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Quantum Theory

Quantum theory is the theoretical basis of modern physics that explains the nature and behaviour of matter and energy on the atomic and subatomic level. The nature and behaviour at that level is sometimes referred to as quantum physics and quantum mechanics.

The different forms of energy such as radio waves, heat rays, ordinary light, x-rays etc., which are emitted by atoms under different situations are all electro-magnetic radiations varying in frequency (or wavelength). We call them electro-magnetic waves under because under suitable circumstances they exhibit refraction, interference and diffraction.

The wave like character of radiation however failed to explain the observed energy distribution in the continuous spectrum of radiation emitted by hot bodies. To meet this serious problem, Planck in 1901, presented his quantum theory of radiation.

According to this theory, radiation is emitted or absorbed discon-

tinuously in indivisible packets of energy. These packets were named 'quanta' or 'photons'. Each photon of radiation of a given frequency ν has the same energy which is hν, where h is now known as Plank's constant. Plank did not suggest anything new regarding the propagation of radiation in space. He was agreeable to that it propagated continuously through space as electromagnetic waves.

Einstein extended Plank's quantum hypothesis by assuming that radiation not only is emitted or absorbed as indivisible photons but also continues to propagate through space as photons. On this hypothesis he in 1905 explained photoelectric effect and in 1907 talked the problem of sp. heat of solids. In 1913, Bohr used the quantum theory to explain the hydrogen spectrum and in 1922, compton applied it to the scattering of X-rays.

properties of Photons:-

(i) Photons are indivisible packets of electromagnetic energy.

(ii) They retain their identity until completely absorbed by some atom.

(iii) The size of a photon (hν) is proportional to the frequency of radiation so that photons

of different radiations of are of different size.

(iv) The intensity of radiation is equal to the no. of photons crossing unit area per second multiplied by size of the photon.

(v) All photon travel with the speed of light in vacuum and have a zero rest mass.

(vi) The total energy E of a particle is related to its rest mass m_0 and momentum P by the relⁿ.

$$E = \sqrt{(m_0^2 c^4 + P^2 c^2)}$$

For photon, $m_0 = 0$

$$E = Pc$$

but $E = h\nu$, thus

$$P = \frac{E}{c} = \frac{h\nu}{c}$$

(vii) The existence of momentum for a photon implies that it must have an effective mass m also. This mass can be computed by mass - energy relⁿ. ($E = mc^2$)

$$m = \frac{E}{c^2} = \frac{h\nu}{c^2}$$