① Neidealni plin $\phi(r) = \begin{cases} \phi_0\left(1-\frac{r}{b}\right) & ; r \le b \\ 0 & ; r > b \end{cases}$



$b = 5\,nm$, $\phi_0 = 0{,}5\,meV$; $\frac{N}{V} = 10^{24}\,\frac{1}{m^3}$, $T = 300\,K$

a) $B_2 = \frac{1}{2}\int_0^\infty \left[1 - e^{-\beta\phi(r)}\right] \cdot 4\pi r^2 dr = 2\pi\beta\phi_0 \int_0^b \left(1-\frac{r}{b}\right) r^2 dr = \frac{\pi\beta\phi_0 b^3}{6} \approx 1{,}26\,nm^3$

$\beta\phi_0 = 0{,}0183 \ll 1$;

$e^{-\beta\phi(r)} \approx 1 - \beta\phi(r)$

1 t.

b) $p = \frac{N}{V} k_B T \left[1 + \frac{N}{V} \cdot B_2\right]$; $p_{id} = \frac{N}{V} k_B T$

$\Delta p = p - p_{id} = \left(\frac{N}{V}\right)^2 k_B T \cdot B_2 = \frac{\pi}{6}\left(\frac{N}{V}\right)^2 \phi_0 b^3 = 5{,}23\,Pa$ 1 t.

c) $\frac{U}{N} - \left(\frac{U}{N}\right)_{id} = \frac{U_{int.}}{N} = \frac{1}{N} \cdot \frac{N^2}{V} \frac{dB_2}{d\beta} = \frac{N}{V} \cdot \frac{\pi}{6} \cdot \phi_0 b^3 = 5{,}23 \cdot 10^{-24} J$

$= 3{,}27 \cdot 10^{-5} eV$ 1 t.

$\left(\frac{U}{N}\right)_{id}$ notranja kinetična

$\frac{U_{int.}}{N}$ interakcija

↑ predelovanja, vaje

② Adsorpcija atomov Ar na steni posode; $T=300K$; $w=0{,}1eV$ (vezavna en.); $N_0=10^{18}$ ads. mest.



Ar: $M=40\,g/mol$, $d>0$

$r=\frac{\sigma_N}{\langle N\rangle}=2\cdot10^{-7}$

$\mu=?$; $p=?$

a) ads. mesta: $e^{-\beta\xi}=\left[1+e^{\beta(w+\mu)}\right]^{N_0}$ * vaje $\Rightarrow$

$$\langle N\rangle=-\left(\frac{\partial\beta\xi}{\partial\beta\mu}\right)_\beta=\frac{N_0}{1+e^{-\beta(w+\mu)}}$$

$$\sigma_N^2=\left(\frac{\partial\langle N\rangle}{\partial\beta\mu}\right)_\beta=N_0\frac{e^{-\beta(w+\mu)}}{\left[1+e^{-\beta(w+\mu)}\right]^2}$$

$$r=\frac{\sigma_N}{\langle N\rangle}=\frac{e^{-\frac{\beta(w+\mu)}{2}}}{\sqrt{N_0}}\ *$$

* $\mu=-w-k_BT\ln(r^2N_0)=-0{,}374eV$ 1/2

predavanja *

b) tlak plina: $\mu=\mu_{ep}$; $p=j\,kT\,e^{\beta\mu_{ep}}=5{,}3\cdot10^5Pa$ 1/4

$j=(2j+1)\left(\frac{2\pi m_1}{h^3}\right)^{3/2}k_B^{5/2}$ ($m_1=M/N_A$) $\approx 6{,}6\cdot10^5\frac{Pa}{K^{3/2}}$

c) interakcija med atomi na steni: $w\to w-\alpha\frac{\langle N\rangle}{N_0}$; $\alpha=10eV$

$$\theta\equiv\frac{\langle N\rangle}{N_0}=\frac{1}{1+e^{-\beta(w-\alpha\frac{\langle N\rangle}{N_0}+\mu)}}$$

($\alpha\frac{\langle N\rangle}{N_0}$: konst.)

$$\theta\left(1+\underbrace{e^{-\beta(w+\mu)}}_{=y=4\cdot10^4}e^{\beta\alpha\theta}\right)=1$$

$\beta\alpha\theta\approx0.00966\ll1$; $e^{\beta\alpha\theta}\approx1+\beta\alpha\theta$

$$\theta\left(1+y(1+\beta\alpha\theta)\right)-1=0$$

$$\beta\alpha y\theta^2+\theta(1+y)-1=0$$

($y\gg1$)

$$\theta_{1,2}=\frac{1}{2\beta\alpha y}\left[-y\pm\sqrt{y^2+4\beta\alpha y}\right]=2{,}47\cdot10^{-5}$$

(+: prava koren za $\alpha\to0$)

$\theta_0=2{,}5\cdot10^{-5}$ ($\alpha=0$)

upoštevanje relativne zasedenosti:

$\frac{\theta-\theta_0}{\theta_0}\approx-1\%$ 1/4