5.2

$A = 238$

$Z = 92$

$m_p = 938{,}3\ MeV/c^2$

$m_n = 939{,}6\ MeV/c^2$

$s = \frac{1}{2}$

$$F(E) = \frac{1}{1 + \exp\left(\frac{E - E_F}{kT}\right)}$$

$$E_F = \frac{p_F^2}{2m}$$

- objem elementární buňky ve fázovém prostoru: h^3
- degenerace: $g = (2s+1) = 2$
- element prostoru hybností: $dV_p = dp_x\, dp_y\, dp_z = p^2 \sin\theta\, dp\, d\theta\, d\varphi = 4\pi p^2\, dp$
- počet elementárních buněk s jedním částicí o hybnosti v intervalu $(p, p+dp)$: $dv = \frac{V \cdot 4\pi p^2 dp}{h^3}$
- počet částic při $T = 0\ K$:

$$N = \int_0^{p_F} g\, dv = \int_0^{p_F} \frac{8\pi V}{h^3} p^2 dp = \frac{8\pi V p_F^3}{3h^3}$$

$$\Rightarrow p_F = h\left(\frac{3N}{8\pi V}\right)^{\frac{1}{3}} = \hbar\left(\frac{3\pi^2 N}{V}\right)^{\frac{1}{3}}$$

$$E_F = \frac{p_F^2}{2m} = \frac{\hbar^2}{2m}\left(\frac{3\pi^2 N}{V}\right)^{\frac{2}{3}}, \qquad V = \frac{4}{3}\pi r_0^3 A$$

- celková kinetická energie:

$$E_{KIN} = \sum_{\alpha=1}^{N} E_{KIN_\alpha} = \int_0^{p_F} \frac{p^2}{2m} \frac{V \cdot 8\pi p^2}{h^3} dp = \frac{8\pi V}{2m h^3} \frac{p_F^5}{5} = \frac{3N}{2m p_F^3} \frac{p_F^5}{5} = \frac{3}{5} N E_F$$

- střední kinetická energie na nukleon: $\overline{E_{KIN}} = E_{KIN}/N = \frac{3}{5} E_F$

$$E_F(p) = \frac{\hbar^2}{2m_p}\left(\frac{3\pi^2 Z}{\frac{4}{3}\pi r_0^3 A}\right)^{\frac{2}{3}} = \frac{(\hbar c)^2}{2m_p c^2 r_0^2}\left(\frac{9\pi Z}{4A}\right)^{\frac{2}{3}} = \frac{197^2}{2\cdot 938{,}3\cdot 1{,}2^2}\left(\frac{9\pi\cdot 92}{4\cdot 238}\right)^{\frac{2}{3}} \doteq \underline{28{,}1\ \text{MeV}}$$

$$E_F(n) = \frac{(\hbar c)^2}{2m_n c^2 r_0^2}\left(\frac{9\pi(A-Z)}{4A}\right)^{\frac{2}{3}} = \frac{(197)^2}{2\cdot 939{,}6\cdot 1{,}2^2}\left(\frac{9\pi(238-92)}{4\cdot 238}\right)^{\frac{2}{3}} \doteq \underline{38{,}1\ \text{MeV}}$$

$$\bar{E}_{KIN}(p) = \frac{3}{5}E_F(p) \doteq \underline{16{,}9\ \text{MeV}}$$

$$\bar{E}_{KIN}(n) = \frac{3}{5}E_F(n) \doteq \underline{22{,}9\ \text{MeV}}$$