Chemistry Study Materials for Class 11 (NCERT Based Notes of Chapter- 02)

Ganesh Kumar Date:- 06/09/2020

Structure of Atom

Wave nature of Electromagnetic Radiation

James Maxwell suggested that when electrically charged particle moves under acceleration, alternating electrical and magnetic fields are produced and transmitted. These fields are transmitted in the forms of waves called e***lectromagnetic waves or electromagnetic radiation (emr)***. These are the radiations associated with electric and magnetic fields. e.g. light.

The important characteristics of these radiations are:

1. The oscillating electric and magnetic fields are perpendicular to each other and both are perpendicular to the direction of propagation of the wave.
2. The electromagnetic waves do not require a medium for propagation and can move in vacuum.
3. There are many types of electromagnetic radiations, which differ from one another in wavelength (or frequency). These constitute electromagnetic spectrum. The important electromagnetic radiations in the increasing order of wavelength are: Cosmic rays, Gamma rays, X-rays, Ultra-violet rays, Visible light, Infra red rays, Microwaves, Radio waves.
4. All electromagnetic radiation travel through vacuum with a constant speed of $3x10^8$ m/s.

Some important terms relating to electromagnetic radiations

1. **Frequency (v):** It is defined as the number of waves that pass through a given point in one second. The SI unit for frequency is hertz (Hz, s^{-1}).
2. **Wavelength (λ)** : It is the distance between two adjacent crusts or two adjacent troughs. Its unit is m or cm.

3. Wave number ($\bar{\upsilon}$): It is defined as the number of wavelengths per unit length. It is the reciprocal of wavelength. Its unit is m^{-1} or cm^{-1}.

The frequency (v), speed of light (c) and the wave length (λ) are related to each other as: **c = v λ**

4. 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 $X10^{8}$m sec^{-1}. It is denoted by v

Particle Nature of Electromagnetic Radiation:

Some of the experimental phenomenon like diffraction and interference can be explained by the wave nature of the electromagnetic radiation. But some phenomena like black body radiation, photoelectric effect, variation of heat capacity of solids with temperature, line spectra of atoms etc. could not be explained by wave nature of emr.

Black body radiation

An ideal body which emits and absorbs all frequencies of radiations is called a *black body* and the radiation emitted by such a body is called *black body radiation*. The frequency distribution of radiation emitted from a black body depends only on its temperature. At a given temperature, intensity of radiation emitted increases with decrease of wavelength, reaches a maximum value at a given wavelength and then starts decreasing.

The phenomenon of black body radiation was first explained by ***Max Planck*** by his ***Quantum theory***.

According to this theory:

- The radiant energy is emitted or absorbed by a black body 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 (E) of a quantum of radiation is proportional to its frequency (v) It is expressed by the equation, **E = hv**

  Where 'h' is known as Planck's constant and its value is 6.626×10^{-34} J s.

- Energy is always emitted or absorbed as integral multiple of this quantum. E=n hυ Where n=1,2,3,4,.....

Photoelectric effect

It is the phenomenon of ejection of electrons by certain metals (like potassium, rubidium, cesium etc.) when light of suitable frequency incident on them. The electrons ejected are called photoelectrons. This phenomenon was first observed by H. Hertz. The important characteristics of photoelectric effect are:

1. The electrons are ejected from the metal surface as soon as the beam of light strikes the surface. i.e., there is no time lag between the striking of light beam and the ejection of electrons from the metal surface.
2. The number of electrons ejected is proportional to the intensity or brightness of light.
3. For each metal, there is a minimum frequency (known as threshold frequency [v_0]) below which photoelectric effect is not observed.
4. The kinetic energy of the ejected electrons is directly proportional to the frequency of the incident light.

Explanation of photoelectric effect

A satisfactory explanation to photoelectric effect was first given by **Albert Einstein** using Planck's Quantum theory.

According to him, when a photon of sufficient energy strikes the metal surface, it transfers its energy to the electron of the atom of the metal instantaneously and the electron is ejected without any time lag. A part of the energy is used to eject the electron from the metal surface (i.e. to overcome the attractive force of the nucleus [work function, hv_0]) and the other part is given to the ejected electron in the form of kinetic energy. Greater the energy possessed by the photon, greater will be transfer of energy to the electron and greater the kinetic energy of the ejected electron.

Since the striking photon has energy equal to hv and the minimum energy required to eject the electron is hv_0 (also called work function, W_0) then the difference in energy ($hv - hv_0$) is transferred as the kinetic energy of the photoelectron.

Following the law of conservation of energy principle, the kinetic energy of the ejected electron is given by

$$K.E = hv - hv_0$$

Or, $$hv = hv_0 + \frac{1}{2} m_e v^2$$

Where m_e is the mass of the electron and v is the velocity of the ejected electron.

A more intense beam of light contains larger number of photons, so the number of electrons ejected is also larger.

****