19.2

Gasfastinn $R = 8.314 \frac{J}{mol \cdot K}$

Kjörgas

Við fast p, $T = 298K$ $C_p = C_V + R = \frac{5}{2}R \simeq 20.8 \frac{J}{mK}$

→ ein atóma gas: $C_p = 20.8 \frac{J}{mK}$

tvíatóma sameind gas ~~með~~ snúning : $C_p = \frac{7}{2}R \simeq 29.1 \frac{J}{mK}$

+ titring : $C_p = \frac{9}{2}R \simeq 37.4 \frac{J}{mK}$

fast efni (kristaller): $C_p = 3R = 24.9 \frac{J}{mK}$

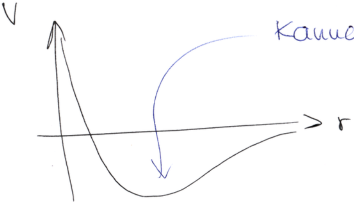
Al	= 24.35	fast
Ar	= 20.79	einatóma gas
Au	= 25.42	fast
Cu	= 24.44	fast
He	= 20.79	einatóma gas
H_2	= 28.82	tvíatóma gas
Fe	= 25.10	fasti
Pb	= 26.44	fasti
Ne	= 20.79	ein atóma gas
⋮		

19-03

$$V(r) = \frac{A}{r^n} - \frac{B}{r} \qquad A, B > 0 \quad \text{og} \quad n > 2$$

Coulomb aðdráttur

harðkjarna fráhrinding



Kanna mættið nærri lágmarkinu. Aðeins radial þátturinn (út þátturinn) skiptir máli. Lítum þess vegna á þetta sem „einvítt" mætti

Finnum lágmarkið:

$$\frac{dV}{dr} = -\frac{nA}{r^{n+1}} + \frac{B}{r^2} = 0$$

$$\to \frac{r_0^{n+1}}{r^2} = \frac{nA}{B} \to r_0^{n-1} = \frac{nA}{B}$$

Beitum Taylor-liðun fyrir $r \approx r_0 + \Delta r$

$$V(r) \simeq V(r_0) + V'(r_0)\cdot \Delta r + \frac{1}{2} V''(r_0)\cdot(\Delta r)^2 + \dots$$

$$V(r) \simeq V(r_0) + \frac{1}{2} V''(r_0) \cdot (\Delta r)^2$$

$V(r_0)$ skiptir ekki máli, heldur ekki gildið á $V''(r_0)$, nema ~~að~~ það sé jákvætt. Um loga þantkinn er malið flugbogið

$$\Rightarrow \quad \langle E \rangle = \left\{ \underbrace{\tfrac{1}{2} k_B T}_{\text{hreyfiorka}} + \underbrace{\tfrac{1}{2} k_B T}_{\text{mattisorka}} \right\} = k_B T$$

19-04

$E_i = \alpha_i x_i^2$ sýna að $\langle x_i^2 \rangle = \dfrac{k_B T}{2\alpha_i}$

$$\langle x_i^2 \rangle = \frac{\int_{-\infty}^{\infty} dx_i \, x_i^2 \exp\{-\beta \alpha_i x_i^2\}}{\int_{-\infty}^{\infty} dx_i \exp\{-\beta \alpha_i x_i^2\}} = \frac{\frac{1}{2}\sqrt{\frac{\pi}{(\beta\alpha_i)^3}}}{\sqrt{\frac{\pi}{\beta\alpha_i}}} = \frac{1}{2}\frac{1}{\beta\alpha_i} = \frac{k_B T}{2\alpha_i}$$

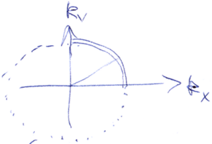
Sýna að Z_1^{2D} fyrir tvívítt gas á fleti A sé

$$Z_1^{2D} = \frac{A}{\lambda_{th}^2} \qquad \text{þ.s.} \quad \lambda_{th} = \frac{h}{\sqrt{2\pi m k_B T}}$$

Til þess þarf að finna ástandaþéttleikann í 2D

Samskonar bylgjufall, en aðeins tvær víddir

$$k_x = \frac{n_x \pi}{L}, \quad k_y = \frac{n_y \pi}{L}, \quad L^2 = A$$



fyrir 3D var

$$g^{3D}(k)dk = \frac{\frac{1}{8} \cdot 4\pi k^2 dk}{\left(\frac{\pi}{L}\right)^3} = \frac{V k^2 dk}{2\pi^2}$$

en fyrir 2D er

$$g^{2D}(k)dk = \frac{\frac{1}{4} \cdot 2\pi k dk}{\left(\frac{\pi}{L}\right)^2} = \frac{L^2 k dk}{2\pi} = \frac{A k dk}{2\pi}$$

$$Z_1^{2D} = \int_0^\infty dk\, g^{2D}(k)\, e^{-\beta E(k)} \quad , \quad E(k) = \frac{\hbar^2 k^2}{2m} \quad , \quad k^2 = k_x^2 + k_y^2$$

(GR-3.461.3)

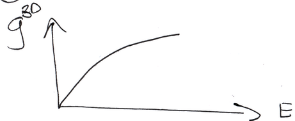
$$= \int_0^\infty dk \frac{Ak}{2\pi} \exp\left\{ -\beta \frac{\hbar^2 k^2}{2m} \right\} = \frac{A}{2\pi} \frac{2m}{\beta \hbar^2} = \frac{A 2\pi m k_B T}{h^2}$$

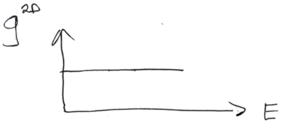
$$\Rightarrow \quad Z_1^{2D} = \frac{A}{\lambda_{th}^2} \quad \text{med} \quad \lambda_{th} = \frac{h}{\sqrt{2\pi m k_B T}}$$

En $\frac{dE}{dk} = \frac{\hbar^2 k}{m}$, både i 2D og i 3D

Pass vegna er hogt ~~å~~ å utbua $g^d(E)dE$ og på fast

$g^{3D}(E) \sim \sqrt{E}$ $\qquad$ $g^{2D}(E) = $ fasti





21-02

Sackur-Tetrode

$$S = N k_B \left\{ \frac{5}{2} - \ln\left(n \lambda_{th}^3\right) \right]$$

fyrir skammta kjörgas (ógreinanlegar eindir) er magnbundin. Athugum með skölun

$$\left.\begin{aligned} V &\to \alpha V \\ N &\to \alpha N \end{aligned}\right\} \to n = \frac{N}{V} \to n$$

$$S' = \alpha N k_B \left\{ \frac{5}{2} - \ln\left(n \lambda_{th}^3\right) \right] = \alpha S$$

$\to$ S er magnbundin

En fyrir ógreinanligar eindir kjörgass fæst

$$S = N k_B \left\{ \frac{3}{2} - \ln\left(\lambda_{th}^3 / V \right) \right\}$$

$$S' = \alpha N k_B \left\{ \frac{3}{2} - \ln\left(\frac{\lambda_{th}^3}{\alpha V} \right) \right\} \neq \alpha S$$

fyrir ógreinanligar kjöreindir í gassi er S

ekki magnbundin stødd!