Ch 1 : Boltzmann & Plank

$h = 6.626 \times 10^{-34}$ Js $\qquad k_B = 1.38 \times 10^{-23}$ JK^{-1}

$c = 3 \times 10^{8}$ m/s

① BLACK BODY RADIATION

★ For a body in thermal Eqbm: $\boxed{e_\nu = J(\nu, T)\, a_\nu}$

e_ν : emitted power per unit Ar, per unit freq

a_ν : fraction of incident power absorbed. → For black Body. ⟹ $\boxed{e_\nu^{BB} = J(\nu, T)}$

★ Density (per unit vol) of standing waves in the freq interval ν and $\nu + d\nu$

$$\boxed{N(\nu)\, d\nu = \frac{8\pi\nu^2}{c^3}\, d\nu}$$

→ we'll derive this soon enough.

★ No of oscillators btwn energy E & $E + dE$: $N(E)\, dE = dN$ & $N = \int dN = \int_0^\infty N(E)\, dE$

★ Maxwell- Boltzmann: $\boxed{N(E)\, dE = \frac{N}{k_B T} e^{-E/k_B T}\, dE}$

★ Avg value of Energy : $\bar{E} = \dfrac{\int_0^\infty E \cdot N(E)\, dE}{\int_0^\infty N(E)\, dE} = k_B T$ for M.B. distribution of Energy.

probability

→ We integrate because every energy $E \in (0, \infty)$ is allowed

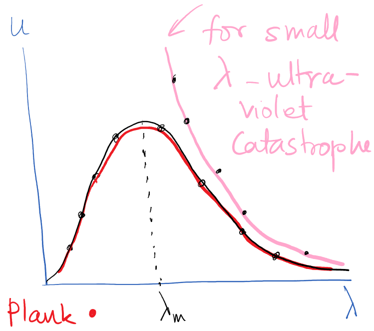
★ Define $u(\nu)\, d\nu \equiv$ Energy per unit volume in freq interval $d\nu$

$$\boxed{u(\nu)\, d\nu = k_B T\, N(\nu)\, d\nu = \frac{8\pi\nu^2}{c^3} \cdot k_B T\, d\nu}$$

→ RAYLEIGH JEANS LAW

$\{u(\nu)\, d\nu = \bar{E} N(\nu)\, d\nu\}$

Remember : $\boxed{J(\nu, T) = u(\nu, T) \times \frac{c}{4}}$ → (won't derive this)



Deviated for small λ - ultra-violet Catastrophe

Plank •

R-J •

★ PLANK'S GUESS → Not every energy level is allowed

$\boxed{E_{oscillator} = nh\nu = E_n}$ (later the exact $(n + \frac{1}{2})h\nu$ — doesn't make a diff here)

$$\therefore \quad \bar{E} = \frac{\sum_{n=0}^{\infty} E_n \cdot e^{-E_n/k_B T}}{\sum_{n=0}^{\infty} e^{-E_n/k_B T}} = \frac{\sum nh\nu\, e^{-nh\nu/k_B T}}{\sum e^{-nh\nu/k_B T}} = \frac{h\nu}{\left[\exp\left(\frac{h\nu}{k_B T}\right) - 1\right]}$$

$\therefore$ Plank ⇒ $u(\nu)\, d\nu = \dfrac{8\pi\nu^2}{c^3} \times \dfrac{h\nu}{(\ldots)}\, d\nu$ → Q.M.

Energy is QUANTIZED = discrete

$\therefore$ Plank $\Rightarrow$ $\boxed{u(\nu)\,d\nu = \frac{8\pi\nu^2}{c^3} \times \frac{h\nu}{\left(\exp\left(\frac{h\nu}{k_B T}\right)-1\right)}\,d\nu}$ $\rightarrow$ Q.M. = Success !

$\star$ Stephan's Law : $\boxed{J = \sigma T^4}$ $\Rightarrow$ Power $= \sigma A T^4$ $\sigma = 5.67 \times 10^{-8}$ S.I. units

$\hookrightarrow$ Radient power per unit area.

$\star$ Wien's Law : $\boxed{\lambda_m T = 2.89 \times 10^{-3}\ m \cdot k}$

λ_m $\rightarrow$ Wavelength with Max intensity on a BBR spectrum

2.89×10^{-3} $\hookrightarrow$ Wein's displacement Const