Name of Teacher – Bhupendra Singh

Exercise Expermental verification of Planck's law and Composition w/d other formula:-

Show the no. of photon in "Black body" radiation at a Temp. T is equal to

$$N = \frac{V}{\pi^2}\left(\frac{kT}{\hbar c}\right)^3 \int_0^\infty \frac{x^2\,dx}{e^x - 1}$$

we already have the no. of resonator per unit volume in the freq^n range ν and $\nu + d\nu$

$$= \frac{8\pi\nu^2}{c^3}\,d\nu$$

And energy of each resonator

$$= \frac{h\nu}{e^{h\nu/kT} - 1}$$

Total Energy of Resonator per unit volume

$$= \left(\frac{8\pi\nu^2 d\nu}{c^3}\right)\left(\frac{h\nu}{e^{h\nu/kT} - 1}\right)$$

photon energy $= h\nu$

$\therefore$ no. of photon per unit volum in the enclosure b/w ν and $\nu + d\nu$ (freq^n)

$$= \frac{8\pi\nu^2 d\nu}{c^3}\,\frac{1}{e^{h\nu/kT} - 1}$$

If V is volume of enclosure, then no. of photon in ~~between~~ freq range ν and $\nu+d\nu$

$$n = \frac{8\pi V \nu^2 d\nu}{c^3} \cdot \frac{1}{e^{h\nu/kT}-1}$$

Total no. of photon

$$= \frac{8\pi V}{c^3}\int_0^\infty \frac{\nu^2 d\nu}{e^{h\nu/kT}-1}$$

Let $\frac{h\nu}{kT} = x$

$\frac{xkT}{h} = \nu$

$d\nu = \frac{kT}{h}dx$

$$\therefore n = \frac{V}{\pi^2}\left(\frac{2\pi kT}{hc}\right)^3 \int_0^\infty \frac{x^2 dx}{e^x - 1}$$

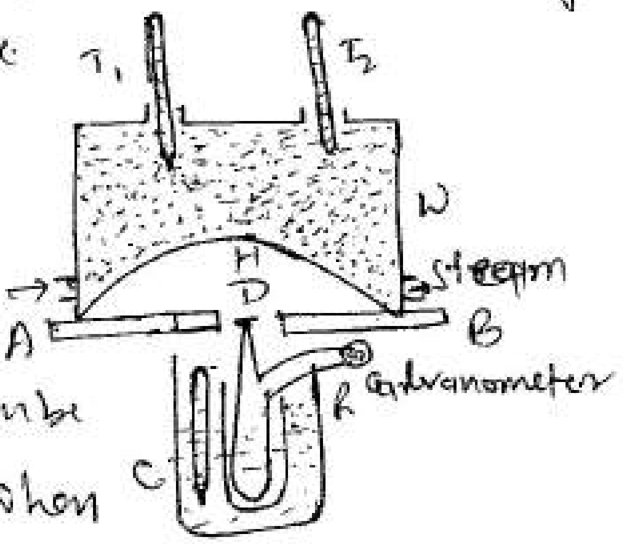
$$\boxed{N = \frac{V}{\pi^2}\left(\frac{kT}{\hbar c}\right)^3 \int_0^\infty \frac{x^2 dx}{e^x-1}}$$

$\hbar = h/2\pi$

Ex: Find out the expression for the wavelength corresponding to maximum energy of emission according to formula of planck.

Determination of Stefan's Constant

Apparatus for Calculation of Stefan's Const. Consist ~~ent~~ of a hallow metallic hemisphere H blackened inside and a wooden box W lined with tin which serves as a steam chamber. Steam can be passed in the chamber when desired and then in steady state the temp. of hemisphere remains const; equal to that of steam and may be measured by thermothermometers T_1 and T_2. The Hemisphere H rest symmetrically on a plateform AB which has a small hole at centre D. A small silver disc ~~AB~~ D blackend at its top surface can be fitted or taken out from the hole.



one junction of the silver-Contantan couple is soldered to the lower surface of D; while other is placed in the water bath or sand container C. A sensitive galvanometer (G) is introduced in thermocouple circuit with resistance R.

When the inner surface of H is heated by passing steam, it acts as a black body radiator. The disc D absorbs the radiation emitted by H and its temperature rises continuously, thus causing a difference of temperature in the two junctions of the thermocouple.

If T_1 is the steady state temp. of H and T_0 is that of disc D, when it is just exposed to radiation from H.

Then by Stefan-Boltzmann law the net energy gained by disc per second $= EA$

$$= \sigma(T_1^4 - T_0^4) A \text{ Joul, A being area of disc.}$$

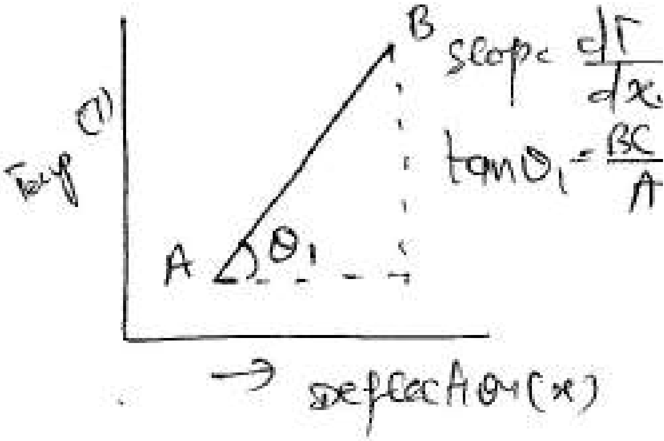
$$= \frac{\sigma(T_1^4 - T_0^4) A}{J} \text{ Kilocal.}$$

If m is the mass of disc, c is specific heat and dT/dt is rate of rise of temp. at T_0 then the energy gained by disc per second would be $mc(dT/dt)$; hence we must have

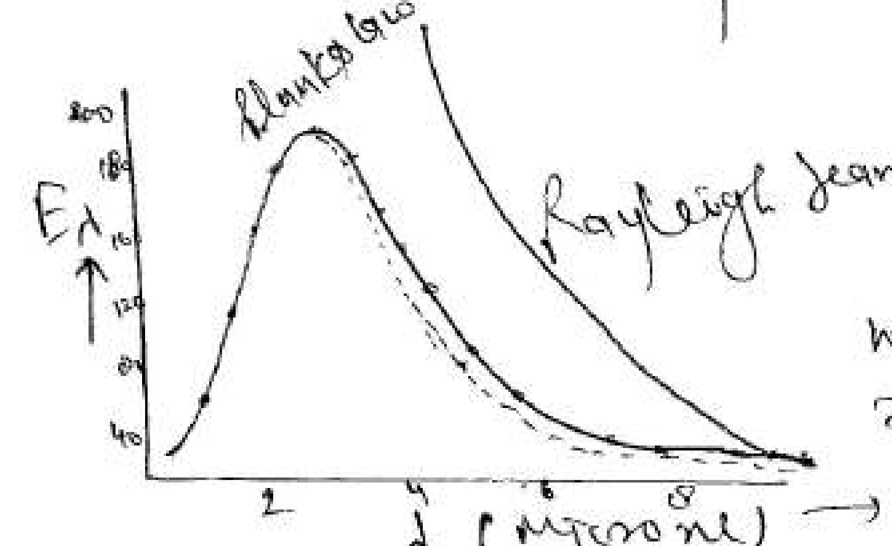
$$mc\frac{dT}{dt} = \frac{\sigma(T_1^4 - T_0^4)A}{J}$$

$$C = \frac{Jmc}{A(T_1^4 - T_0^4)}\frac{dT}{dt} \quad \text{watt } m^{-2}K^{-4}$$

. evaluate $\frac{dT}{dt}$



Experimental verification of planck's Radiatio law and Comparison w/d other formula



spectrum of BB radiat was produced by ~~refra~~ refraction through a fluorspar prism

A concave mirror was used to obtain the image of the slit. This was focussed on Lummer Kurlbaum linear spectrum bolometer which was ~~eaablarch~~ used to measure the radiant energy or distribution of energy.

Ex. 1 Impacts and unility of plancks laws. sol?.

Ex - 2.1 White dwarf Star
2.2 Chandra ~~sekhar limit~~ Sekhar Mass limit

Drive the Stefan's constant and Wein's constant in terms of plank's and Boltzman's constant. (using Planck's constant.

Using plank formula the total radiant energy in unit volume of an isothermal enclosure is given by

$$U = \int_0^\infty E_\lambda d\lambda = 8\pi hc \int_0^\infty \frac{d\lambda}{\lambda^5 (e^{hc/\lambda KT} - 1)} \longrightarrow (1)$$

But the total radiant energy in unit volume of an isothermal enclosure is also given by

$$U = AT^4 \longrightarrow (2)$$

Where A is constant and T is the absolute temp. of enclosure

Comparing (1) and (2)

$$AT^4 = 8\pi hc\int_0^\infty \frac{d\lambda}{\lambda^5\left(e^{hc/\lambda kT}-1\right)}$$

Let $x = \frac{hc}{\lambda kT} \Rightarrow \lambda = \frac{hc}{xkT}$

$d\lambda = -\frac{hc}{x^2 kT}dx$, we have

$$AT^4 = 8\pi hc\int_\infty^0 \frac{-\frac{hc\,dx}{x^2kT}}{\left(\frac{hc}{xkT}\right)^2\left(e^x-1\right)}$$

$$\Rightarrow \quad A = \frac{8\pi^5 k^4}{15h^3c^3}$$

Since Stefan's constant (σ) is given by

$$\sigma = \frac{Ac}{4}$$

$$\sigma = \frac{8\pi^5k^4}{15h^3c^3}\times\frac{c}{4} = \frac{2}{15}\frac{\pi^5k^4}{h^3c^2}$$

which is required expression for Stefan's const.

Wein's const. → Acc. to Weins law

$$b = \lambda_m T$$

wavelength ← $\lambda_m = \frac{hc}{4.965\,kT}$ (we have already

$$\lambda_m T = \frac{hc}{4.965\,k} = b$$