Wien's Displacement Law for Radiation.

Ans. Suppose that radiation is enclosed in an evacuated space with perfectly reflecting walls and provided with a perfectly reflecting position ; so that no heat transference take place between the radiation and the walls. We assume that at one point in the wall, there is a small speck of ordinary matter by means of which the enclose is filled with radiation at a uniform temperature T (the heat capacity of the matter may be neglected.

If E is the energy density of the radiation which is function of T only. Maxwell's electronic theory of light shows that isotropic radiation of density E exerts a pressure P given by

$$p = \frac{E}{3}$$

If V is the volume of the enclosure , the total energy of radiation in it is

$U = E.v$

Let us now suppose that a small amount of heat dQ flow into the enclosure from out side and at the same time the volume is allowed to change from v to v+ dv. The temperature T & consequently the energy density E also changes by an infinitesimal amount . According to 1st law of thermodynamics

$$dQ = d\,(E\ v) + Pdv$$

Or

$$dQ = d\,(E\ v) + Pdv$$

$$= E\ dv + vdE + Pdv$$

$$= E\ dv + vdE + \frac{E\ dv}{3}$$

$$dQ = vdE + \frac{4}{3}Edv$$

If the expansion is adiabatic, then dQ = 0, so that

$$\frac{4}{3}Edv + vdE = 0$$

$$\frac{4}{3}\frac{dv}{v} + \frac{dE}{E} = 0$$

On integration,

$$\frac{4}{3}\ \log v + \log E = \text{constant}$$

$$v^{\frac{4}{3}}.E = \text{constant}$$

According to Stefan law ,the energy density of the radiation

$$E = \sigma T^{4}$$