STRUCTURE OF ATOM

Atoms are made up of three subatomic particles such as electrons, protons and neutrons. Protons have a positive electrical charge, electrons have a negative electrical charge and neutrons have no electrical charge at all. Protons and neutrons are present in a small nucleus at the centre of the atoms. Electrons are outside the nucleus.

Atoms of all the elements (except hydrogen) are made up of the three subatomic particles like electrons, protons and neutrons. Hydrogen atom is made up of just one electron and one proton. It does not contain any neutrons. The atoms of different elements differ in the no. of electrons, protons and neutrons.

Charge particles in matter

If we rub a glass rod with a piece of silk cloth, then the electrons from the glass rod are transferred to the silk cloth. Hence, the glass rod becomes positively charged. When the positively charge glass rod is brought near the inflated balloon, then the balloon will be attracted to the glass rod.

Similarly, if we rub a comb in dry hair, then this comb attracts small pieces of paper. The electric charge produced on the comb on rubbing in hair comes from the atoms found in the comb.

SUBATOMIC PARTICLES OF ATOMS

(i) Electron
(ii) Proton
(iii) Neutron

DISCOVERY OF ELECTRON

The existence of electrons in an atom was discovered by J.J Thomson in 1897. When Thomson passed electricity at high voltage through a gas at very low pressure taken in a discharge tube. Stream of minute particles were given out by the cathode (negative electrode). These steams of cathode ray in the gas discharge tube consist of negatively charged particles called electrons. Atoms contain negatively charged particles is called electrons.

(i) Electron is discovered by J.J. Thomson.
(ii) The absolute mass of electron, $M_e = 9.1 \times 10^{-31}$ kg
(iii) The relative mass of electron is 1/1840 u.
(iv) The absolute charge of electron = -1.6×10^{-19} Coulomb.
(v) The relative charge of electron is -1 (minus one).
(vi) An electron is represented by e^-.

DISCOVERY OF PROTON

The existence of protons in the atoms was discovered by E. Goldstein / Rutherford.

When Goldstein passes at high voltage through a gas at very low pressure taken in a discharge tube, streams of heavy particles were given out by the anode (positive electrode). These streams of particles are called anode rays. The anode rays obtained from hydrogen gas in the discharge tube consists of positively particles called protons. The anode rays obtained from hydrogen gas in the discharge tube consists of positively charged particles called protons. It is formed by the removal of an electron from a hydrogen atom.

(i) Charge of a proton is equal and opposite to the charge of an electron.
(ii) A proton is represented by the symbol p^+.
(iii) The absolute Charge of protons is 1.6×10^{-19} Coulomb.
(iv) The relative charge of a proton is +1 (plus one).
(v) The absolute mass of proton, $M_p = 1.673 \times 10^{-27}$ kg
(vi) The relative mass of protons is 1 u.
(vii) The mass of proton is equal to the mass of a Hydrogen atom.
(viii) Canal rays are positively charged radiation consisting of protons. Canal rays were discovered by Goldstein and this led to the discovery of the proton.
(ix) Protons and neutrons found in the nucleus of an atom are together referred to as nucleons.

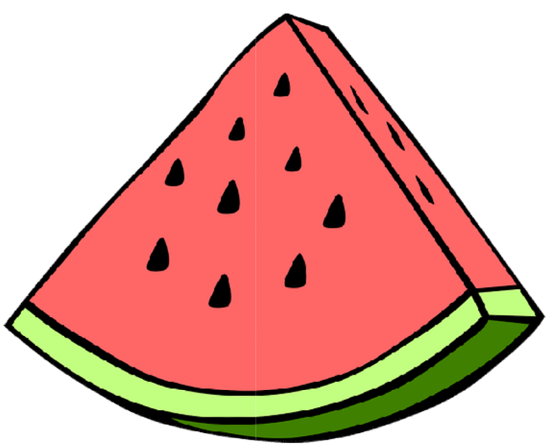
DISCOVERY OF NEUTRON

The existence of neutron in the atoms was discovered by James Chadwick in 1932. The neutron is a neutral particle present in the nucleus of an atom. Atoms of all the elements contain neutrons except hydrogen atom which does not contain any neutron. Neutron is subatomic particle which is not found in hydrogen. A hydrogen atom contains only one proton and one neutron.

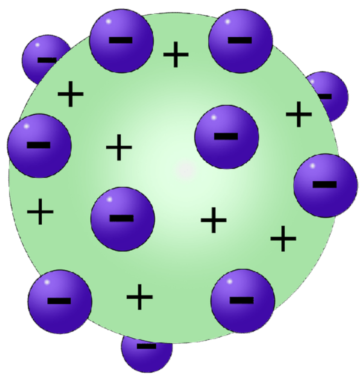
(i) The relative mass of a neutron is 1 u.
(ii) The absolute mass of neutron is 1.675×10^{-27} kg.
(iii) A neutron is represented by the symbol n.
(iv) Neutron has no charge.
(v) Neutron is located in the nucleus of the atom.

THOMSON'S MODEL OF THE ATOM

Thomson's model of the atom is called plum pudding model. The plum pudding model is one of the several historical scientific models of the atom. First proposed by J.J. Thomson in 1903 soon after the discovery of the electron, but before the discovery of the atomic nucleus.



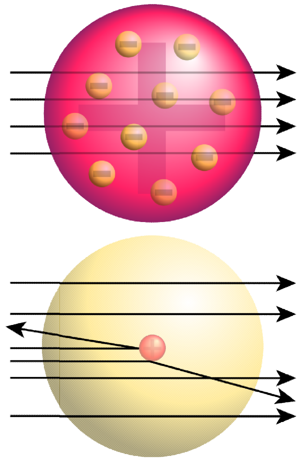
Thomson’s model of an atom is shown in above figure. The coloured area in the watermelon contains all the positively charge in the atom. The negatively charged electrons are spread throughout the positive charge. The total negative charge of electrons is equal to the total positive charge of the watermelon. These equal and opposite charges balance each other due to which an atom becomes electrically neutral on the whole.



Gold foil is very thin sheet of gold metal. Such a gold foil was used in Rutherford’s alpha particles scattering experiment which led to discovery of nucleus.

Rutherford’s Experiment – Discovery of Nucleus

When fast moving alpha particles are allowed to strike a very thin gold foil in vacuum, it is found that:



(i) Most of the alpha particles pass straight through the gold foil without any deflection from their original path; it shows that there is a lot of empty space in the atom.

(ii) A few alpha particles are deflected through small angles and a few are deflected through large angles show that there is a centre of positively charge in the atom which repels the positively charged alpha particles and deflects them their original path. This centre of positive charge in the atom is known as nucleus.

(iii) The observation that a very few alpha particles completely rebound on hitting the gold foil and turn back on their path shows that that the nucleus is very dense and hard which does not allow the alpha particles to pass through it.

Characteristics of Nucleus

(i) Nucleus of an atom is positively charged.

(ii) Nucleus is very dense and hard.

(iii) It is very small as compared to the size of the atom.

(iv) Nucleus was discovered by Ernest Rutherford.

(v) The nucleus is a small positively charged part at the centre of an atom. It contains all the protons and neutrons.
(vi) Protons and neutrons take together are known as nucleons because they present in the nucleus.

Rutherford's model of the atom

Rutherford's model is also called nuclear atom or planetary model of the atom, description of the structure of atoms proposed by Ernest Rutherford.

(i) An atom consists of a positively charged, dense and very small nucleus containing all the protons and neutrons. Almost the total mass of an atom is concentrated in the nucleus.
(ii) Rutherford model proposed that the negatively charged electrons surround the nucleus of the atom. The electrons are revolving round the nucleus in circular paths at very high speeds. The circular paths of electrons are called orbits.
(iii) Electron being negatively charged and nucleus being a densely concentrated mass of positively charged particles are hold together by strong electrostatic force of attraction.
(iv) An atom is electrically neutral because the number of protons and electrons in an atom is equal.
(v) Most of the atom is empty space.
(vi) According to Rutherford's theory, a hydrogen atom consists of small nucleus containing one proton and one electron revolving around it. The nucleus is

almost at the centre of the atom. Since the hydrogen atom contains equal number of protons and electron, it is electrically neutral. The nucleus of the ordinary hydrogen atom does not contain any neutrons in it.

Limitations of Rutherford Atomic Model

(i) If we apply this electromagnetic theory to the Rutherford's atomic model, it will mean that the negatively charged particles electrons revolving around the nucleus with accelerated motion will lose their energy continuously by radiation. Thus, the energy revolving electrons will decrease gradually and their speed will also go on decreasing. The electrons will be attracted more strongly by the oppositely charged nucleus due to which they will come more and more close to the nucleus and ultimately the electrons should fall into the nucleus by taking a spiral path. This should make the atom very unstable and hence the atom should collapse. But we know that atom do not collapse on their own. The Rutherford's model does not explain the stability of an atom.

(ii) One of the limitations of the Rutherford model was also that he did not say anything about the arrangement of electrons in atom which made his theory incomplete.

(iii) Rutherford's model was unable to explain the stability of an atom. According to Rutherford's model, electrons revolve at very high speed around a nucleus of the atom in a fixed orbit. However, Maxwell explained accelerated charged particles release electromagnetic radiation. Therefore, electron revolving around the nucleus will release electromagnetic radiation.

Bohr's Model of the Atom

A Danish physicist named Neil Bohr in 1913 proposed the Bohr atomic model. He modified the problems and drawbacks associated with Rutherford's model of an atom. The Bohr's model of the atom can be described as follows:

(i) An atom is made up of three particles electrons, protons and neutrons. Electrons have negative charge, protons have positive charge and neutrons have no charge. Due to the presence of equal number of negative electrons and positive protons, the atom on the whole is electrically neutral.

(ii) The electrons revolve around the nucleus in fixed circular paths called energy levels or shells. The energy level are counted from the centre outwards.

(iii) Each energy level is associated with a fixed amount of energy, the shell nearest to the nucleus having minimum energy and the shell farthest from the nucleus having the maximum energy.

(iv) The protons and neutrons are located in a small nucleus at the centre of the atom. Due to the presence of protons, nucleus is positively charged.

(v) There is a limit to the number of electrons which each energy level can hold. The maximum number of electrons in energy level is $2n^2$, where 'n' is the number of energy level. For example, the first energy level can hold a maximum of two electrons, second energy level can hold a maximum of 8 electrons, third energy level can hold a maximum of 18 electrons and forth energy level can hold a maximum of 32 electrons.

(vi) 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 the element is known as atomic number of the element.

(i) Atomic number is denoted by Z.
(ii) Two elements cannot have same element number.
(iii) The atomic number of an element is equal to the number of electrons in a neutral atom of that element.
(iv) All the atoms of the same element have the same number of protons in their nuclei, and hence they have the same atomic number.

ELEMENT	SYMBOL	ATOMIC NUMBER
1. Hydrogen	H	1
2. Helium	He	2
3. Lithium	Li	3
4. Beryllium	Be	4
5. Boron	B	5
6. Carbon	C	6
7. Nitrogen	N	7
8. Oxygen	O	8

9. Fluorine	F	9
10. Neon	Ne	10
11. Sodium	Na	11
12. Magnesium	Mg	12
13. Aluminium	Al	13
14. Silicon	Si	14
15. Phosphorus	P	15
16. Sulphur	S	16
17. Chlorine	Cl	17
18. Argon	Ar	18
19. Potassium	K	19
20. Calcium	Ca	20

Mass Number

The total number of protons and neutrons present in one atom of the element is known as its mass number. An atom consists of electrons, protons and neutrons. Since mass of electrons is negligible, the real mass of atom is determined by the protons and neutrons only.

(i) Mass number is also known as atomic number.
(ii) Mass number is denoted by A.

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

OR

Mass number = Atomic number + No. of neutrons

ELEMENT	**SYMBOL**	**ATOMIC NUMBER**	**Mass Number**

1. Hydrogen	H	1	1
2. Helium	He	2	4
3. Lithium	Li	3	7
4. Beryllium	Be	4	9
5. Boron	B	5	11
6. Carbon	C	6	12
7. Nitrogen	N	7	14
8. Oxygen	O	8	16
9. Fluorine	F	9	19
10. Neon	Ne	10	20
11. Sodium	Na	11	23
12. Magnesium	Mg	12	24
13. Aluminium	Al	13	27
14. Silicon	Si	14	28
15. Phosphorus	P	15	31
16. Sulphur	S	16	32
17. Chlorine	Cl	17	35.5
18. Argon	Ar	18	40
19. Potassium	K	19	39
20. Calcium	Ca	20	40

Arrangement of Electrons in the atoms

Electrons are arranged to their potential energy in different energy levels or shells. The shells of the electrons are represented by the letters K, L, M, N, O, and P whereas energy levels are denoted by the numbers 1, 2, 3, 4, 5 and 6. The energy levels are represented by circles around the nucleus. K shell having minimum energy is nearest to the nucleus, L shell which has a little more energy is a bit farther away from the nucleus, and so on.

1^{st} energy level is called K shell.

2nd energy level is called L shell.

3rd energy level is called M shell.

4th energy level is called N shell, and so on.

According to Bohr-Bury scheme:

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

The maximum number of electrons in first energy level = $2n^2$

$= 2 \times (1)^2$

$= 2$

The maximum number of electrons in 2nd energy level = $2n^2$

$= 2 \times (2)^2$

$= 8$

The maximum number of electrons in 3rd energy level = $2n^2$

$= 2 \times (3)^2$

$= 18$

The maximum number of electrons in fourth energy level = $2n^2$

$= 2 \times (4)^2$

$= 32$

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

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

Electronic Configuration

Arrangement of electrons in the various shells of an atom of the element is called electronic configuration. The maximum 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.

Valence Electrons

The electrons present in the outermost shell of an atom are called valence electrons. Valence electron is also called valency electron.

Cause of Chemical Combination

The atoms combine with each one another to achieve the inert gas electron arrangement and become more stable. An atom can achieve the noble gas(or inert gas) electron arrangement in three ways:

(i) By losing one or more electrons
(ii) By gaining one or more electrons
(iii) By sharing one or more electrons

Valency of elements

The capacity of an atom of an element to form chemical bonds is known as its valency. It decided by the number of valence electrons in its atom.

(i) The valency of a metal element is equal to the number of valence electrons in its atom.

(ii) The valency of a non-metal element is usually equal to eight minus the number of valence electrons in its atom. There is one exception to this rule and that is the valency of hydrogen. The valency of hydrogen is equal to the number of valence electrons, which is 1 through hydrogen is a non metal element.

Types of Valency

There are two types of valency:

(i) Electrovalency

(ii) Covalency

Electrovalency

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

Ex: Valency of magnesium – one magnesium atom loses 2 electrons to achieve the inert gas electron configuration, therefore, the valency of magnesium is 2(or +2).

Ex: Valency of oxygen – one atom of oxygen requires 2 electrons to achieve the nearest inert gas electron arrangement, so the electrovalency of oxygen is 2(or minus 2).

Covalency

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

Example:

(a) Covalency of hydrogen → one atom of hydrogen shares 1 electron to achieve the nearest inert gas electron configuration, therefore, the covalency of hydrogen is 1.

(b) Covalency of nitrogen → one atom of nitrogen shares 3 electrons to achieve the nearest inert gas electronic configuration, therefore, the covalency of nitrogen is 3.

ELEMENT	**Electronic configuration**	**Valency**
1. Hydrogen	1	1
2. Helium	2	0
3. Lithium	2,1	1
4. Beryllium	2,2	2
5. Boron	2,3	3
6. Carbon	2,4	4
7. Nitrogen	2,5	3
8. Oxygen	2,6	2
9. Fluorine	2,7	1

10. Neon	2,8	0
11. Sodium	2,8,1	1
12. Magnesium	2,8,2	2
13. Aluminium	2,8,3	3
14. Silicon	2,8,4	4
15. Phosphorus	2,8,5	3
16. Sulphur	2,8,6	2
17. Chlorine	2,8,7	1
18. Argon	2,8,8	0
19. Potassium	2,8,8,1	1
20. Calcium	2,8,8,2	2

Different Between Isotopes and Isobars

Isotopes

Isotopes are atoms of the same element having the same atomic number but different mass numbers. Isotopes of an element have the same atomic number because they contain the same number of protons (and electrons). Isotopes of an element have different mass number because they contain different number of neutrons.

Example: ${}_{17}Cl^{35}$ and ${}_{17}Cl^{37}$ are the isotopes of chlorine.

Isobars

Isobars are the atoms of different elements having different atomic numbers but the same mass number. Isobars have different number of protons in their nuclei but the total number of nucleons in them is the same.

Example: ${}_{18}Ar^{40}$ and ${}_{20}Ca^{40}$ are example of Isobars.