

# task\_tx86fewvysrcy8fc\_with\_calculation

## Student Group

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### Exercise E5 Electron Velocity in Semiconductors (written test, approx. 6 % of a 120-minute written test, SS2022)

A current of  $I=1\text{ mA}$  flows through a cross-sectional area  $A=10\text{ }\mu\text{ m}^2$  in a semiconductor.

The electron density in the semiconductor is given by the number of dopant atoms per volume.

The doping shall provide 1 donor atom (= one electron) per  $10^{10}$  silicon atoms. The molar volume of silicon is  $V_{\text{mol,Si}} = 12 \cdot 10^{-6}\text{ m}^3/\text{mol}$ , with  $N_{\text{A}} = 6.022 \cdot 10^{23}$  silicon atoms per  $1\text{ mol}$ .

The elementary charge is given as:  $e_0 = 1.602 \cdot 10^{-19}\text{ As}$

What is the average electron velocity  $v_e$  in this semiconductor?

Path

The following formula gives the speed, where  $n_e$  is the number of electrons per volume. 
$$v_e = \frac{I}{n_e \cdot e_0 \cdot A}$$

$n_e$  can be derived from the overall number of Si-atoms per volume ( $\frac{N_{\text{A}}}{V_{\text{mol,Si}}}$ ) and the fraction  $k_{\text{Donators}}$  of these atoms, which got substituted by donators. 
$$n_e = \frac{N_{\text{A}}}{V_{\text{mol,Si}}} \cdot k_{\text{Donators}} \cdot e_0 \cdot A$$

Putting in the numbers: 
$$v_e = \frac{1 \cdot 10^{-3}\text{ A}}{\frac{6.022 \cdot 10^{23}}{12 \cdot 10^{-6}\text{ m}^3/\text{mol}} \cdot 10^{-10} \cdot 1.602 \cdot 10^{-19}\text{ As} \cdot 10 \cdot (10^{-6}\text{ m})^2}$$

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