STRUCTURE OF ATOM

- **Atoms are made up of three subatomic particles : electrons, protons and neutrons.**
- **Protons and neutrons are present in a small nucleus at the centre of the atom.**
- **Electrons are outside the nucleus.**
- **The atoms of different elements differ in the number of electrons, protons and neutrons.**

DISCOVERY OF ELECTRON

- **The existence of electrons in an atom was shown by J.J. Thomson in 1897.**
- **Cathode rays consist of small, negatively charged particles called electrons. Since all the gases form cathode rays, it was concluded that all the atoms contain negatively charged particles called electrons.**
- **Thomson explained the formation of cathode rays as follows. The gas taken in the discharge tube consists of atoms, and all the atoms contain electrons. When high electrical voltage is applied, the electrical energy pushes out some of the electrons from the atoms of the gas. These fast moving electrons form cathode rays. Thus, the formation of cathode rays shows that one of the subatomic particle present in all the atoms is the negatively charged 'electron'.**
- **The electron is a negatively charged particle found in the atoms of all the elements.**

Characteristics of an Electron

1. Mass of an Electron.
the relative mass of an electron is 1/1840 u.

2. Charge of an Electron.
the relative charge of an electron is, –1 (minus one).

DISCOVERY OF PROTON

The existence of protons in the atoms was shown by E. Goldstein.

- **the anode rays obtained from hydrogen gas consist of protons.** ***A proton is formed by the removal of an electron from a hydrogen atom.***

- **These fast moving protons form the anode rays.**

- **The proton is a positively charged particle found in the atoms of all the elements.**

Characteristics of a Proton
1. Mass of a Proton.
the relative mass of a proton is 1 u.

2. Charge of a Proton.
The charge of a proton is equal and opposite to the charge of an electron.
the relative charge of a proton is +1 (plus one).

- **The formation of cathode rays and anode rays on passing electricity through gases at very low pressure tells us that atom is not indivisible, it is made up of smaller particles. Actually,** ***the formation of cathode rays tells us that atoms contain negatively charged particles (electrons) inside them whereas the formation of anode rays tells us that atoms contain positively charged particles (protons) in them.***

DISCOVERY OF NEUTRON
James Chadwick in 1932 discovered a particle called neutron.

- **The neutron is a neutral particle found in the nucleus of an atom.**

- **the subatomic particle not present in a hydrogen atom is neutron.**

Characteristics of a Neutron
1. Mass of a Neutron.
The relative mass of a neutron is 1 u.

2. Charge of a Neutron. Neutron has no charge.

SUMMARY OF SUBATOMIC PARTICLE

Subatomic particle	*Relative mass*	*Relative charge*	*Location in the atom*
(*i*) Proton	1 u	+1	In the nucleus
(*ii*) Neutron	1 u	0	In the nucleus
(*iii*) Electron	$\frac{1}{1840}$ u	–1	Outside nucleus

STRUCTURE OF ATOM

The discovery of electrons and protons suggested that atoms are divisible and they do have an inner structure.

THOMSON'S MODEL OF THE ATOM

J.J. Thomson proposed his model of the atom in 1903.

1. An atom consists of a sphere (or ball) of positive charge with negatively charged electrons embedded in it.
2. The positive and negative charges in an atom are equal in magnitude, due to which an atom is electrically neutral. It has no overall positive or negative charge.

ALPHA PARTICLE

- **Alpha particle is a positively charged particle having 2 units of positive charge and 4 units of mass.**
- **The fast moving alpha particles have a considerable amount of energy. They can penetrate through matter to some extent.**

Rutherford's Experiment – Discovery of Nucleus

- **most of the alpha particles pass straight through the gold foil without any deflection, it shows that there is a lot of empty space in the atom.**

- **some of the alpha particles are deflected through small and large angles shows that there is a 'centre of positive charge' in the atom which repels the positively charged alpha particles and deflects them from their original path.**

- **a very few alpha particles completely rebound on hitting the gold foil shows that the nucleus is very dense and hard which does not allow the alpha particles to pass through it.**

- **Rutherford's alpha-particle scattering experiment shows the presence of a nucleus in the atom.**

Nucleus

- The nucleus is a small positively charged part at the centre of an atom.
- almost the entire mass of an atom is concentrated in the nucleus.
- Protons and neutrons taken together are known as nucleons. The volume of the nucleus of an atom is very small as compared to the volume of the extranuclear part of the atom.

RUTHERFORD’S MODEL OF THE ATOM

1. An atom consists of a positively charged, dense and very small nucleus containing all the protons and neutrons (protons have positive charge whereas neutrons have no charge). Almost the entire mass of an atom is concentrated in the nucleus.

2. The nucleus is surrounded by negatively charged electrons. The electrons are revolving round the nucleus in circular paths at very high speeds. The circular paths of the electrons are called orbits.

3. The electrostatic attraction between the positively charged nucleus and negatively charged electrons holds the atom together.

4. An atom is electrically neutral. This is because the number of protons and electrons in an atom is equal.

5. Most of the atom is empty space.

Drawback of Rutherford’s Model of the Atom

- A major drawback (or defect) of Rutherford's model of the atom is that it does not explain the stability of the atom.
- It doesn’t explain the structure of electron around nucleus .

Neils Bohr Explained the Stability of Atom

1. The electrons could revolve around the nucleus in only ‘‘certain orbits’’ (or ‘‘certain energy levels’’), each orbit having a different radius.

2. When an electron is revolving in a particular orbit or particular energy level around the nucleus, the electron does not radiate energy (does not lose energy), even though it has accelerated motion around the nucleus.

BOHR'S MODEL OF THE ATOM

1. An atom is made up of three particles : electrons, protons and neutrons.

2. The protons and neutrons are located in a small nucleus at the centre of the atom.

3. The electrons revolve rapidly round the nucleus in fixed circular paths called energy levels or shells (K, L, M, N ….)

4. There is a limit to the number of electrons which each energy level (or shell) can hold and the formula to calculate the no of electron is $2n^2$ (here n is shell number).

5. Each energy level (or shell) is associated with a fixed amount of energy.

6. There is no change in the energy of electrons as long as they keep revolving in the same energy level, and the atom remains stable.

ATOMIC NUMBER

The number of protons in one atom of an element is known as atomic number of that element.

Atomic number of an element = Number of protons in one atom of element

- The atomic number of an element is denoted by the letter *Z*.
- All the atoms of the same element have the same number of protons in their nuclei, and hence they have the same atomic number.
- No two elements can have the same atomic number.
- atomic number can be used to identify an element.
- the atomic number of an element is equal to the number of electrons in a neutral atom of that element.
- It is very important to note here that the atomic number of an element is equal to the number of electrons only in a neutral atom, and not in an ion

MASS NUMBER

The total number of protons and neutrons present in one atom of an element is known as its mass number.

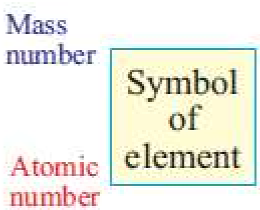
Mass number = No. of protons + No. of neutrons

- **The mass number of an element is denoted by the letter *A*.**

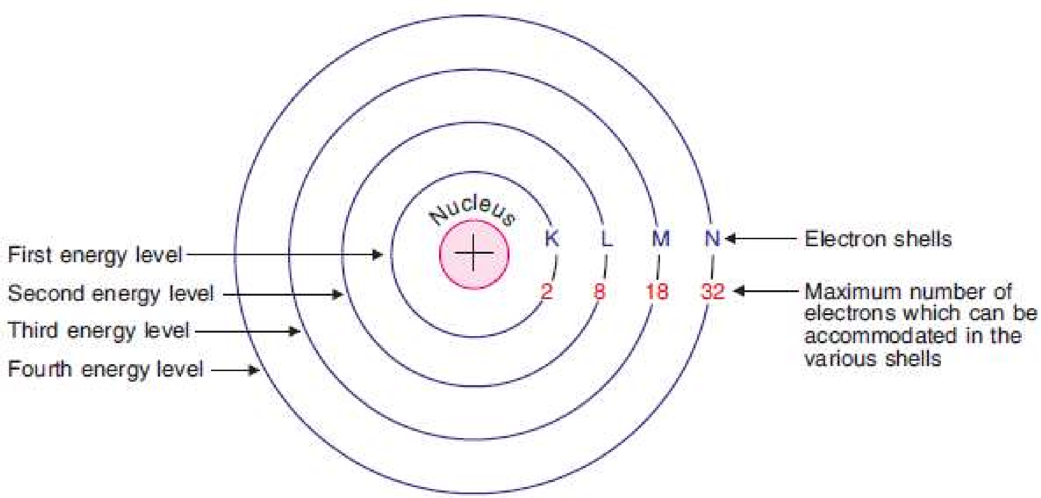
Relationship Between Mass Number and Atomic Number

Mass number = Atomic number + No. of neutrons

REPRESENTATION OF ELEMENT



ARRANGEMENT OF ELECTRONS IN THE ATOMS



- **the outermost shell of an atom is at the highest energy level.**

Electronic Configurations of Elements

The arrangement of electrons in the various shells (or energy levels) of an atom of the element is known as electronic configuration of the element.

1. The maximum number of electrons which can be accommodated in any energy level of the atom is given by $2n^2$ (where n is the number of that energy level).

- **the maximum number of electrons which can be accommodated in K shell is 2, for L shell is 8, for M shell is 18 and for N shell is 32.**

2. The outermost shell of an atom cannot accommodate more than 8 electrons, even if it has the capacity to accommodate more electrons.

3. Electrons in an atom do not occupy a new shell unless all the inner shells are completely filled with electrons

VALENCE ELECTRONS (OR VALENCY ELECTRONS)

The electrons present in the outermost shell of an atom are known as valence electrons (or valency electrons) because they decide the valency (combining capacity) of the atom.

- **those electrons of an atom which take part in chemical reactions are called valence electrons. Valence electrons are located in the outermost shell of an atom.**

- **In order to find out the number of valence electrons in an atom of the element, we should write down the electronic configuration of the element by using its atomic number. The outermost shell will be the valence shell and the number of electrons present in it will give us the number of valence electrons.**

Inertness of Noble Gases

only the outermost electrons of an atom take part in a chemical reaction. Since the noble gases are chemically unreactive, we must conclude that the electron arrangements in their atoms are very stable which do not allow the outermost electrons to take part in chemical reactions.

- **all the noble gases have completely filled outermost shells.**

- **the atoms having 8 electrons (or octet of electrons) in their outermost shell are very stable and hence chemically unreactive.**

- **2 electrons in the outermost shell is considered to be a stable arrangement of electrons only when the atom has just one shell, K shell, and there are no other electron shells in the atom.**

- **8 electrons in the outermost shell always impart stability to an atom, but 2 electrons in the outermost shell impart stability only when the outermost shell is the first shell (K shell), and no other shells are present in the atom.**

Cause of Chemical Combination

The atoms combine with one another to achieve the inert gas electron arrangement and become more stable.

An atom can achieve the inert gas (or noble gas) electron arrangement in three ways :
(*i*) by *losing* one or more electrons (to another atom)
(*ii*) by *gaining* one or more electrons (from another atom)
(*iii*) by *sharing* one or more electrons (with another atom)

VALENCY OF ELEMENTS

The capacity of an atom of an element to form chemical bonds is known as its valency.

Relation Between Valency and Valence Electrons

The valency of an element is either equal to the number of valence electrons in its atom or equal to the number of electrons required to complete eight electrons in the valence shell.

- the valency of a metal element is equal to the number of valence electrons in its atom.
  Valency of a metal = No. of valence electrons in its atom

- the valency of a non-metal element is usually equal to eight minus the number of valence electrons in its atom.
  Valency of a non-metal = 8 – No. of valence electrons in its atom

Types of Valency

There are two types of valency : Electrovalency and Covalency.

1. ELECTROVALENCY

the number of electrons lost or gained by one atom of an element to achieve the nearest inert gas electron configuration is known as its electrovalency.

2. COVALENCY

the number of electrons shared by one atom of an element to achieve the nearest inert gas electron configuration is known as its covalency.

ISOTOPES

Isotopes are atoms of the same element having the same atomic number but different mass numbers.

- The isotopes of an element differ in the number of neutrons in their nuclei.

- For example, the two isotopes of chlorine contain different number of 18 and 20 neutrons, and hence they have different atomic masses of 35 u and 37 u respectively.

RADIOACTIVE ISOTOPES

The isotopes which are unstable (due to the presence of extra neutrons in their nuclei) and emit various types of radiations, are called radioactive isotopes (or just radioisotopes).

Applications of Radioactive Isotopes

1. Radioactive isotopes are used as a fuel in nuclear reactors of nuclear power plants for generating electricity. Uranium-235 isotope is used as a fuel in the reactors of nuclear power plants for generating electricity.

2. Radioactive isotopes are used as 'tracers' in medicine to detect the presence of tumors and blood clots, etc., in the human body.

3. Radioactive isotopes are used in the treatment of cancer. Cobalt-60 radioisotope is used to cure cancer.

4. Radioactive isotopes are used to determine the activity of thyroid gland which helps in the treatment of diseases like goitre. Doctors use iodine-131 radioisotope.

5. Radioactive isotopes are used in industry to detect the leakage in underground oil pipelines, gas pipelines and water pipes.

ISOBARS

Isobars are the atoms of different elements having different atomic numbers but the same mass number (or same atomic mass).

- **An example of isobars is argon and Calcium.**