

## CHAPTER: PHOTON

According to Einstein's quantum theory of light, light is propagated in packets of small energy, called as photons.

- Photons are the smallest packet of energy moving with speed of light.
- Photons are created due to vibrational motion of charged particles. However, photons are chargeless.
- Frequency of photon is equal to the frequency of vibration of charged particles.

If,  $f = \text{frequency of a photon}$ , then it's energy  $E = hf$

$h = \text{Plank's constant, } h = 6.62 \times 10^{-34} \text{ JS.}$

- If a light (or EM-radiation) contains ' $N$ ' number of photons, then

Total energy of light is:  $E = Nhf$

- Energy of photon  $E = hf = h \frac{hc}{\lambda}$  ;  $\lambda = \text{Wavelength of Photon.}$

✓ **Photons behave as particles.**

✓ Light possesses wave-particle dual behavior.

- In Some cases (like reflection, refraction, dispersion, interference, diffraction, polarization), Light behaves as waves.
- In Some other cases (like: Photoelectric effect, Compton effect, Raman effect), light behave as particles.
  - Photon is the basic unit of all electromagnetic waves.
  - Photons are always in motion.

Properties of photons:

1. They have zero rest mass and zero rest energy - They only exist as moving particles.
2. They are Chargeless. [Not affected by EM field].
3. They carry energy [ $E = hf$ ] and momentum [ $p = mc$ ] [**Also, momentum:  $p = h/\lambda$** ]
4. The energy of a photon of frequency  $f$ :  $E = hf = h \frac{hc}{\lambda}$
5. Mass of a photon is given by:

$$m = \frac{hf}{c^2}$$

Photon as particle:  $E = mc^2$

Photon as wave:  $E = hf$

*As radiations emitted from different sources have different frequencies, photons have different masses (also have different energies).*

*Theoretically, mass of body will increase when it absorbs photon and mass of a body will decrease when it emits photon. Experimentally, the change in mass is negligible.*

- ✓ From Einstein's relativistic theory, mass of a particle moving with velocity  $v$  is:  $m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

**For photon,  $v = c$ ,  $\therefore m_0 = 0$ . The rest mass of photon is zero.**

6. Photons travel with the speed of electromagnetic radiation (or light) =  $2.998 \times 10^8 \text{ m/s}$  (In vacuum)
7. Photons exert force and pressure when incident on a surface.
8. A photon is created due to the vibrational motion (SHM) of charged particles.
9. Photons exhibit both particle and wave nature.
10. The spin of photon is 1.
11. The photons are the carriers (or mediators) of electromagnetic force.
12. As a photon travels from one medium to another, it's velocity changes (maximum in vacuum). **This change in velocity causes the change in wavelength but frequency remains the same.**

**It obeys principle of conservation of energy.**