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2018 統計力学

(1) $Z(V,T) = \frac{1}{h^3} 4\pi \int_0^\infty p^2 e^{-\frac{1}{k_B T} cp}\, dp$

$I = \int_0^\infty p^2 e^{-\frac{c}{k_B T} p}\, dp$

$\frac{c}{k_B T} = \alpha$, $\alpha p = t \Rightarrow p = \frac{t}{\alpha}$

$dp = \frac{1}{\alpha} dt$

p	$0 \to \infty$
t	$0 \to \infty$

$I = \frac{1}{\alpha^3} \int_0^\infty t^2 e^{-t}\, dt$

$\Gamma(z) = \int_0^\infty t^{z-1} e^{-t}\, dt$ より

$\Gamma(3) = \int_0^\infty t^2 e^{-t}\, dt$

$\Gamma(3) = 2\Gamma(2) = 2 \cdot 1 \Gamma(1) = 2$

$\Gamma(1) = \int_0^\infty e^{-t}\, dt$

$= 1$

$I = \frac{2}{\alpha^3} = \frac{2}{\left(\frac{c}{k_B T}\right)^3} = 2\left(\frac{k_B T}{c}\right)^3$

$f(x) = x^3$

(2) $\log Z = \log V + \log \frac{k_B^3 T^3}{c^3} + a_2$

$U = k_B T^2 \frac{\partial}{\partial T} \log Z = k_B T^2 \cdot \frac{c^3}{k_B^3 T^3} \times 3 \frac{k_B^3}{c^3} T^2$

$= 3 k_B T$

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(3) $F(V,T) = -k_B T \log Z(V,T)$

$$P = -N\frac{\partial F}{\partial V} = Nk_B T \frac{1}{V}$$

$$P = \frac{N}{V} k_B T$$

$$= \rho k_B T$$

(4) $P = \rho k_B T$

$u = \rho U$. $\quad \rho = \frac{u}{U}$

$$P = \frac{u}{U} k_B T$$

$u = \frac{U}{k_B T} P$ $\quad U = 3k_B T$ より $\quad u = 3P$