INTRODUCTION

The Greek Philosopher Democritus expressed the beliefe in the 5th century (BC) that all matters consisted of very small indivisible particles, which he named the atom (Greek= atom not cutable= indivisible) nowadays called as atoms.

Q:1 Outline the main points of Daltons atomic theory?

DALTON'S ATOMIC STRUCTURE

1. All elements are made up of small indivisible, indestructible particles called atoms.
2. All atoms of given elements are identical in all respects, having same size, mass and chemical properties. But the atoms of one element differ from the other elements.
3. Compounds are formed when atoms of more than one element combine in a simple whole number ratio.
4. A chemical reaction is a rearrangement of atoms but atoms themselves are not changed this means that atoms are neither created nor destroyed in chemical reaction.

MODERN ATOMIC THEORY

- Dalton's atomic theory assumed that the atoms are divisible and no particles smaller than atoms exist, but according to modern atomic theory, atom is a complex organization, composed of even smaller particles called subatomic atomic particles e.g. Electrons, Protons and Neutrons.
- Dalton's view that all atoms of an element have the same mass is modified in the light of discovery of isotopes.
- According to modern theory the ratio between atoms of various elements in many organic compounds is not simple.

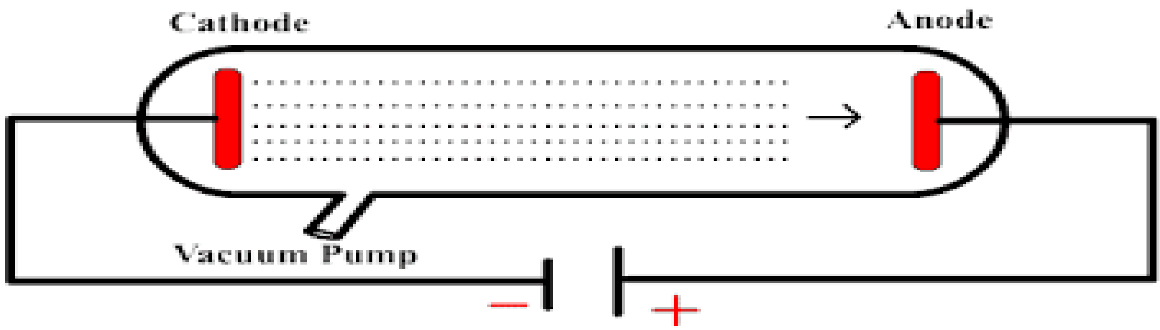
DISCOVERY OF ELECTRON

Introduction:

The fundamental particle, carrying negative charge, "Electron" was discovered in 1897 William Crooke and J.J Thomsan during the phenomenon of discharge of electricity through gases at a very high pressure and high voltage.

Construction Of Discharge Tube:

- A discharge tube consists of a strong glass tube with two metal plates sealed at either ends.
- The tube is usually about 40cm long and 4cms in diameter.
- One of the metallic plates is connected to negative terminal of the battery (Cathodes) and the other positive terminal of the battery (anode).
- The tube also possesses a small side tube, which is connected to a vacuum pump.
- The inside face of the tube is painted with zinc sulphide.
- The tube is filled with air or any other suitable gas.



Observation:

Gases are bad conductor of electricity, but current can pass through them at low pressure. When the tube is evacuated and a current of high potential is applied across electrodes at reduced pressure (0.001mm Hg), a stream of bluish light (rays) is observed to be emitted from cathode extending to the anode. As these rays are emitted from cathode, they are named as Cathode Rays.

DEFINITION OF CATHODE RAYS

"When high voltage electric current is passed through gases in a discharged tube under a low pressure (0.001mm Hg), the rays which arise from cathode extending perpendicularly towards anode having negative charge is called Cathode Rays."

PROPERTIES OF CATHODE RAYS

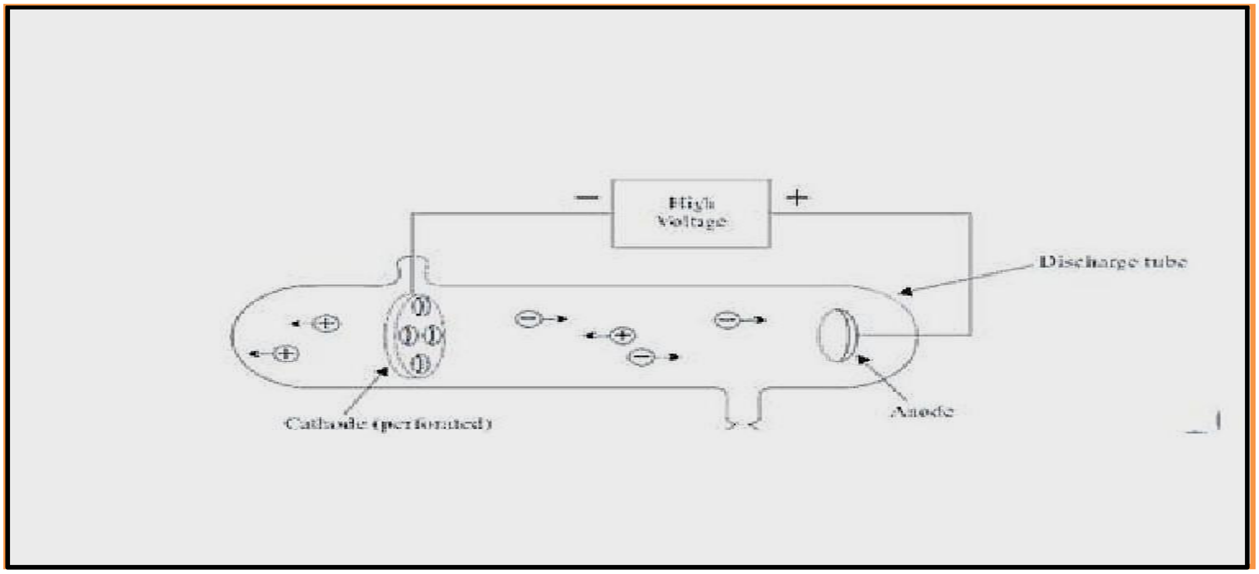
- Cathode rays travel in straight line because they can cast the shadow of an opaque body placed in their path.
- The rays consist of material particles because they can rotate a pinwheel placed in their path.
- They produce florescence on striking the wall of the tube coated with ZnS.
- Their behavior in electric field shows that they consist of negatively charged particles because cathode rays are attracted towards the positive charged plate placed in their path.
- The e/m ratio of each particle of cathode ray was determined to be 1.7588 X 10^8 C/g and the ratio was equal to that of electron which constitute the electric current, hence cathode rays consist of electron.

CONCLUSION

- Atom is not an ultimate particle of matter but it is divisible and consists of sub-atomic particles.
- Cathode rays which was later proved to be electron by G.J Stoney, is one of the fundamental particles of the atoms.
- An electron has negative charge. As atom as a whole is neutral, therefore, an atom should also contain equal number of positively charged particles to neutralize the charge of electron.

DISCOVERY OF PROTON

Goldstein in 1886 found that if the cathode in Crook's tube is perforated, a beam of rays pass through the cathode and away from anode. Since, these rays pass through perforations or canals, these rays were known as *CANAL RAYS*. These rays were found to possess positive charge and hence they also referred to as *POSITIVE RAYS*. It was soon found that unlike cathode rays the canal rays do not originate from anode but are formed due to ionization of the gas in tube. Hence they are not known as anode rays.



PROPERTIES OF POSITIVE RAYS

- If an opaque substance is placed in their path, a well-defined shadow is formed on the wall which proves that these rays travel in straight path.
- When a miniature wheel is placed in their path, it rotate, become hot and sparks are produced. All this proves that they consist of fast moving particles.
- When passes through electric or magnetic field they are deflected opposite to cathode rays proving that they are positive particles.
- Their mass varies with the nature of gas in a tube and is found to be nearly equal to atomic weight of the gas.
- Their ratio of charge to mass is found to vary with the nature of gas used. This is because basically they are positive ions of gas. The highest e/m ratio obtained in the case of Hydrogen atom.

CONCLUSION

- Since particles of the least charge and least mass is obtained in the case of Hydrogen atom, therefore nucleus of Hydrogen atom is the smallest positive particle of matter and was assumed to be fundamental particle.
- This particle was named PROTON by Rutherford. Mass of proton was found to be 1.672 $X10^{-27}$ kg and charge was determined to be 1.6022 $X10^{-19}$ C, which is equal in quantity but opposite to that of electron. Hence Proton like Electron is a fundamental and essential constituent of all matter.

DISCOVERY OF NEUTRON

CHADWICK'S EXPERIMENT

Neutron was discovered by Chadwick in 1932, when he bombarded α-particles (Helium nuclei with double +ve charge and mass equal to 4a.m.u) on Beryllium metal. The radiations coming due to bombardment were investigated and a new particle was discovered having atomic mass nearly equal to proton and having no charge. These particles are known as NEUTRON. The nuclear reaction can written as

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

This reaction is described as α-neutron reaction between the Beryllium and carbon where the 'α' is the incoming particle and neutron is the outgoing particle.

CHARACTERISTICS OF NEUTRON

- They are neutral particles carrying no charge because they remain un deflected in electric or magnetic field.
- Their mass is equal to mass of hydrogen atom i.e 1.008a.m.u.
- The total number of proton and neutron in the nucleus of an atom is called Mass Number (atomic mass).
- Mass No: minus the atomic No: equal to No: of Neutron ($n = A - Z$)

CONCLUSION

- Like proton and electron, neutron is also a fundamental and essential constitute of all atoms.
- Proton and neutron are present in the nucleus and are called Nucleons.

PROPERTIES OF ELECTRONS, PROTONS AND NEUTRON

PROPERTIES OF ELECTRON

- Electron is a negatively charged particle.
- The charge is measure in coulomb.
- The electric charge is equal to $1.602X10^{-19}$ C.
- The electron carries a negligible mass. Its mass is 1/1836 part of that of proton.
- The actual mass of an electron is $9.109X10^{-31}$kg.

PROPERTIES OF PROTON

- Proton is positively charges particle.
- The actual charge on proton is $1.602X10^{-19}$ C.
- A proton is 1836 times heavier than electron.
- The actual mass of a proton is $1.672X10^{-27}$kg.

PROPERTIES OF NEUTRON

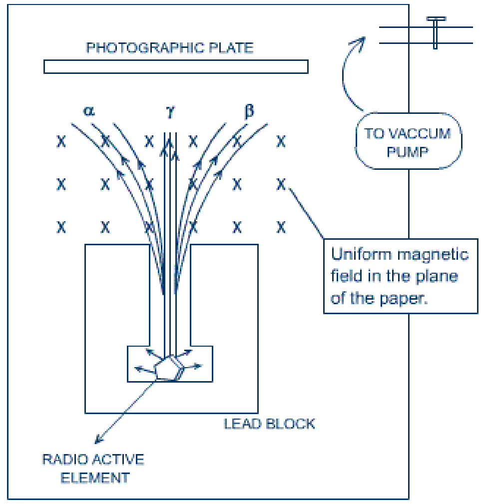
- The neutron is neutral particle, i.e. it has no charge.
- Its mass is almost equal to that of proton.
- The actual mass of neutron is $1.76X10^{-27}$kg.

RADIOACTIVITY

The first conclusive evidence that atoms are complex rather than indivisible as stated in the atomic theory came with the discovery of radioactivity by Henry Becquerel, a French physicist in 1896.

Definition:

Radioactivity is the spontaneous disintegration of nucleus of an atom, in which invisible radiation are emitted from the nucleus of atoms. The substances which emit such kind of radiation are known as radioactive elements and the phenomenon is termed as radioactivity.



NATURE OF RADIOACTIVE RAYS

Experiment:

The British physicist Ernest Rutherford in 1902 determined the nature of radioactive rays by the following experiment and showed that, it is composed of three types of rays.

Procedure:

A sample of radioactive substance was placed in a lead block, between the two opposite charged plates (electric field).

Observation:

- ♣ One component was deflected towards the negative plate, proving that is carried a positive charge. These were named as α-rays
- ♣ The second component deflected towards the positive plate, showing that it carried a negative charge. These were named as β-rays.
- ♣ The third type carried no charge no mass and were not deflected in the electric field. These were named as γ-rays.

CHARACTERISTICS OF α–RAYS

- ♣ Alpha α –rays are made up of particles called helium nuclei. They carry 2^+ charge i.e. (He^{2+})
- ♣ Their speed is about $1/10^{th}$ of the speed of light.
- ♣ They cannot pass through a thick metal foil because of their heavy mass.
- ♣ These rays bend towards the negative pole when they are allowed to pass through an electric or magnetic field.
- ♣ They can ionize sir or gas.

CHARACTERISTICS OF β – RAYS

- ♣ These rays are negative charges, become they bend towards the positive pole on passing through an electric or magnetic field.
- ♣ These are electrons because their e/m ratio resembles that of an electron.
- ♣ They travel with the speed of light.
- ♣ They can pass through a few millimeters thick metal sheet, because they possess greater power to penetrate.
- ♣ They produce ions when pass through air or gas.

CHARACTERISTICS OF γ – RAYS

- ♣ They are electromagnetic in nature.
- ♣ They are photons of light.
- ♣ They do not carry any charge, hence are not affected by magnetic or electric field.
- ♣ They travel with the speed of light.
- ♣ They possess greater penetrating power than α or β rays
- ♣ They can also ionize air or gas.

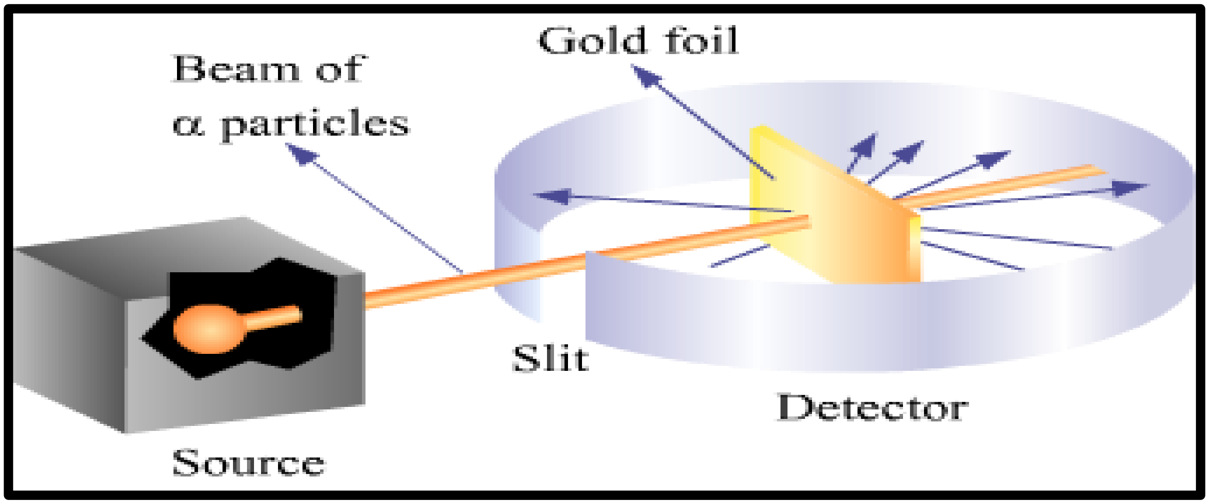
RUTHERFORD'S ATOMIC MODEL

Introduction:

After the discoveries of electron, proton and neutron attempts were made to see how these particles are arranged in the atom.

α- Particles Scattering Experiment:

In 1911, Lord Rutherford's performed an experiment in which he bombarded a gold foil (0.0004 cm thick) i.e. $4X10^{-5}$ cm with 'α' particles emitted from polonium (radioactive element) and observed their effects on ZnS screen or photographic plate.



Observation:

1. Nearly all the α- particles passed through the gold foil without suffering any deflection in their expected straight path.
2. A few α- particles were deflected through large angles.
3. A very few α-particles were reflected (bounced) back from the gold foil.

Conclusion:

Since most of the α- particles pass through the foil undeflected, most of the volume occupies by the atom is empty.

1. The deflection of few positively charged particles indicates the central portion of the atom is positively charged. Rutherford's called this portion as "nucleus".
2. It was found that the whole mass of an atom is concentrated in nucleus.
3. The atom as a whole is neutral. There it was concluded that the number of positively charged particles (protons) with in nucleus must be equal to the number of negative charged particles (electron).

Defects In Rutherford's Picture Of Atom:

Neil Bohr pointed out two defects in Rutherford's picture of atom, these defects are as follows:

a. According to classical electromagnetic theory, the revolving electron which is a charges particle will emit energy continuously. Due to decrease in energy, the orbit of revolving electron will become smaller and smaller until it would fall into nucleus.

b. Since, revolving electron according to Rutherford emits energy continuously so it should give continuous spectrum but in actual practice a line spectrum in obtained.

BOHR'S ATOMIC MODEL

Rutherford's model could not explain why electrons did not fall into nucleus. In order to improve Rutherford's Model and to account for line spectra, Neil Bohr in 1913 proposed new model for structure of atom based on Plank's Quantum Theory.

Basic Postulates:

1) The electrons in an atom revolve around the nucleus in definite circular orbits or shells. Each orbit is associated with definite amount of energy that is why orbits are called as Energy Level or Energy States.
2) As long as an electron keeps revolving in a particular energy level, it neither absorbs nor loses energy, so the energy of electron remains constant. These fixed energy states or orbits are termed as Stationary States. Electrons in these stationary states or permissible orbits is completely stable and do not emit energy.
3) The emission or absorption of energy in the form of radiation can only occur when electrons moves from one stationary state to another. In other words, electron loses energy when it jumps from higher energy level to low energy level.
4) The orbit closest to the nucleus corresponds to lowest energy state which is the most stable state of atom. The only way an electron can change its energy is to shift from one energy level to another. If on lower lever is available, electrons cannot level emit energy. For this reason electrons do not fall into the nucleus.

5) The electrons loses definite quantity of energy called Quantum of energy when it jumps back from higher energy level to lower energy level, which is equal to energy difference between the two levels.

$$\Delta E = E_2 - E_1 = h\nu$$

Where

ΔE = Energy difference between the two levels.
E_1 = Energy of electron in lower energy state.
E_2 = Energy of electron in higher energy state.
h = Planck's constant (6.62×10^{-34} joule-sec)
ν = frequency of energy emitted.

6) The product of momentum of electron and circumference ($2\pi r$) is equal to Planck's constant or its some integral multiple i.e.

$$\text{Momentum} \times \text{Circumference} = h$$

$$mv \times 2\pi r = h$$

For n^{th} orbits

$$mv \times 2\pi r = nh$$

or

$$mvr = nh/2\pi$$

Where; mvr = Angular momentum of electron.

ATOMIC NUMBER (Z)

Definition:

The number of protons in the nucleus of an atom is called the atomic number. Atomic number indicates the total number of electrons also because in neutral atom number of proton is equal to no: of protons.

Symbol:

- The atomic number is generally denoted by (z).
- Atomic number (z) is written as subscript on the left side of the chemical symbol of an element.
- Atomic number =2= no: of protons or no: of electrons

Example:

- **Carbon:**

Atomic number of carbon(C) is six. This means that each carbon atom has six protons and six electrons in it.

- **Nitrogen:**

The atomic number of nitrogen (N) is seven. It means that nitrogen atom has seven protons and seven electrons.

- **Oxygen:**

The atomic number of oxygen (O) is eight. It means that oxygen atom has eight protons and eight electrons.

MASS NUMBER (A)

Definition:

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

Symbol:

It is denoted by A. the mass number (A) is written as superscript on the left side of the chemical symbol.

Example:

The sodium (Na) atom has atomic number eleven and the mass number twenty three. It indicates that sodium atom has eleven protons and twelve neutrons

ISOTOPES

Definition:

Atoms of an element having same atomic number but different mass number are called isotopes.

Isotopes Of Hydrogen:

Hydrogen has following three types of isotopes.

- Protium
- Deuterium
- Tritium
- **PROTIUM**

Naturally occurring hydrogen has the largest percentage of protium atoms present in it. It is denoted by symbol ${}^{1}_{1}H$.

- It has no neutron.
- It has one proton.
- It has one electron.

- Its atomic number is 1 and mass number is also 1.

- **DEUTERIUM**

The presence of Deuterium in naturally occurring hydrogen is 0.015%. It is denoted by symbol $^{2}_{1}H$ or D.

- It has one neutron.
- It has one proton.
- It has one electron.
- Its atomic number is 1 and mass number is also 2.

- **TRITIUM:**

The number of tritium isotopes is one in ten millions. It is denoted by $^{3}_{1}H$ or T.

- It has two neutrons.
- It has one proton.
- It has one electron.
- Its atomic number is 1 and mass number is also 3.

Isotopes Of Oxygen:

Oxygen has three isotopes.

- **$^{16}_{8}O$**

The natural abundance of $^{16}_{8}O$ isotopes is 99.7%

- Number of neutrons = 8
- Number of protons = 8
- Number of electrons = 8
- Atomic number = 8
- Mass number =16

- **$^{17}_{8}O$**

The natural abundance of $^{17}_{8}O$ isotopes is 0.037%

- Number of neutrons = 9
- Number of protons = 8
- Number of electrons = 8
- Atomic number = 8
- Mass number =17

- **$^{18}_{8}O$**

The natural abundance of $^{18}_{8}O$ is 0.204%.

- Number of neutrons = 10
- Number of protons = 8
- Number of electrons = 8
- Atomic number = 8
- Mass number =18

Isotopes Of Chlorine:

The chlorine atom is found in two isotopic forms.

- **$^{35}_{17}Cl$**

The natural abundance of $^{35}_{17}Cl$ is 75.53%.

- Number of neutron =18
- Number of protons = 17
- Number of electrons = 17

- Atomic number = 17
- Mass number =35

$^{37}_{17}Cl$

The natural abundance of $^{37}_{17}Cl$ is 24.47%.

- Number of neutron= 20
- Number of protons = 17
- Number of electrons = 17
- Atomic number = 17
- Mass number =37

ELECTRONIC CONFIGURATION

The arrangement of electrons in different orbits or shells or energy levels around the nucleus of an atom is called electronic configuration.

Orbits Or Shell Or Energy Level:

According to Bohr's theory electrons move in a specific circular paths called the orbits, shell or energy level. Their orbits are designed as K, L, M, N, O, P orbits and represented by 1, 2, 3, 4, 5, 6 starting from one nearest to the nucleus.

Formula For Calculating Number Of Electrons In A Shell:

The maximum number of electrons in the given shell can be calculated by the formula $2n^2$. Where "n" is the number of orbit (shell or energy level).

Example:

Maximum number of electron in second shell can be calculated by = $2n^2$

= $2(2)^2$

Number of electrons in second shell = 8

Number Of Electrons In Different Shells

1^{st} shell (K) = 2 electrons
2^{nd} shell (L) = 8 electrons
3^{rd} shell (M) = 18 electrons
4^{th}shell (N) = 32 electrons

FILL IN THE BLANKS.

i	Rutherford's	**ii**	11	**iii**	mass number	**iv**	isotopes
v	3	**vi**	atomic number	**vii**	neutrons	**viii**	electrons