Unit – 4

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Thermal Physics and Statistical Mechanics
B.Sc (H) GE–IV

LECTURE – I

> Black Body Radiation:

Whenever a body is irradiated with radiation of any wavelength a fraction of the total incident radiation is absorbed, a part is reflected and the remaining is transmitted.

i.e.

$$\alpha + \rho + t = 1 \quad \text{——— (1)}$$

where α = Absorptivity
ρ = Reflectivity
t = Transmissivity

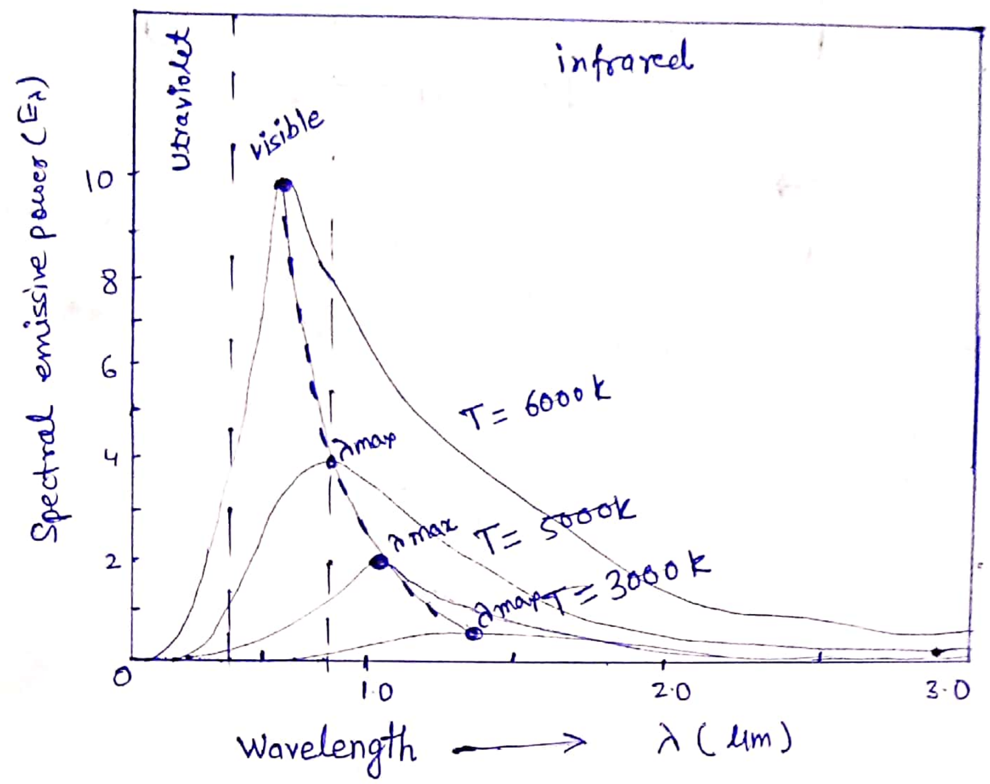
Thus, Absorptivity is the fraction of radiation absorbed by a surface.
Reflectivity is the fraction of radiation reflected by the surface.
Transmissivity is the fraction of radiation, transmitted by the surface.

The values of α, ρ and t depending on the nature of the surface or body.

A body for which $\alpha = 1$ for all wavelengths is a Black body.

i.e. A perfectly Black-body is one which absorbs all the heat radiations of any wavelength incident on it. It neither reflects nor transmits any of the incident radiations and, therefore appears black.

> Spectral distribution:→



The first attempt was made by Lummer and Pringsheim in 1899. They plotted some curves between E_λ (spectral emissive power) and λ (wavelength) for various temperature as shown in figer. these plots are known as spectral energy distribution cure of Black-body radiation.

From the cure it is clear that :-

(i) The graph is continuous, which means that at every temperature radiation for all wavelengths are emitted but the spectral emissive power is different for different wevelengths. In other words the distribution of energy is not uniform in the radiation spectrum of a Black-body.

(ii) The spectral energy density E_λ for each λ (wavelength) increases with temperature or as the temperature of the object increases.

(iii) For a perticular temperature, first E_λ increases with λ but after reaching a certain maximum value it decreases. ~~i.e. $E_{\lambda max}$~~ when

i.e. The highest value is denoted by $E_{\lambda m}$ and the wavelength at which E_λ is maximum is denoted by λ_m.

(iv) As seen from the graph the ~~wade~~ wavelength (λm) corresponding to maximum emission, shifts towards lower wavelength with increase in temperature. It was Wein who first discovered mathematically that

$$\lambda_m \propto \frac{1}{T}$$

$$\Rightarrow \lambda_m = \frac{b}{T}$$

$$\Rightarrow \boxed{\lambda_m T = b}$$ (constant), which is wein's displacement law

where $b = 2.968 \times 10^{-3}$ meter-kelvin.

(v) It can also be seen the graph that the value corresponding to peak of the curve increases rapidly with temperature. it was found that $\boxed{E_{\lambda m} \propto T^5}$

(vi) The total energy emitted by the body at a perticular temperature is represented by the area under the curve.

i.e. $\int_0^\infty E_\lambda d\lambda$, this is the total emissive Power of Black-body.

It was found that area under the curve is directly proportional to the fourth power of absolute temperature, hence

$$E \propto T^4$$

OR $E = \sigma T^4$

where σ is Stephan's constant and has the value

$$\sigma = 5.67 \times 10^{-8} \text{ watt/m}^2/K^4$$

This is known as Stephan-Boltzmann's law.

(vii) The Black-body spectrum depends only on temperature of the body not on its nature, i.e. All ~~body~~ bodies will emit the same Black-body ~~spectrum~~ spectrum, if their temperature are the same.

---X---X---X---X---