Семинар №6

Драчов Ярослав
Факультет общей и прикладной физики МФТИ

12 марта 2021 г.

0-6-1.

Решение.

$$\sigma = \frac{ne^2\tau}{m}.$$

$$n \sim \exp\left(-\frac{\Delta}{2kT}\right).$$

$$\frac{\sigma_2}{\sigma_1} = \exp\left(\frac{\Delta}{2kT}\frac{T_1 - T_2}{T_1T_2}\right) \sim e^{2{,}13} \approx 23.$$

0-6-2.

Решение.

$$\mathrm{Ry}^* = \left(\frac{me^4}{2\hbar^2}\right)^* = \frac{\mathrm{Ry}}{m_e}\frac{m_h m_n}{m_h + m_n}\frac{1}{\varepsilon^2} \sim 6{,}8 \text{ мэВ}.$$

$$a_B^* = \left(\frac{\hbar^2}{me^2}\right)^* = \frac{\varepsilon}{m}m_e \cdot \underbrace{a_B}_{0{,}5\ \text{Å}} \approx 100\ \text{Å}.$$

4.2.

Решение.

$$\frac{mv^2}{R} = \frac{e^2}{\varepsilon R^2}.$$

$$mvR = \hbar.$$

$$R = \frac{\varepsilon\hbar^2}{me^2}.$$

$$\varepsilon_1 = -\frac{e^2}{2\varepsilon R} = -\frac{me^4}{2\varepsilon^2\hbar^2}.$$

$$m \mapsto m^* \implies R \sim 65 \text{ нм} \implies \varepsilon_1 \sim 0{,}7 \text{ мэВ}.$$

4.50.

Решение.

$$n_{\min} \sim \frac{1}{(a_B^*)^3}.$$

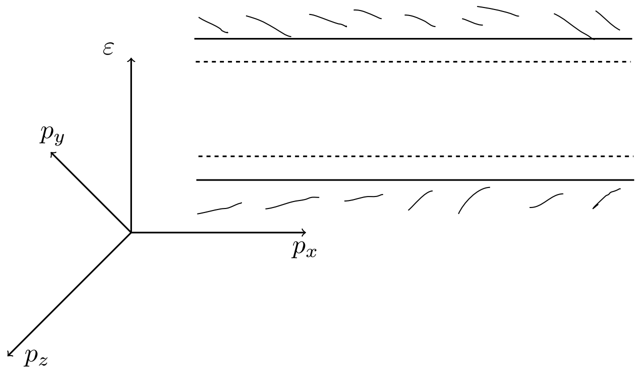

Рис. 1: К задаче 4.50

$$n = 2\left(\frac{m_n kT}{2\pi\hbar^2}\right)^{3/2} e^{\frac{\varepsilon}{kT}}.$$

$$p = 2\left(\frac{m_p kT}{2\pi\hbar^2}\right)^{3/2} e^{-\frac{\Delta+\varepsilon}{kT}}.$$

$$n = p \text{ — сообств. п/п.}$$

$$\mu = -\frac{\Delta}{2} + \frac{3}{4}kT\ln\frac{m_p}{m_n}.$$

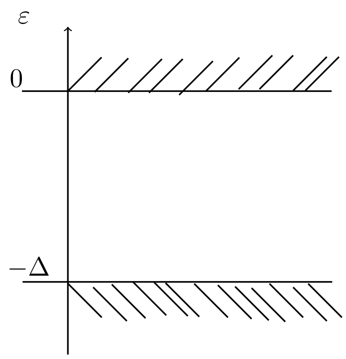

Рис. 2

4.40.

Решение.

$$n_h = 2\left(\frac{m_h kT}{2\pi\hbar^2}\right)^{3/2} e^{-\frac{\mu+\Delta}{kT}}.$$

$$n_e = n_h.$$

4.2.

Решение.

$$\sigma = \frac{ne^2\tau}{m^*} = ne\mu.$$

$$\tau_h \sim 10^{-12}\ \text{с} \gg \tau_{\text{соуд}}.$$

$$L = \sqrt{D\tau} \approx 0{,}2\ \text{см}.$$

$$D = \frac{kt\mu}{e}.$$

4.25.

Решение.

$$n_{\text{Sb}} = n_{\text{Au}^-} + 2n_{\text{Au}^{2-}} + n_-.$$

$$n_{\text{Au}^-} + n_{\text{Au}^{2-}} = n_{\text{Au}}.$$

$$n_- + n_{\text{Au}^{2-}} = n_{\text{Sb}} - n_{\text{Au}}.$$

$$f(\Delta+\varepsilon) = \frac{n_{\text{Au}^{2-}}}{n_{\text{Au}}} = \frac{1}{1+e^{\frac{-\Delta+\varepsilon_2-\mu}{kT}}}.$$

$$n = Q\,\underbrace{e^{\frac{\mu}{kT}}}_{x}.$$

$$Qx + n_{\text{Au}}\frac{x}{x+e^{\frac{-\Delta+\varepsilon_2}{kT}}} = n_{\text{Sb}} - n_{\text{Au}}.$$

$$x = \frac{n_{\text{Sb}} - n_{\text{Au}}}{2n_{Au} - n_{\text{Sb}}} e^{\frac{-\Delta+\varepsilon_2}{kT}} = e^{\frac{\mu}{kT}}.$$

$$\mu = -\Delta + \varepsilon_2 + kT\ln\frac{n_{\text{Sb}} - n_{\text{Au}}}{2n_{\text{Au}} - n_{\text{Sb}}} = -\Delta + \varepsilon_2.$$

$$n_- = Q_- e^{\frac{-\Delta+\varepsilon_2}{kT}} \sim 8{,}3\cdot 10^4\ \text{см}^{-3}.$$