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 ledd bidrar

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

$\overline{E} = U$.

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

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

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

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

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

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

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

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

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

②

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

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

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

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

$$\left.\begin{aligned} \dot p_i &= -\frac{\partial H}{\partial q_i} \\ \dot q_i &= \frac{\partial H}{\partial p_i} \end{aligned}\right| \begin{aligned} q_i \\ p_i \end{aligned}$$

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

$$\frac{1}{T}\left[pq\right]_0^T = \frac{1}{T}\int_0^T (\quad " \quad)$$

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

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

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

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

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

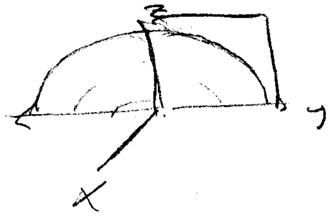
$$v^3\left(-\frac{\theta}{m}\right) d\, e^{-\frac{\beta}{\sqrt{1-v^2}}}$$

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

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

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

$d\varphi$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\left(\frac{N}{V}\right) = \frac{\rho_{masse}}{m_{He^4}} = \frac{0.178}{6.64\cdot10^{-24}} = \underline{2,67\cdot10^{+22}}\ (cm^{-3})$$

$$T_E = \frac{h^2}{2m}\cdot\frac{1}{k}\cdot\left(26,7\cdot10^{+21}\right)^{2/3}\cdot\left(\frac{1}{\pi\cdot 4.63}\right)^{2/3}$$

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

$$\frac{h^2}{2mk} = \frac{6,62^2\cdot10^{-54}}{13,28\cdot1,38\cdot10^{-16}\cdot10^{-24}} = \underline{2.4\cdot10^{-14}}$$

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

$$T_E = 2.4\cdot10^{-14}\cdot 1,5\cdot 10^{-14} = \underline{\underline{3.6\ °K}}$$