Chapter 2

ATOMIC STRUCTURE

Time Allocation

Teaching periods	= 14
Assessment period	= 4
Weightage	= 14

Major Concepts

2.1 Discovery of Sub Atomic Particles, electron, proton and neutron.

2.2 Theories and Experiments Related to Atomic Structure.

2.3 Modern Theories of Atomic Structure.

2.4 Electronic Configuration.

2.5 Isotopes and their common application.

STUDENTS LEARNING OUT COMES (SLO'S)

Students will be able to:

- Describe the discovery of electron, proton and neutron.
- Define Atomic Number (Z) and Mass Number (A) in term of number of proton and/or neutron.
- Describe the contributions Rutherford made to the development of the atomic theory.
- Explain how Bohr's atomic model is different.
- Define Modern theories of Atomic Structure(De Broglie Hypothesis & Schrodinger atomic model)
- Describe the presence of sub shells in a shell.
- Distinguish between Shells and Sub shells.
- Write Electronic Configuration of the first 18 Elements in the Periodic Table.
- Define and compare isotopes of an Atom.
- Discuss the properties of the isotopes of the H, C, Cl and U.
- Draw the structure of different isotopes from mass number and atomic number.
- State the importance and uses of the isotopes in various fields of life.

Introduction

The word atom is derived from a Greek word ATOMOS means indivisible, which was first describe by Greek philosopher Democritus. Democritus beleived that all matter consist of very small indivisible particles which are known as atoms. Johan Dalton an English school teacher and chemist suggested the fundamental atomic theory, which explains that all elements are made up of tiny indivisible particles called atoms. Dalton assumed that no particles smaller than atom exist, but by the passage of time new experiments showed that atom is composed of even smaller particles which are known as sub-atomic particles. After that these sub-atomic particles were discovered and named as electron, proton and neutron. We will discuss all these discoveries in this chapter.

Fig 2.1 Democritus

2.1 Discovery of Sub Atomic Particles (Electron, Proton, Neutron) of an Atom

Dalton's atomic theory explains the chemical nature of matter and existence of indivisible atoms, but at the end of 19^{th} century sub-atomic particles were discovered by different scientists. First sub-atomic particle Electron was discovered by M. Farady, William Crooks and J.J. Thomson, second sub-atomic particle Proton was identified by Goldstein and Ernest Rutherford, while third sub-atomic particle Neutron was revealed by Chadwick. All of these findings were milestone in the knowledge of atomic structure which we have now.

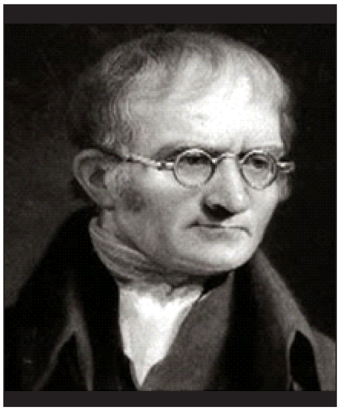


Fig 2.2 john Dalton

2.1.1 Discovery of Electrons

Electron is the lightest particle carrying negative charge in an atom discovered by J.J.Thomson and William crooks.

Fig 2.3 Chadwick

Fig 2.4 J.J.Thomson

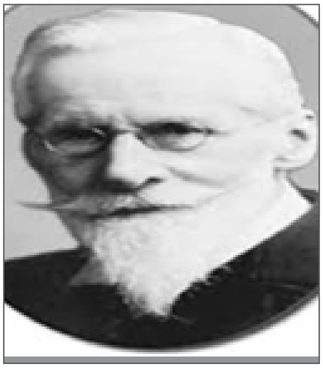


Fig 2.5 William Crooks

Fig 2.6 M.Faraday

The apparatus used for this type of experiment is called discharge tube which consists of glass tube fitted with two metal electrodes connected to a high voltage source and a vacuum pump. Discharge tube inside is evacuated, and electrodes are connected with high voltage source at very low pressure(1mm of Hg), when the high voltage current start passing between electrodes then a streak of bluish light originate and travel in straight line from cathode (-ve electrode) to anode(+ve electrode), Which cause glow at the wall of opposite end. These rays are called cathode rays.

Discovery of Electrons

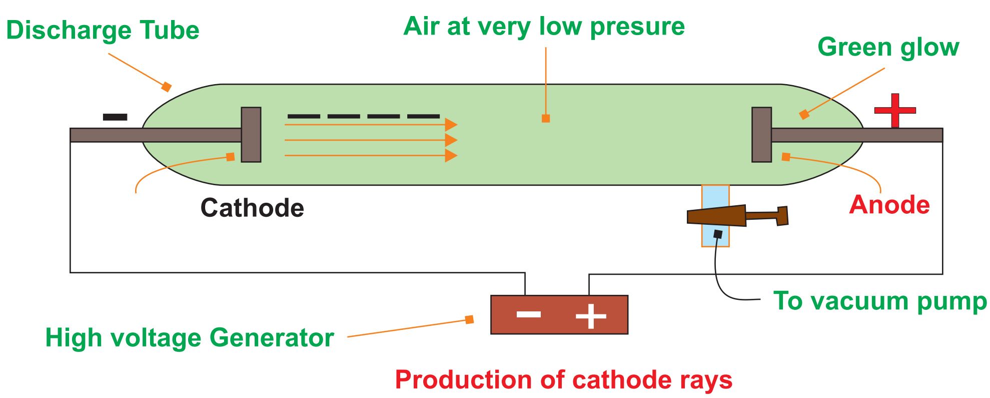


Fig 2.7 William Crooks Discharge Tube

J.J.Thomson justified that these rays were deflected towards positive plate in electric and magnetic field which shows that these rays possess negative charge due to this negative charge, particle was named Electron .These electrons were obtained from the cathode and when cathode material was changed the same phenomenon was observed which proves that electrons are constituent of all matter.

Properties of Cathode Rays (Electrons)

1. They travel in straight line from cathode towards Anode.
2. They produce sharp shadow of an opaque object placed in their path.
3. They have negative charge and bend towards positive plate in electric and magnetic field.
4. These rays when strike with glass or other material and cause the material to glow.
5. The charge to mass ratio (e/m) of cathode particles is 1.7588×10^8 coulomb per gram. This is same for all electrons, regardless of any gas in discharge tube.
6. They can produce mechanical pressure indicating they possess kinetic energy (K.E).

2.1.2 Discovery of Protons

The Proton is positively charged particle discovered by Goldstein in 1886. J.J.Thomson investigated properties of proton in 1897.

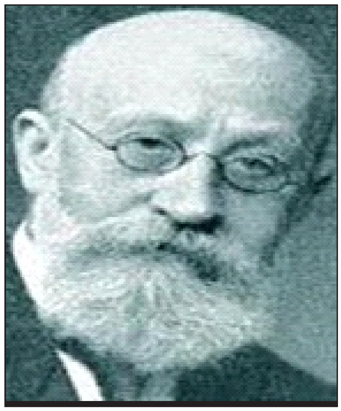


Fig 2.8 Goldstein

Protons were observed in same apparatus of cathode rays tube but with perforated cathode. Goldstein discovered that not only negatively charged cathode rays but positively charged rays are moving in opposite direction through perforated cathode. These positive rays passes through the holes of cathode, where they strike with walls of tube and cause the glow of tube. These rays were named as Canal rays (protons).

Discovery of Protons

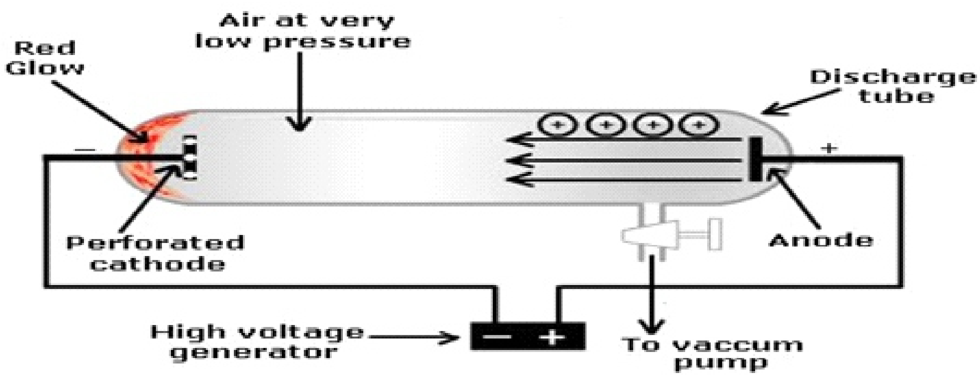


Fig 2.9 Gold Stein Discharge Tube

Remember that canal rays are not emitted by anode, but they are result of striking of electron with residual gas molecules in discharge tube. Electrons ionize the gas molecules as follows.

$$M + e^{-} \longrightarrow M^{+1} + 2\,e^{-}$$

Goldstein justified that atoms are electrically neutral, while electrons carry negative charge. It mean for each electron there must be one equivalent positive charge to neutralize that electron. This particle is called proton and it is a fundamental particle of all Atoms.

Properties of Canal Rays (Protons)

1. They travel in straight line towards Cathode.
2. They produce sharp shadow of object placed in their path.
3. They have positive charge and bend towards negative plate in electric and magnetic field.
4. The charge to mass ratio (e/m) of positive particles is much smaller than electron. It varies according to nature of gas present in tube.
5. The mass of proton is 1836 times more than electron.

2.1.3 Discovery of Neutrons

In 1920 Rutherford predicted that atom must possess another neutral particle with equivalent mass of proton. Different scientists started working on this neutral particle. later on, in 1932 Chadwick successfully discovered Neutron. Chadwick found that when alpha (α)particles bombarded on Beryllium plate some penetrating radiations were given out. Chadwick suggested that these radiations were due to material particle with mass comparable to hydrogen atom but have no charge. These radiations (particle) are called Neutron. It can be expressed in equation as follows.

$$^{9}_{4}Be + ^{4}_{2}He \longrightarrow ^{12}_{6}C + _{0}n^{1}$$

The neutron is fundamental part of an Atom, present inside nucleus with proton and is included in atomic mass.

Properties of Neutrons

1. The Neutrons are neutral particles.
2. They have no charge.
3. The mass of neutron is almost equal to that of proton.
4. These particles are most penetrating in matter.

2.1.4 How Atomic Number (Z) and Mass Number (A) are related with number of proton and neutron

As we discussed in discovery of fundamental particles of an atom, that Atom consist of three particles Electron, Proton and Neutron. But if all atoms have same fundamental particles then why the atoms of one element are different from the atoms of another element?

For example: How does an atom of Carbon (C) is different from an atom of Nitrogen (N)?Because all atoms can be identified by their number of protons they contain. Therefore no two elements have the same number of protons.

Atomic Number (Z)

The number of protons inside the nucleus of an atom is called Atomic Number. Atomic number is represented by Z. The elements are identified by their atomic number. Different elements have different atomic numbers because of different number of protons. In neutral atoms number of protons are equal to number of electrons, so the atomic number also indicate total number of electrons outside the nucleus. For example atomic number of Carbon(C) is 6. It mean that each carbon atom has 6 protons and 6 electrons in it.

Atomic number= Z = Number of proton in nucleus = Total number of electron around nucleus

Atomic number (Z) is written as subscript on the left hand side of the chemical symbol e.g $_{6}C$. Some other examples are as follows.

$$_{3}Li, \quad _{8}O, \quad _{1}H$$

Mass Number (A)

The total sum of protons and neutrons in the nucleus of an atom is called Mass Number. It is also known as "Nucleon number"Mass number represented by A. For example, the sodium (Na) atom has atomic number 11 and mass number 23. It indicates that sodium atom has 11 protons and 12 neutrons. The mass number (A) is written as superscript on left hand side of chemical symbol. e.g $^{23}_{11}Na$

$$\text{Mass number} = A = \text{Number of protons (Z)} + \text{Number of neutrons (N)} \quad \text{OR}$$

$$\text{Mass number} \quad A = Z + N$$

$$\text{And} \quad \text{number of neutron} \quad N = A - Z$$

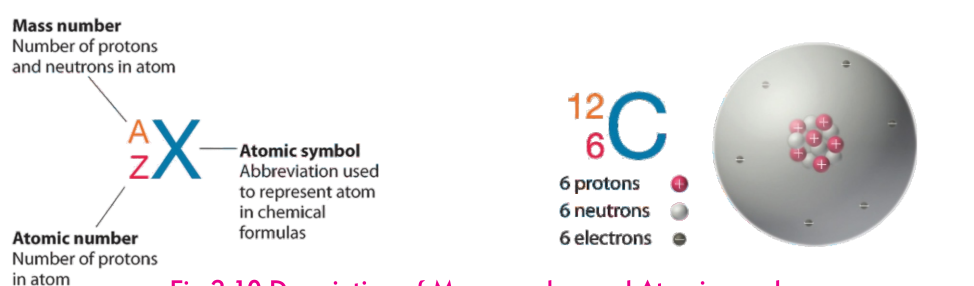


Fig 2.10 Description of Mass number and Atomic number

Test Yourself

a. What is atomic number of an oxygen atom which have 8 Neutrons and 8 protons?

b. Find out mass number of chlorine which have 17 protons and 18 neutrons?

c. How many electrons, protons and neutrons are present in Co ?

d. Do you know any element which have no neutron in its atom?

2.2 Theories and Experiments Related to Atomic Structure

2.2.1 Rutherford Atomic Model

Lord Rutherford in 1911, carried out series of experiments and proposed a new model for the atom.

EXPERIMENT

Rutherford took a thin sheet of gold foil and bombarded it with alpha (α) particles obtained from a radioactive element (Like Polonium). These rays were scattered after passing through the foil and examined on a zinc sulphide (ZnS) screen.

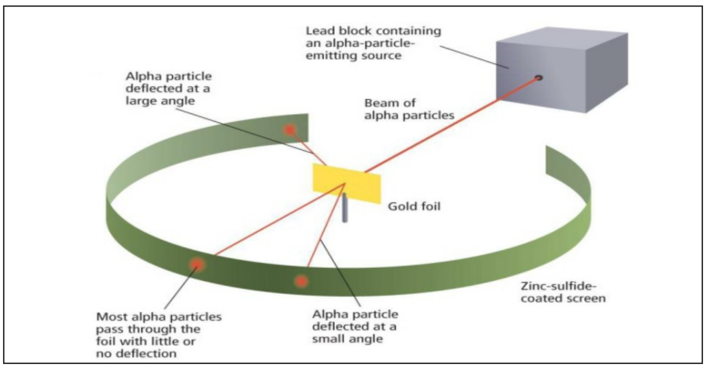


Fig 2.11 Gold Foil experiment

Do you know?

Radioactive element are unstable isotopes that release subatomic particles or energy as they decay.

For example:

Uranium, Radium and Polonium

Observations

1. Most of the particles passed straight and un deflected through the sheet and produced illumination on the zinc sulphide screen.
2. Very few alpha (α) particles undergo small and strong deflection after passing through gold sheet.
3. A very few alpha (α) particles (one out of 8000) retraced their path.

Do you know?

Illumination:

It is the action of supplying or brightening with light The luminous flux per unit area on an intercepting surface at any given point called illumination

Conclusion

1. According to Rutherford an atom consist of two parts nucleus and extra nuclear part.
2. Majority of the alpha particles passed straight line and un-deflected, shows that most volume occupied by atom is empty.
3. Alpha particles are positively charged and their deflection indicates that the centre of atom has a positive charge, which is named as nucleus.
4. The mass is concentrated in the nucleus and the electrons are distributed outside the positively charged nucleus.
5. The electrons are revolving around the nucleus in extra nuclear part called orbits.

Conclusion of Ruther Ford "Gold Foil" experiment

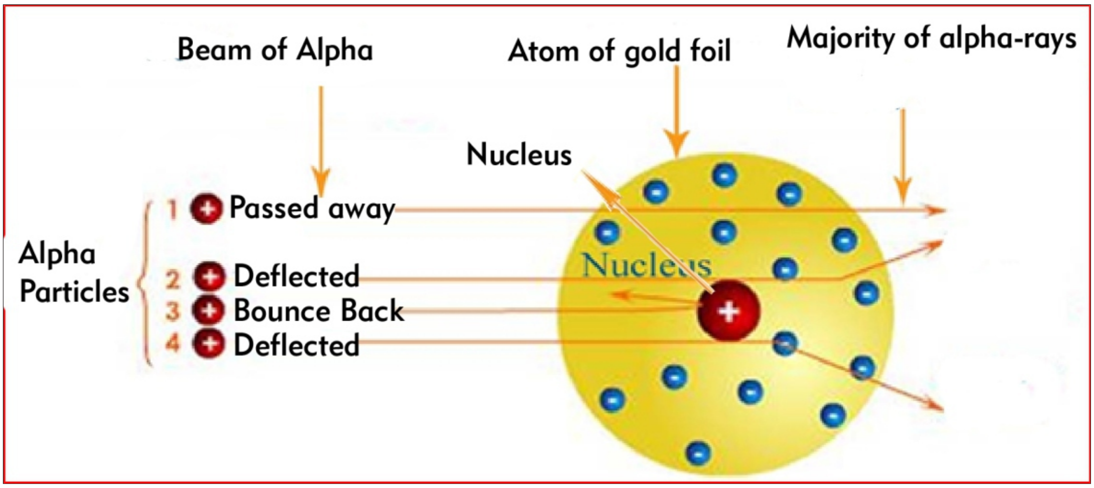


Fig 2.12 Pictorial description of bombardment of alpha particles on gold foil

Rutherford postulates

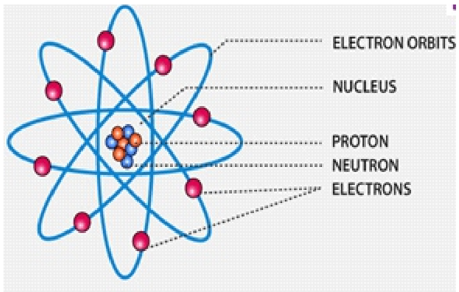


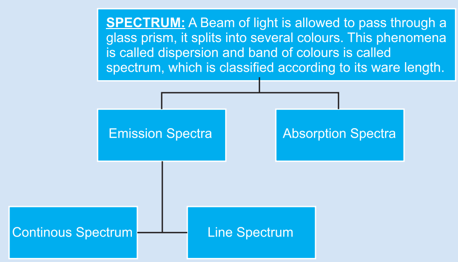
Fig 2.13 Rutherford Atomic Model

- An atom consists of positively charged, dense and very small nucleus containing protons and neutrons. The entire mass is concentrated in the nucleus of an atom.
- The nucleus is surrounded by large empty space which is called extra nuclear part where probability of finding electron is maximum.
- The electrons are revolving around the nucleus in circular paths with high speed (Velocity).
- These circular paths are known as orbits (Shells).
- An atom is electrically neutral because it has equal number of protons and electrons.
- The size of the nucleus is very small as compared to the size of its original atom.

Defects of Rutherford atomic model

1. Rutherford did not explain the stability of an atom.
2. In Rutherford atomic model the negatively charged electrons revolve around the nucleus in circular path and emits energy continuously. Due to continuous loss of energy ultimately it must fall into the nucleus.
3. If the revolving electron emits energy, continuously then there would be a continuous spectrum but in contrast to it we get line spectrum from the atoms of elements.

Do you know?



2.2.2 Neil Bohr's Atomic Model

In 1913 Neil Bohr proposed another atomic model. This atomic model was different in this manner that it showed two folds, first removed the Rutherford atomic model and second explained the line spectrum of Hydrogen atom based on quantum theory of Max Planck.

Do you know?

What is quantum?

A discrete quantity of energy proportion which can exist independently.

Postulates of Neil Bohr's Atomic Model

Neil Bohr proposed the following postulates for atomic structure.

1. The atom has fixed orbits in which negatively charged electrons are revolving around the positively charged nucleus.
2. These orbits possess certain amount of energy which are called shells and named as K, L, M, N shells.
3. The energy levels are represented by an integer (n= 1, 2, 3....) known as quantum number, this quantum range starts from nucleus side, where n=1 is lowest energy level.
4. Electrons are revolving in particular orbits (ground state) continuously, but they do not emit energy.
5. When electron absorbs energy, it jumps from lower energy level (E_1) to higher energy level (E_2) (excited state).
6. When electrons jumps back from higher energy level (E_2) to lower energy level (E_1), it emits energy.
7. The emission or absorption is discontinuous in the form of energy packet called Quantum or Photon.
8. The ΔE difference in energy of higher (E_2) and lower (E_1) energy level.

   $\Delta E = E_2 - E_1$

   $\Delta E = h\nu = 1$ photon

Here h is planks constant, its value is 6.63×10^{-34} Js and ν is a frequency of light.

9. Stationary state were present in those orbits in which angular moment of electron would be integral multiple of $h/2\pi$

   $mvr = nh/2\pi$ (where n = no: of orbits) h=(planks constant) m= (mass of electron)

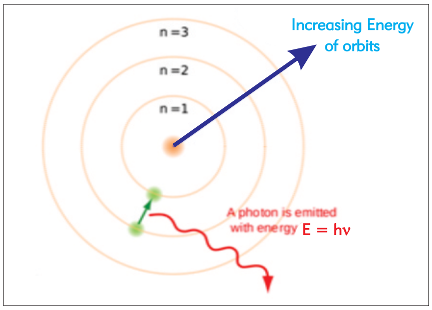


Fig 2.14 Neil Bohr's Atomic model

Limitations of Bohr's Atomic Model :

- Bohr's model of an atom failed to explain the Zeeman Effect (effect of magnetic field on the spectra of atoms).
- It also failed to explain the Stark effect (effect of electric field on the spectra of atoms).
- It deviates the Heisenberg Uncertainty Principle.
- It could not explain the spectra obtained from larger atoms.
- It only explain the monoelectronic species like He^{+}, Li^{+2}, Be^{3+}.

Test Yourself

- Which particles shows mass of an atom?
- Prove Rutherford atomic model based on classical theory and Bohr atomic model based on quantum theory?
- How you can relate living things with chemistry?

2.3 Modern Theories of Atomic Structure

In the year of 1900 Max Planck proposed quantum nature of radiations and energy in a photon wave E=hν as quantum theory. This quantum theory accepted by Albert Einstein in 1905 and proposed relationship between mass and energy to explain photoelectric effect by wave particle duality as $E = mc^2$. In 1913 Neil Bohr continue to use quantization of radiation with angular momentum of electrons. Bohr predicted and explained the line spectrum of Hydrogen atom

2.3.1 de Broglie Hypothesis

In 1923 Lois de Broglie extended the wave particle duality to electron, and proposed a hypothesis that all matter has particle as well as wave nature at the submicroscopic level.

De Broglie combined the Einstein and Planck equations and argued that if

E=hν where E = energy, h = plank 'constant, ν= frequency of light

And $E = mc^2$ where E = energy, m = mass, c = speed of light

Then

$$h\nu = mc^2$$

$$\frac{hc}{\lambda} = mc^2 \qquad \left(\nu = \frac{c}{\lambda}\right)$$

or $$\lambda = \frac{h}{mc}$$

or $$\boxed{\lambda = \frac{h}{P}} \qquad (P = mc) \text{ or } P = mv$$

The wave nature of a particle is quantified by De Broglie wavelength defined as $\lambda=h/p$ where p is the momentum of the particle.

According to De-Broglie a light, or any other electromagnetic wave, can also exhibit the properties of a particle, similarly a particle should also exhibit the properties of a wave, and those two nature are interchangeable.

DeBroglie wave particles duality hypothesis

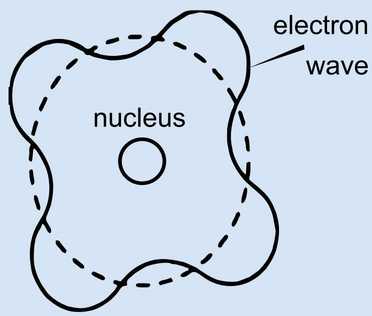


Fig 2.15 De Broglie wave duality hypothesis

2.3.2 Schrodinger Atomic Model

In 1926 Erwin Schrödinger, an Austrian physicist, took the Bohr's atomic model one step forward. Schrödinger used mathematical equations to describe the likelihood of finding an electron in a certain position. This atomic model is known as the quantum mechanical model of the atom.

Schrodinger model is just an improvement of Bohr's atomic model. He took an atom of hydrogen because it has one proton and one electron. He proved mathematically that electron can be find in different position around the nucleus and determined by probability.

- The quantum mechanical model determines that electron can be find in various location around the nucleus. He found electrons are in orbit as an electron cloud.
- Each subshell in an orbit have different shapes which determine the presence of electron.
- Different subshells of orbitals are named as s, p, d and f with different shapes as 's' is spherical and 'p' is dumbbell shaped.
- The numbers and kind of atomic orbitals depends on the energy of shell.

According to quantum mechanical model probability of finding an electron within certain volume of space surrounding the nucleus can be represented as a fuzzy cloud. If the cloud is denser the probability of finding electron is high which are called atomic orbitals. Detail and mathematical derivation will be discussed in next classes.

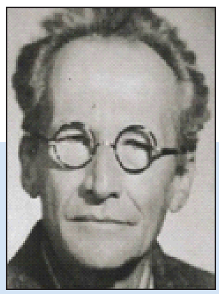


Fig 2.16 Schrodinger

2.4 Electronic Configuration

Before discussing electronic configuration we must understand the concept of shells and subshell.

As we know that nucleus is present in the centre of an atom and around the nucleus electrons are revolving. Now we have to understand how these electrons are revolving around the nucleus. These electrons are revolving around nucleus in different levels according to their potential energy.

2.4.1 Concept of Shell (K, L, M, N,O, P & Q)

The Energy levels or Shell or Orbit are all possible paths on which electrons are revolving around nucleus. Which is shown by 'n'. These shells are named as K, L, M, N, O, P & Q with quantum numbers n= 1, 2, 3, 4, 5, 6 and 7 respectively. These shells have definite amount of energy by means of increasing order as they become away from nucleus.

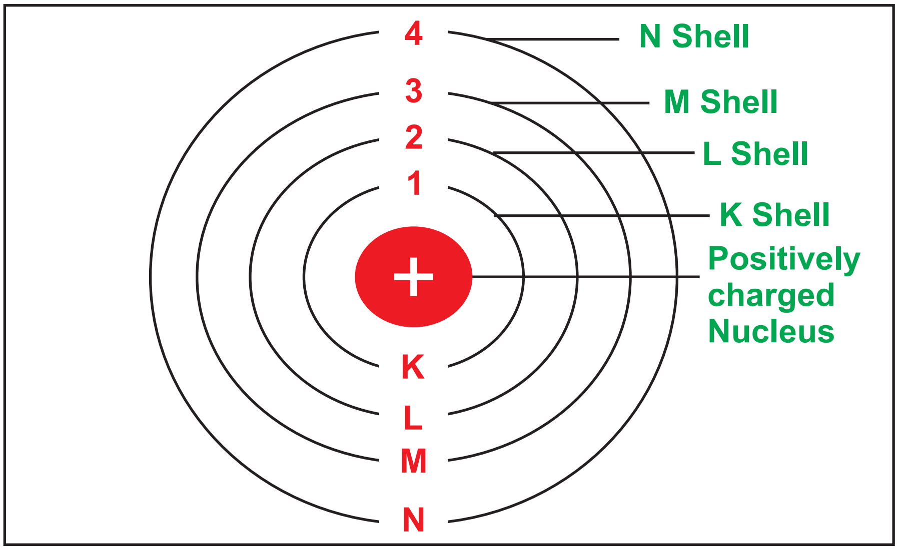


Fig 2.17 Shell (Energy level)

First energy level is K shell and has less energy.

Second energy level is L shell and has more energy than K shell.

Third energy level is M shell and has more energy than K and L shells.

Fourth energy level is N shell and has more energy than K, L and M shells.

Fifth energy level is O shell and has more energy than K, L, M and N shells.

2.4.2 Concept of Sub Shell (s,p,d & f)

When atomic spectra of substances were observed in a high powered spectroscope, it was found that they consist of two or more lines closely packed with each other as discussed in zemen and stark effects. These lines means that electrons in the same shell may differ in energy by small amount. Thus main energy level are divided in to sub energy levels and known as sub shells. When electrons are many in numbers in a shell they show repulsion and main shell splits into subshell which are named as s, p, d and f subshells.

The number of subshells in a shell is according to value of that shell, which are given in table 2.1

Table 2.1 Values of shell and sub shell

Value of 'n'	Shell	Sub shell
1	K	Only s
2	L	s, p
3	M	s. p,d
4	N	s,p, d, f

Do you know?

The atomic spectrum of substance consists of spectral lines. These lines differ in energy by small amount. Energy levels are divided into subshells/ subenergy levels due to repulsion. The shell or orbit split into subshell which are named as s, p, d, and f.

2.4.3 Electronic Configuration of First 18 Elements

Now we can understand that 'the distribution of electrons among the different orbits/shells and subshells according to some rules is known as the electronic configuration of an atom'. Generally, the most stable electronic configuration is represented when an atom is at the ground state with less energy level. Electrons filled in increasing order from lower to higher energy levels as

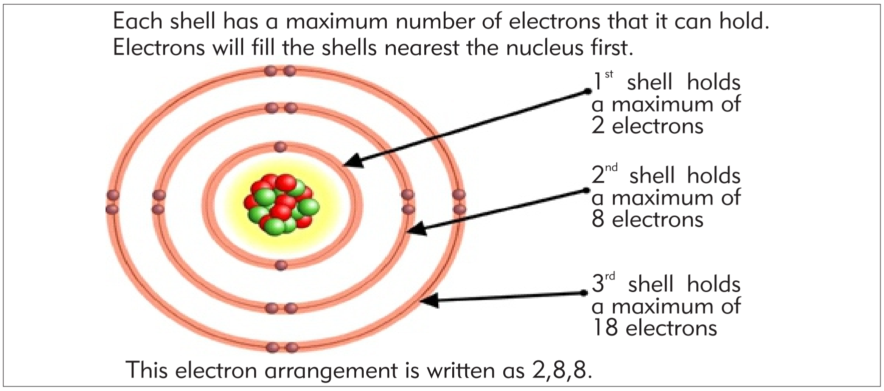


Fig 2.18 Filling of energy level

The maximum number of electrons that can be accommodated in a shell is represented by the formula $2n^2$, where 'n' is the shell number. The distribution of electrons in different orbits are as follows:

K-shell/ 1^{st} orbit (n=1) = $2(1)^2$ = 2
L-shell/ 2^{nd} orbit (n=2) = $2(2)^2$ = 8
M-shell/ 3^{rd} orbit (n=3) = $2(3)^2$ =18
N-shell/4^{th} orbit (n=4) =$2(4)^2$ =32 and so on

There is slight difference in Energy of subshells, the subshell "s" filled first then subshell 'p' and onward. The distribution of maximum electrons in subshells is as follows.

2 electrons in's' subshell

6 electrons in 'p' subshell

10 electrons in 'd' subshell

14 electrons in 'f' subshell

Whenever we write electronic configuration always remember following points.

1. Number of Electrons in an Atom.
2. Arrangement of shells and subshells according to energy levels.
3. Maximum number of electrons for shells and subshells.

Example 2.1: write down electronic configuration of an element which has 8 electrons.

For this element first of all electrons will be filled in K shell which have maximum capacity of 2 electrons, than remaining electrons will be filled in L shell which has maximum capacity of 8 electrons. Now arrangement of electrons will be as:

K L M

2, 6, 0

The above element is Oxygen which has 8 electrons. In writing electronic configuration first two electrons will go into '1s' subshell of K shell which hold two electrons. The next two electrons for oxygen go in the 2s subshell of L shell and remaining four electrons will go into 2p subshell of L shell. Now electronic configuration of oxygen is $1s^2\ 2s^2\ 2p^4$

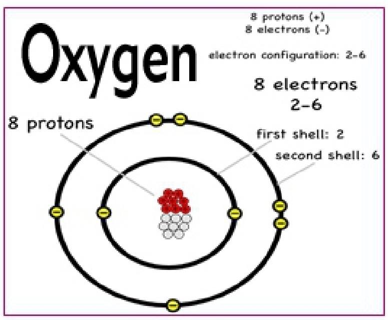


Fig 2.19
Electronic Configuration of Oxygen

The electronic configuration of different subshell of atom is written as $1s^2$, $2s^2$, $2p^6$, $3s^2$, as shown in figure 2.20.

Where coefficient shows number of shell, s,p are subshells and superscript is number of electrons in subshells. The electronic configuration of first 18 elements is given in table 2.2

Order of Filling of Electrons in Subshells

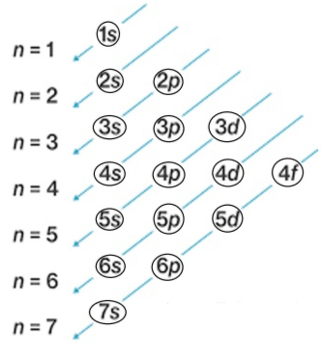


Fig 2.20 Order of filling of electrons in sub shells

Table 2.2 Electronic arrangement of the first 18 elements of the periodic table

Elements	Symbol	Atomic Number (number of electrons)	Electronic Configuration
Hydrogen	H	1	$1s^1$
Helium	He	2	$1s^2$
Lithium	Li	3	$1s^2, 2s^1$
Beryllium	Be	4	$1s^2, 2s^2$
Boron	B	5	$1s^2, 2s^2, 2p^1$
Carbon	C	6	$1s^2, 2s^2, 2p^2$
Nitrogen	N	7	$1s^2, 2s^2, 2p^3$
Oxygen	O	8	$1s^2, 2s^2, 2p^4$
Fluorine	F	9	$1s^2, 2s^2, 2p^5$
Neon	Ne	10	$1s^2, 2s^2, 2p^6$
Sodium	Na	11	$1s^2, 2s^2, 2p^6, 3s^1$
Magnesium	Mg	12	$1s^2, 2s^2, 2p^6, 3s^2$
Aluminum	Al	13	$1s^2, 2s^2, 2p^6, 3s^2, 3p^1$
Silicon	Si	14	$1s^2, 2s^2, 2p^6\ 3s^2, 3p^2$
Phosphorus	P	15	$1s^2, 2s^2, 2p^6, 3s^2, 3p^3$
Sulphur	S	16	$1s^2, 2s^2, 2p^6, 3s^2, 3p^4$
Chlorine	Cl	17	$1s^2, 2s^2, 2p^6, 3s^2, 3p^5$
Argon	Ar	18	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6$

Test Yourself

- What is maximum number of electrons that can be accommodate in's' subshell?
- How many electrons will be in L shell of an atom having atomic number 11?
- In the distribution of electrons of an atom, which shell filled first and why?
- If both K and L shells of an atom are completely filled, what is the total number of electrons are present in them?

2.5 ISOTOPES AND THEIR COMMON APPLICATION

As we know that atom is composed of three particles electrons, protons and neutrons. In all the atoms of an element number of electrons, protons and number of neutron are same, due to this their atomic number and mass number are same but in few elements some atoms have different atomic number and mass number.

2.5.1 What are Isotopes?

Atoms of the same elements having same atomic number but different Mass number are called isotopes. They have same number of electrons and protons but different number of neutrons. These elements have same chemical properties due to same electronic configuration but different physical properties due to difference in mass number.

2.5.2 Examples of Isotopes

(1) Isotopes of Hydrogen

There are three isotopes of Hydrogen. These are known as Protium, deuterium and tritium as shown in fig 2.21

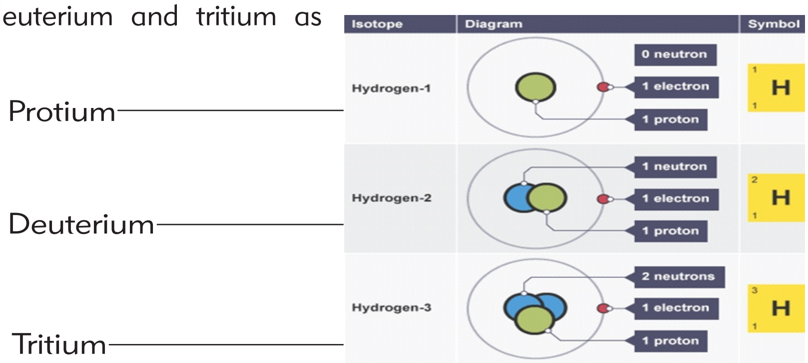


Fig 2.21 Isotopes of Hydrogen

(2) Isotopes of Uranium

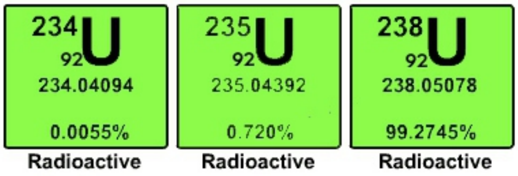


Fig 2.22 Isotopes of Uranium

There are three common isotopes of uranium with atomic number 92 and mass number 234,235 and 238 respectively, as shown in fig 2.22. The uranium $^{238}_{92}U$ is found 99% in nature.

(3) Isotopes of Carbon

There are two stable isotopes and one radioactive isotope of carbon. Which are shown in fig 2.23.

The carbon 12 contain 6 proton and 6 neutron, Carbon 13 possess 6 proton and 7 neutron, carbon 14 contain 6 proton and 8 neutron. Carbon 12 is the most abundant (98.89%) isotope.

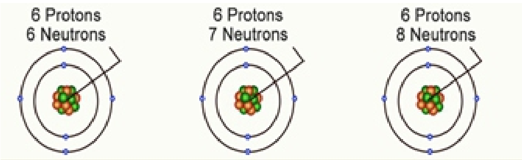


Fig 2.23 Isotopes of Carbon

(4) Isotopes of Chlorine

There are two isotopes of Chlorine with atomic number 17 and mass number 35 and 37. as shown in figure 2.24. Chlorine 35 is 75% and chlorine 37 is 25% abundant in nature.

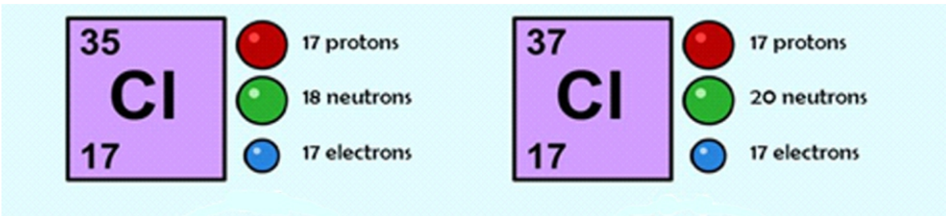


Fig 2.24 Isotopes of Chlorine

Table 2.3 Applications of Isotopes

S. No	Name of Radioactive Isotopes	Fields	Uses
(1)	Phosphorous -32 or strontium -90	Radiotherapy	• Treatment of skin cancer
(2)	Cobalt-60	Radiotherapy	• Treatment of body cancer due to more penetrating power.
(3)	Iodine isotopes	Radiotherapy	• Detestations of thyroid glands in he neck.
(4)	Technetium	Radiotherapy	• To monitor the bone growth in fracture healing.
(5)	Gamma ray of cobalt – 60	Medical instrumentation	• To sterilization of medical instruments and dressings from harmful bacteria.
(6)	Americium -241	Safety measures & industries	• Used in back scatter gauges, smoke detectors fill height detectors and measuring ash content of coal.
(7)	Gold -198 and Technetium - 99	Sewage & liquid waste movement for water pollution	• Tracing factory waste causing ocean pollution • Tracing sand movement in rivers and oceans.
(8)	Uranium -235	Power Generation	• Conversion of water energy from steam to generate electricity.
(9)	Plutonium -238	Medicine	• Used to stimulate a regular heart beat in heart pace maker.
(10)	Carbon -14	Archaeology and Geology	• Used to estimate the age of fossils.

Test Yourself

- Which of the isotopes of hydrogen contains greater number of neutrons?
- Why do isotopes of same elements have same chemical but different physical properties?
- How the isotopes of Carbon are different from isotopes of Hydrogen?

Summary

- The Electron is lightest particle carrying a negative charge in an Atom discovered by J.J.Thomson and William Crooks.
- The Proton is positively charged particle discovered by Goldstein in 1886.J.J.Thomson investigated properties of proton in 1897.
- In 1932 Chadwick become successful to discover Neutron.
- Lord Rutherford in 1911, carried out series of experiments and proposed a new model for the atom that an atom contains nucleus at the center and electrons revolve around this nucleus.
- In 1913 Neil Bohr proposed another atomic model. This atomic model was different in this manner that it shows two folds, first to remove the Rutherford atomic model and second explain the line spectrum of Hydrogen atom based on quantum theory of Max Planck.
- In 1923 Lois De Broglie extend the wave particle duality to electron, and propose a hypothesis that all matter has particle as well as wave nature at the sub microscopic level.
- The Energy levels or Shell or Orbit are all possible paths on which electrons are revolving around nucleus. Which is shown by 'n'. these Shells are named as K, L, M, N, O, P.
- Main energy level are divided in to sub energy levels and known as sub shells.
- The distribution of electrons among the different orbits/shells and subshells is known as the electronic configuration of an atom.
- Atoms of the same elements having same atomic number but different atomic masses are called isotopes. They have same number of electron and same number of protons, but different number of neutrons.
- The Isotopes are used in worldwide applications of daily life. Research laboratories, medical centers, industrial facilities, food irradiation plants and many consumer products all use or contain isotopes.

EXERCISE

SECTION- A: MULTIPLE CHOICE QUESTIONS

Tick Mark (✓) the correct answer

1. In an atom number of protons and neutrons are added to obtain:
   (a) number of electrons (b) number of nucleons
   (c) atomic number of element (d) number of isotopes
2. If proton number is 19, electron configuration will be:
   (a) 2, 8, 9 (b) 2, 8, 8, 1
   (c) 2, 8, 1 (d) 2, 8, 3
3. If nucleon number of potassium is 39 and its atomic number is 19 then, number of neutrons will be:
   (a) 39 (b) 19
   (c) 20 (d) 29
4. The isotope C-12 is present in abundance of:
   (a) 96.9% (b) 97.6%
   © 98.89% (d) 99.7%
5. Electronic configuration is distribution of:
   (a) protons (b) neutrons
   (c) electrons (d) positrons
6. Which one of the following is most penetrating?
   (a) electron (b) Proton
   (c) alpha particle (d) neutron
7. How many subshells in a L shell:
   (a) one (b) two
   (c) three (d) four
8. De Broglie extend the wave particle duality to electron in:
   (a) 1920 (b) 1922
   (c) 1923 (d) 1925
9. Name the material of screen which is used in Rutherford atomic model :
   (a) Aluminum foil (b) zinc sulphide
   (c) sodium sulphide (d) Aluminum sulphide
10. Which rays are used for sterilization of medical instruments :
    (a) α-rays (b) β-rays
    (c) γ-rays (d) x-rays

SECTION- B: SHORT QUESTIONS:

1. Draw the structure of isotopes of chlorine to justify the definition of isotopes?
2. An atom has 5 electrons in M shell than:

   (a) Find out its atomic number?

   (b) Write Electronic configuration of atom?

   (c) Name the element of atom?
3. Justify that Rutherford atomic model has defects?
4. Describe wave particle duality of electron of De Broglie Hypothesis?
5. What are Limitations of Bohr's Atomic Model?
6. Differentiate between shell and sub shell with examples?
7. How the atoms of O_8^{17} and O_8^{16} are similar or different from each other?
9. Write down the names of sub atomic particles their masses in a.m.u with their unit charges.

SECTION- C: DETAILED QUESTIONS:

1. Discuss Rutherford' gold metal foil experiment in the light of structure of atom.
2. Writ down the applications of isotopes in daily life.
3. Explain how Bohr's atomic model is different from Rutherford atomic model.
4. Prove that modern theory of De Broglie is related with Einstein and Plank's equations.
5. How are cathode rays produced? What are their major characteristics?
6. Describe the schrodinger atomic model.
7. Describe briefly the experiments which provide clue and evidences of electron, proton and neutron in an atom.
8. How many protons, neutrons and electrons are present in the following elements ?

   (i) Fe_{26}^{56} (ii) O_8^{17} (iii) Cl_{17}^{37} (iv) U_{92}^{235} (v) C_6^{14}