Chapter- 02

Structure of the atom

CLASS-XI SUB-CHEMISTRY

Aoms:

Atom is the smallest indivisible particle of the matter. Atom is made of electron, proton and neutrons.

PARTICLE	ELECTRON	PROTON	NEUTRON
Discovery	Sir. J. J. Thomson (1869)	Goldstein (1886)	Chadwick (1932)
Nature of charge	Negative	Positive	Neutral
Amount of charge	1.6×10^{-19}Coloumb	1.6×10^{-19}Coloumb	0
Mass	9.11×10^{-31}kg	1.672614×10^{-27}kg	1.67492×10^{-27}kg

Electrons were discovered using cathode ray discharge tube experiment.

Nucleus was discovered by Rutherford in 1911.

Cathode ray discharge tube experiment: A cathode ray discharge tube made of glass is taken with two electrodes. At very low pressure and high voltage, current starts flowing through a stream of particles moving in the tube from cathode to anode. These rays were called cathode rays. When a perforated anode was taken, the cathode rays struck the other end of the glass tube at the fluorescent coating and a bright spot on the coating was developed

Results of Rutherford experiments:

a. Cathode rays consist of negatively charged electrons.
b. Cathode rays themselves are not

visible but their behavior can be observed with help of fluorescent or phosphorescent materials.

c. In absence of electrical or magnetic field cathode rays travel in straight line. In presence of electrical or magnetic field, behaviour of cathode rays is similar to that shown by electrons

e. The characteristics of the cathode rays do not depend upon the material of the electrodes and the nature of the gas present in the cathode ray tube.

Charge to mass ratio of an electron was determined by Thomson. The charge to mass ratio of an electron as 1.758820×10^{11} C kg^{-1}

Charge on an electron was determined by R A Millikan by using an oil drop experiment. The value of the charge on an electron is -1.6×10^{-19}C.

The mass on an electron was determined by combining the results of Thomson's experiment and Millikan's oil drop experiment. The mass of an electron was determined to be 9.1094×10^{-31}kg.

Discovery of protons and canal rays:

Modified cathode ray tube experiment was carried out which led to the discovery of protons.

Characteristics of positively charged particles:

a. Charge to mass ratio of particles depends on gas from which these originated.

b.The positively charged particles depend upon the nature of gas present in the cathode ray discharge tube

c. Some of the positively charged particles carry a multiple of fundamental of electrical charge.

d. Behaviour of positively charged particles in electrical or magnetic field is opposite to that observed for cathode rays

Neutrons were discovered by James Chadwick by bombarding a thin sheet of beryllium by α-particles. They are electrically neutral particles having a mass slightly greater than that of the protons.

Atomic number (Z) : the number of protons present in the nucleus(Moseley1913).

Mass Number (A) : Sum of the number of protons and neutrons present in the nucleus.

Thomson model of an atom:

This model proposed that atom is considered as a uniform positively charged sphere and electrons are embedded in it. An important feature of Thomson model of an atom was that mass of atom is considered to be evenly spread over the atom.Thomson model of atom is also called as Plum pudding, raisin pudding or watermelon model Thomson model of atom was discarded because it could not explain certain experimental results like the scattering of α- particles by thin metal foils.

Observations from α- particles scattering experiment by Rutherford:

a. Most of the α- particles passed through gold foil un deflected
b. A small fraction of α- particles got deflected through small angles
c. Very few α- particles did not pass through foil but suffered large deflection nearly180^{o}

Conclusions Rutherford drew from α- particles scattering experiment:

a. Since most of the α-particles passed through foil undeflected, it means most of the space in atom is empty
b. Since some of the α-particles are deflected to certain angles, it means that there is positively mass present in atom

c. Since only some of the α-particles suffered large deflections, the positively charged mass must be occupying very small space

d. Strong deflections or even bouncing back of α-particles from metal foil were due to direct collision with positively charged mass in atom

Rutherford's model of atom :

This model explained that atom consists of nucleus which is concentrated in a very small volume. The nucleus comprises of protons and neutrons. The electrons revolve around the nucleus in fixed orbits. Electrons and nucleus are held together by electrostatic forces of attraction.

Drawbacks of Rutherford's model of atom :

a. According to Rutherford's model of atom, electrons which are negatively
charged particles revolve around the nucleus in fixed orbits. Thus,
b. The electrons undergo acceleration. According to electromagnetic theory of Maxwell, a charged particle undergoing acceleration should emit electromagnetic radiation.

Thus, an electron in an orbit should emit radiation. Thus, the orbit should shrink. But this does not happen

c.The model does not give any information about how electrons are distributed around nucleus and what are energies of these electrons

Isotopes: These are the atoms of the same element having the same atomic number but different mass number.e g $_1H^1$,$_1H^2$,$_1H^3$

Isobars: Isobars are the atoms of different elements having the same mass number but different atomic number.e g $_{18}Ar^{40}$, $_{20}Ca^{40}$

Isoelectronic species: These are those species which have the same number of electrons.

Electromagnetic radiations:

The radiations which are associated with electrical and magnetic fields are called electromagnetic radiations. When an electrically charged particle moves under acceleration, alternating electrical and magnetic fields are produced and transmitted. These fields are transmitted in the form of waves. These waves are called electromagnetic waves or electromagnetic radiations.

Properties of electromagnetic radiations:

a. Oscillating electric and magnetic field are produced by oscillating

charged particles. These fields are perpendicular to each other and both are perpendicular to the direction of propagation of the wave.
b. They do not need a medium to travel. That means they can even travel in vacuum.

Characteristics of electromagnetic radiations:

a. **Wavelength:** It may be defined as the distance between two neighbouring crests or troughs of wave as shown. It is denoted by λ.
b. **Frequency (v):** It may be defined as the number of waves which pass through a particular point in one second.

c. **Velocity (v):** It is defined as the distance travelled by a wave in one second. In vacuum all types of electromagnetic radiations travel with the same velocity. Its value is 3 $\times 10^{8}$ m sec^{-1}. It is denoted by v

d. Wave number: The reciprocal of wavelength is known as wave number.

Planck's Quantum Theory-

The radiant energy is emitted or absorbed not continuously but discontinuously in the form of small discrete packets of energy called 'quantum'. In case of light , the quantum of energy is called a 'photon'

The energy of each quantum is directly proportional to the frequency of the radiation, i.e. $E \alpha v$ or $E= hv$

where h= Planck's constant = 6.626×10^{-27} Js

Energy is always emitted or absorbed as integral multiple of this uantum. $E=nhv$ Where n=1,2,3,4,.....

Black body: An ideal body, which emits and absorbs all frequencies, is called a black body. The radiation emitted by such a body is called black body radiation.

Photoelectric effect:

The phenomenon of ejection of electrons from the surface of metal when light of suitable frequency strikes it is called photoelectric effect. The ejected electrons are called photoelectrons.

Experimental results observed for the experiment of Photoelectric effect-

o When beam of light falls on a metal surface electrons are ejected immediately.

 Number of electrons ejected is proportional to intensity or brightness of light

 Threshold frequency (v_0): For each metal there is a characteristic minimum frequency below which photoelectric effect is not observed. This is called threshold frequency.

If frequency of light is less than the threshold frequency there is no ejection of electrons no matter how long it falls on surface or how high is its intensity.

Photoelectric work function (Wo): The minimum energy required to eject electrons is called photoelectric work function.

$W_0 = hv_0$