Jaya

UNIT- I
Quantum Physics

classical theory is a macroscopic theory. It fails to explain the micro-concepts like stability of atoms, black body radiation, photoelectric effect, compton effect etc. Also according to classical theory the hydrogen spectrum is a continuous spectrum but the actual experimentally observed spectrum is found to be discrete. Thus to avoid these discrepancies a new microscopic theory called Quantum theory was introduced by maxplank and the same was developed by others.

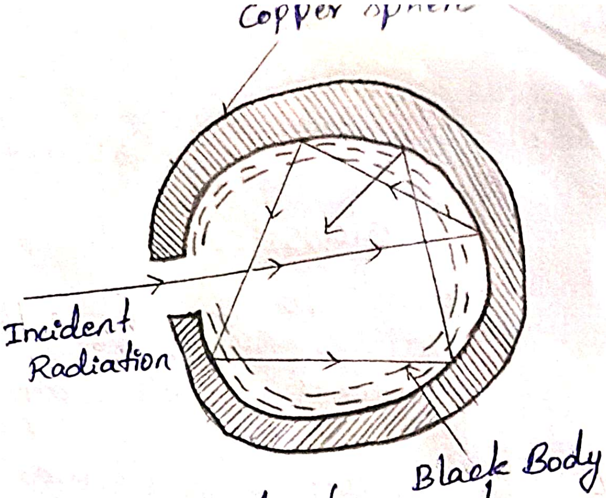
Black Body Radiation.

Perfect black body : A perfect black body is the one which absorbs and emits all the radiations that fall on it. The radiation given out by a perfect black body is called black body radiation.

Kirchoff's law : Ratio of emmisive power to the co-efficient of absorption of any given wavelength is the same for all bodies at a given temperature and is equal to the emissive power of the black body at that temperature.

$$\frac{e_\lambda}{a_\lambda} = E$$

Experiment :



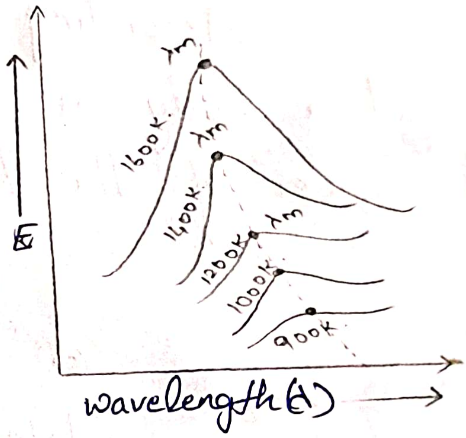
In practice, a perfect black body is not available. Therefore let us consider a hollow copper sphere coated with lamp black on its inner Surface. A fine hole is made for radiations to enter into the sphere as shown in the figure.

Now, when the radiations are made to pass through the hole it undergoes multiple reflections and are completely absorbed. Thus, the black body act as a perfect absorber. Now, when this black body is placed in a temperature bath of fixed temperature, the heat radiations will come out only through the hole in the sphere and not through the walls of the sphere.

Therefore, we can conclude that the radiations are emitted only from the inner surface of the sphere and not from the outer surface of the sphere. Thus a perfect black body is a perfect absorber and also a perfect radiator of all wavelengths.

Energy Spectrum

when a perfect black body is allowed to emit radiations at different temperatures, then the distribution of energy for different wavelengths at various temperatures is obtained as shown in figure.
From figure the following results are formulated.



① The energy distribution is not uniform for any given temperature.

② The intensity of radiation increases with respect to the increase in wavelength and at a particular wavelength, it becomes maximum (λ_m and after this, it starts decreasing with respect to the increase in wavelength.

③ When the temperature is increased, the maximum wavelength (λ_m) decreases.

④ For all the wavelengths, an increase in temperature causes increase in energy.

⑤ The total energy emitted at any particular temperature can be calculated from the area under that particular curve.

Energy Distribution Laws.

Different laws were proposed for explaining the energy distribution with respect to the wavelength. They are as follows.

1. Stefan - Boltzmann's law.

According to this law the radiant energy (E) of a body is directly proportional to the fourth power of the temperature (T) of the body.

$$E \propto T^4$$

(or) $$E = \sigma T^4$$

where σ - stefan constant given by.

$$\sigma = \frac{2\pi^5 K_B^4}{15h^3c^2}$$

2. Wien's Displacement Law

This Law states that the product of the wavelength (λ_m) corresponding to maximum energy and the absolute temperature (T) is a constant.

ie $\lambda_m T$ = constant.

This law shows that, as the temperature increases, the wavelength corresponding to maximum energy decreases.

Wien also showed that the maximum energy (E_{max}) is directly proportional to the fifth power of the absolute temperature.

$$E_{Max} \propto T^5$$

(or) $$E_{max} = \text{Constant } T^5$$

By deducing this law, he obtained a law called wiens law of distribution of energy (E_λ) given by

$$E_\lambda = C_1 \lambda^{-5} e^{-C_2/\lambda T}$$

where C_1 and C_2 are constants given by $C_1 = 8\pi hc$ and

$$C_2 = \frac{hc}{K_B}$$

This law holds good only for shorter wavelengths and not for longer wavelengths.

3. Rayleigh - Jeans law.

According to this law, the energy distribution is directly proportional to the absolute temperature and is inversely proportional to the fourth power of the wavelength. It is governed by the equation.

$$E_\lambda = \frac{8\pi K_B T}{\lambda^4}$$

where K_B is the Boltzmann constant.

This law holds good only for longer wavelength regions and not for shorter wavelengths.

It is found that, both wiens and Rayleigh - Jeans law do not agree with the experimental results. Therefore we can conclude that the classical theory was not able to explain the emission of black body radiation.