
- **Mass number = Number of nucleons**
- Isotopes are atoms with the **same atomic number but different mass numbers**.
- Isobars are atoms of the **same mass number but different atomic numbers**.