a) $dw = e^{\frac{\psi - E}{\Theta}} (dq\, dp)^f$

$\psi = F$, $E = \mathcal{H}(q, p)$ $\Theta = kT$ $f = \#$ frihedsgrader

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b) Hvis $E = \Sigma\, \alpha_i p_i^2 + \Sigma\, \beta_i q_i^2$

så er

~~$\int q_i^2 e^{-\alpha q_i^2 + f(q)} = -\frac{\partial \psi}{\partial \alpha_i}$~~

Hvis $E = \Sigma\, \varepsilon_i$, $\varepsilon_i = \frac{p_i^2}{2m} + \alpha_i q_i^2$

så er: $\overline{\frac{p_i^2}{2m}} = \frac{1}{2} kT$ $\overline{\alpha_i q_i^2} = \frac{1}{2} kT$

$E = 2f \cdot \frac{1}{2} kT$ ∴ hvert kvadratisk led bidrager

med $\frac{1}{2} kT$ til middelenergien. = den indre energi

$\overline{E} = u$.

<u>Bevis:</u> $\overline{\alpha q^2} = \int (dq\, dp)^{f-1} \cdot e^{-\frac{\alpha_i}{\Theta} q_i^2} q_i^2 dq_i \cdot e^{-\frac{E - \alpha_i q_i^2}{\Theta}}$

$$= \frac{\alpha \int dq_i\, q_i^2 e^{-\frac{\alpha q_i^2}{\Theta}}}{\int dq_i\, e^{-\frac{\alpha q_i^2}{\Theta}}} = \frac{-d}{d\left(\frac{1}{\Theta}\right)} \cdot \int e^{-\frac{\alpha_i q_i^2}{\Theta}} dq_i \Big/ \int e^{-\frac{\alpha_i q_i^2}{\Theta}} dq_i$$

$$= -\frac{d}{d\frac{1}{\Theta}} \log \sqrt{\frac{\pi\Theta}{\alpha}} = \Theta^2 \frac{d}{d\Theta} \left(\frac{1}{2} \log \Theta + \text{konst.}\ \Theta\right)$$

$$= \underline{\frac{1}{2} \Theta} \quad \text{q. e. d.}$$

$\overline{x} = 0$ $\overline{\Delta x^2} = \overline{x^2} = \int_{-\infty}^{\infty} x^2 e^{-\frac{a}{2}\frac{x^2}{\Theta}} dx \Big/ \int_{-\infty}^{\infty} e^{-\frac{\alpha x^2}{2\Theta}} dx$

$$= -\frac{2}{2}\Theta \frac{d}{d\alpha} \log \sqrt{\frac{2\pi\Theta}{\alpha}}$$

$$= -2\Theta \frac{d}{d\alpha} \left(-\frac{1}{2} \log \alpha + \text{konst. m. h. t. } \alpha\right) = \underline{\underline{\frac{\Theta}{\alpha}}}$$

$F_{min} = m_{min} \cdot g = a(\overline{x^2})^{1/2} = a \cdot \sqrt{\frac{\Theta}{a}} = \sqrt{kTa}$

$$\underline{\underline{m_{min} = \frac{1}{g} \cdot \sqrt{a kT}}}$$

②

$$w(\underline{v}) = w(-\underline{v}) = w(v^2)$$

$$w(|v|^2) = w(v_x^2+v_y^2+v_z^2)$$

$$= w(v_x^2)\cdot w(v_y^2)\cdot w(v_z^2)$$

$$\cancel{\int q_i \frac{\partial H}{\partial q_i}}$$

$$\dot{p}_i = -\frac{\partial H}{\partial q_i} \quad \Big| \quad q_i$$

$$\dot{q}_i = \frac{\partial H}{\partial p_i} \quad \Big| \quad p_i$$

$$\frac{d}{dt}(pq) = \left(p_i\frac{\partial H}{\partial p_i} + q_i\frac{\partial H}{\partial q_i}\right)$$

$$\frac{1}{T}\Big[pq\Big]_0^T = \frac{1}{T}\int_0^T (\quad '' \quad)$$

$$\lim_{T\to 0} \text{v. s.} = 0 \qquad \left\langle p_i\frac{\partial H}{\partial p_i}\right\rangle = \left\langle q_i\frac{\partial H}{\partial q_i}\right\rangle$$

$$\left\langle p_i\frac{\partial H}{\partial p_i}\right\rangle = \frac{\int \frac{p_i^2}{m}\cdot e^{-\frac{p_i^2}{2m\theta}}dp_i \cdot \int dq_i\, dp_{k\neq i}\cdots}{\int (dq\,dp)^f\cdot e^{-\frac{H}{\theta}}}$$

$$= \overline{\frac{p_i^2}{m}} = 2\cdot\frac{1}{2}kT \quad \text{iflg. ekv. p. prinsipet.}$$

$$dw = C\prod_i e^{-\frac{m_{0i}}{\sqrt{1-v^2/c^2}}\cdot\frac{1}{\theta}} v_i^2\,dv_i$$

$$\left\langle\frac{v_i^2}{\sqrt{1-\frac{v_i^2}{c^2}}}\right\rangle = C'\cdot\int v_i^{2}\,dv_i\,\frac{v_i^2}{\sqrt{1-v^2}}\cdot e^{-\frac{m/\theta}{\sqrt{1-v^2}}} \quad (\beta = m/\theta)$$

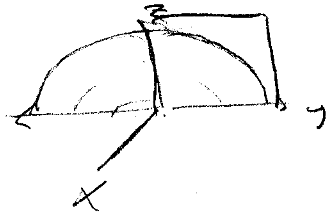
$$v^3\left(-\frac{\theta}{m}\right)_c d\, e^{-\frac{\beta}{\sqrt{1-v^2}}}$$

$$= C\left[-0 + 3(\beta^{-1})\int_0^c v_i^2\, e^{-\frac{\beta}{\sqrt{1-v^2}}}\right] \Big/ C\int v_i^2 e^{-\frac{\beta}{\sqrt{1-v^2}}}$$

$$= 3\cdot\frac{\theta}{m_{0i}} \qquad \text{q. e. d.}$$

liker ikke denne oppgaven. $\displaystyle\int_{-k}^{+k}\int_{-k}^{+k} e^{-\frac{\beta}{\sqrt{1-x^2-y^2-z^2}}}\,dy\,dz$

$x^2 - \sin^2\vartheta - \cos^2\varphi$



③

$d\varphi$

$$w(n, m_\cdot) = C \cdot e^{-n\beta(\varepsilon-\mu)}$$

$$\langle m_\varepsilon \rangle = C\left(-\frac{1}{\beta}\frac{\partial}{\partial\varepsilon}\right) C^{-1}$$

$$= C \cdot \frac{1}{C^2}\, C_\varepsilon' \cdot \frac{1}{\beta} = \frac{C_\varepsilon'}{C} \cdot \frac{1}{\beta}.$$

$$C^{-1} = \frac{1}{1-e^{-\beta(\varepsilon-\mu)}} =$$

$$C = 1 - e^{-\beta(\varepsilon-\mu)}$$

$$C_\varepsilon' = e^{-\beta(\varepsilon-\mu)}$$

$$\langle n \rangle = \frac{e^{-\beta(\varepsilon-\mu)}}{1-e^{-\beta(\varepsilon-\mu)}} = \frac{1}{e^{\beta(\varepsilon-\mu)}-1} \quad \text{q. e. d.}$$

$$w_N(q, p) \quad \sum \frac{e^{\frac{N\mu}{\theta}}}{N!}\, e$$

$$\langle N \rangle = \sum_\varepsilon \langle n_\varepsilon \rangle \Rightarrow \int_0^\infty \frac{2\pi \cdot (2m/h^2)^{3/2} \cdot V \cdot \varepsilon^{1/2}\, d\varepsilon}{e^{\beta(\varepsilon-\mu)}-1}$$

$\beta_{\text{Einstein}} \leftrightarrow \mu = 0$

$$\rho = 2\pi \cdot \left(\frac{2m}{h^2}\right)^{3/2} \int_0^\infty \frac{\varepsilon^{1/2}\, d\varepsilon}{e^{\beta_E \cdot \varepsilon}-1}$$

$$\rho = \text{"} \quad \text{"} \quad \frac{1}{\beta_E^{3/2}} \cdot \int_0^\infty \frac{x^{1/2}\, dx}{e^x - 1}$$

$$= \text{"} \quad \text{"} \quad \text{"} \quad \cdot 2{,}315$$

$$\beta_E^{3/2} = \frac{1}{\rho} \cdot 2\pi \cdot \left(\frac{2m}{h^2}\right)^{3/2} 2{,}315 = \frac{1}{kT_E}^{3/2}$$

$$\left(kT_E\right)^{3/2} = \left(\frac{h^2}{2m}\right)^{3/2} \cdot \left(\frac{N}{V}\right) \cdot \frac{1}{2\pi} \cdot \frac{1}{2{,}315}$$

Gegeben $\rho_{masse} = 0{,}178 \ g/cm^3$

$$\left(\frac{N}{V}\right) = \frac{\rho_{masse}}{m_{He^4}} = \frac{0.178}{6.64 \cdot 10^{-24}} = \underline{2{,}67 \cdot 10^{+22}} \ (cm^{-3})$$

$$T_E = \frac{h^2}{2m} \cdot \frac{1}{k} \cdot \left(26{,}7 \cdot 10^{+21}\right)^{2/3} \cdot \left(\frac{1}{\pi \cdot 4.63}\right)^{2/3}$$

$$= \frac{h^2}{2m} \cdot \frac{1}{k} \cdot \left(\frac{26{,}7}{\pi \cdot 4{,}63}\right)^{2/3} \cdot 10^{14}$$

$$\frac{h^2}{2mk} = \frac{6{,}62^2 \cdot 10^{-54}}{13{,}28 \cdot 1{,}38 \cdot 10^{-16} \cdot 10^{-24}} = \underline{2.4 \cdot 10^{-14}}$$

$$\left(\frac{26.7}{4.63 \cdot \pi}\right)^{2/3} = \underline{1.5}$$

$$T_E = 2.4 \cdot 10^{-14} \cdot 1{,}5 \cdot 10^{-14} = \underline{\underline{3.6 \ {}^\circ K}}$$