Marwari college Darbhanga

Subject---physics (Hons)

Class--- B.Sc. part 1

Paper---02 ; Group—A

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Stefan-Boltzman law

According to Stefan Boltzmann law, the amount of radiation emitted per unit time from an area A of a black body at absolute temperature T is directly proportional to the fourth power of the temperature.

$u = sAT^4$ . . . . . . (1)

where s is Stefan's constant = 5.67×10^{-8} W/m^2 k^4

A body which is not a black body absorbs and hence emit less radiation, given by equation (1)

For such a body, $u = e\sigma AT^4$ . . . . (2)

where e = emissivity (which is equal to absorptive power) which lies between 0 to 1.

With the surroundings of temperature T_0, net energy radiated by an area A per unit time.

$\Delta u = u - u_o = e\sigma A [T^4 - T_0^4]$ . . . . (3)

Stefan Boltzmann Law relates the temperature of the blackbody to the amount of the power it emits per unit area. The law states that;

"The total energy emitted/radiated per unit surface area of a blackbody across all wavelengths per unit time is directly proportional to the fourth power of the black body's thermodynamic temperature. "

$\Rightarrow \varepsilon = \sigma T^4$

Derivation of Stefan Boltzmann Law

The total power radiated per unit area over all wavelengths of a black body can be obtained by integrating Plank's radiation formula. Thus, the

$$\frac{dP}{d\lambda}\frac{1}{A} = \frac{2\pi hc^2}{\lambda^5\left(e^{\frac{hc}{\lambda kT}} - 1\right)}$$

radiated power per unit area as a function of wavelength is:

Where,

1. P is Power radiated.
2. A is the surface area of a blackbody.
3. λ is the wavelength of emitted radiation.
4. h is Planck's constant
5. c is the velocity of light
6. k is Boltzmann's constant
7. T is temperature.

On simplifying Stefan Boltzmann equation, we get:

$$\frac{d\left(\frac{P}{A}\right)}{d\lambda} = \frac{2\pi hc^2}{\lambda^5\left(e^{\frac{hc}{\lambda kT}} - 1\right)}$$

On integrating both the sides with respect to λ and applying the limits we get;

$$\int_0^\infty \frac{d\left(\frac{P}{A}\right)}{d\lambda} =$$

$$\int_0^\infty \left[\frac{2\pi hc^2}{\lambda^5\left(e^{\frac{hc}{\lambda kT}} - 1\right)}\right] d\lambda$$

The integrated power after separating the constants is:

$$\frac{P}{A} = 2\pi hc^2 \int_0^\infty \left[\frac{d\lambda}{\lambda^5\left(e^{\frac{hc}{\lambda kT}} - 1\right)}\right]$$

–(1)