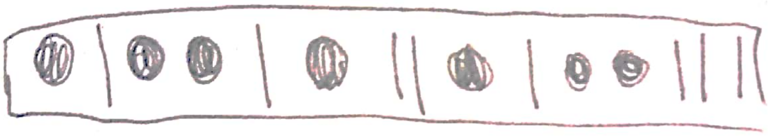
4b) dividir P cuantos de energía

en N osciladores



es como distribuir P cuantos y N-1

separaciones |

$W = m!$ formas de distribuir m elementos

$(m = P+N-1)$

$W = \frac{m!}{P!}$ los cuantos son idénticos

(bosones?)

$W = \frac{m!}{P!(N-1)!}$ las separaciones o

osciladores son

iguales.

microestados

Escaneado con CamScanner

Para la entropia $S = k_b \ln(w)$

$$S = k_b \ln W = k_b \{ \ln[(P+N-1)!] - \ln[P!] - \ln[(N-1)!] \}$$

Para P y N grandes

$$S \simeq k_b \{ \ln[(P+N)!] - \ln[P!] - \ln[N!] \}$$

aprox. de Stirling $\ln[N!] = N \ln N - N$

$$\ln[(P+N)!] = (P+N) \ln(P+N)$$

$$\ln(P!] = P \ln(P] \; ; \; \ln(N!] = N \ln(N]$$

$$* \; S = k_b \{ (P+N) \ln(P+N) - P \ln(P) - N \ln(N] \}$$

$$* \Rightarrow (P+N) \ln(P+N] - N \ln(N]$$

$$\Rightarrow P \ln(P+N] + N \ln\left(\frac{P+N}{N}\right]$$

$$P = \frac{N \cdot U}{h_f} \qquad N \ln\left(\frac{P+N}{N}\right] = N \ln\left(1 + \frac{U}{h_f}\right]$$

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calculo intermedio

$$\rightarrow P\,Ln(P+N] - P\,Ln(P]$$

$$\rightarrow P\,Ln\left(\left(\frac{P}{N}+1\right)N\right] - P\,Ln(P]$$

$$\rightarrow P\,Ln(N] + P\,Ln\left(\frac{U}{nf}+1\right] - P\,Ln(P]$$

$$\rightarrow P\,Ln\left(\frac{U}{hf}+1\right] + P\,Ln\left(\frac{N}{P}\right]$$

Escaneado con CamScanner

Con los calculos intermedios (46 fin.

$$S = k_b \left\{ N \ln\left(1 + \frac{u}{hf}\right] + P \ln\left(1 + \frac{u}{hf}\right] + P \ln\left(\frac{N}{P}\right] \right\} \quad / \quad \frac{P}{N} = \frac{\cancel{N} u}{hf} \cdot \frac{1}{\cancel{N}}$$

$$S = k_b N \left\{ \left(1 + \frac{u}{hf}\right] \ln\left(1 + \frac{u}{hf}\right] \ldots \right.$$

$$\left. \ldots - \frac{u}{hf} \ln\left(\frac{u}{hf}\right] \right\}$$

Escaneado con CamScanner

4C 1

Para varios osciladores

$$m\ddot{x} + m\omega_0^2 x - \gamma\dot{x} = eE\cos\omega t$$

$$A = \frac{eE}{\sqrt{m^2(\omega_0^2 - \omega^2) + (\gamma\omega)^2}} \qquad U = \frac{1}{2} m\omega_0^2 A^2$$

Planck jugó y llegó a

$$\rho(f,T) = \left(\frac{8\pi f^2}{c^3}\right) U(f,T)$$

Escaneado con CamScanner

4c 2 a

$$\frac{S}{N} = k_b\left[\left(1+\frac{U}{n_f}\right)\ln\left(1+\frac{U}{n_f}\right] - \frac{U}{n_f}\ln\left(\frac{U}{n_f}\right]\right]$$

$$\frac{\partial s}{\partial U} = k_b\left[\frac{1}{n_f}\frac{\partial}{\partial U}\left((n_f+U)\ln\left(1+\frac{U}{n_f}\right]\right.\right.$$

$$\left.\left. - U\ln(U] + U\ln(n_f)\right)\right]$$

Escaneado con CamScanner

4c (2b)

$$\frac{k_b}{h_f}\left(\ln\left(1+\frac{U}{h_f}\right) + \frac{U}{h_f}\cdot\frac{1}{1+\frac{U}{h_f}} - \ln(U) - 1 + \ln(h_f)\right)$$

$$\frac{k_b}{h_f}\left(\ln\left(1+\frac{U}{h_f}\right) - \ln\left(\frac{U}{h_f}\right) + \frac{U}{\cancel{h_f}}\,\frac{\cancel{h_f}}{h_f+U} - 1\right)$$

$$/\, h_f \simeq 0 \qquad \frac{U}{h_f+U} = 1$$

$$\frac{k_b}{h_f}\left(\ln\left(1+\frac{U}{h_f}\right) - \ln\left(\frac{U}{h_f}\right)\right) = \frac{\partial S}{\partial U}$$

//

4c ③

$$\ln\left(1+\frac{U}{hf}\right)-\ln\left(\frac{U}{hf}\right)=\frac{hf}{kT} \quad / e^{y}$$

$$\ln\left(\frac{hf}{U}+1\right)=\frac{hf}{kT}$$

$$\frac{hf}{U}+1=e^{hf/kT}$$

$$\frac{hf}{U}=e^{hf/kT}-1$$

$$U=\frac{hf}{e^{hf/kT}-1} \quad //$$

Escaneado con CamScanner

4C (4)

$$\rho(f,T) = \frac{8\pi f^2}{c^3}\left(\frac{hf}{e^{hf/kT} - 1}\right)$$

Ley de Planck

Escaneado con CamScanner