

Question

- (a) Derive Planck's law of Black body radiation. Discuss its experimental verification as well.
- (b) Show that Rayleigh Jean's law and Wien's law are special cases of Planck's law.

Ans: - Planck's Law of Radiation →

Wien's law derived on the basis of classical thermodynamics and Rayleigh-Jean's law deduced from the classical electromagnetic theory with the application of statistical mechanics and equipartition of energy not only failed to give results compatible with experimental observations, but also led to the absurd conclusion.

The most satisfactory formulae both on theoretical and experimental grounds is that Planck which can be stated as

$$u_{\lambda} d\lambda = \frac{8\pi hc}{\lambda^5} \cdot \frac{1}{e^{hc/\lambda KT} - 1} d\lambda \quad \text{--- (1)}$$

we can readily show that classical formulae: - Wien's law and Rayleigh Jean's law are simply particular cases of it.

There are two cases arises: →


for short wavelength i.e. λT is small, $\left(\frac{hc}{\lambda KT}\right) \gg 1$ and accordingly 1 in the denominator of (1) can be neglected, so from Wien's law

$$u_{\lambda} = \frac{8\pi hc}{\lambda^5} e^{-hc/\lambda KT} \rightarrow \text{Wien's law of radiation} \quad \text{--- (2)}$$

for long wavelength i.e. λT is large. $e^{hc/\lambda KT}$ may be expanded by the exponential theorem and

$$e^{hc/\lambda KT} = 1 + \frac{hc}{\lambda KT} \quad (\text{approximately})$$

$$\therefore u_{\lambda} = \left(\frac{8\pi}{\lambda^4}\right) KT \rightarrow \text{Rayleigh-Jean's law} \quad \text{--- (3)}$$



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Deduction of Planck's Radiation :->

Suppose legitimately that the enclosure of an experimental black body is filled with linear electromagnetic oscillators. Now the problem of the spectral distribution of radiant energy present in the enclosure can be reduced to that of the mean energy of an oscillator at a given temperature.

Planck abandoned the hypothesis of continuous emission of radiation by resonators and assumed that they emit energy only when the energy absorbed.