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Exercises and Complements for the Introduction to Physics II

for Students

of Biology, Pharmacy and Geoscience

Sheet 4 / 25.04.2021 **Solutions**

Exercise 13.

See also script 306-3 and following pages

a) Resistance:

$$R = \varrho_{Cu}\frac{l}{A} = \varrho_{Cu}\frac{l}{\pi r^2} = 0.54\ \Omega$$

b) Voltage drop:

$$\Delta U = RI = 54\ \text{V}$$

Therefore, the final voltage is: $U_{Ende} = 166$ V.

c) Current density:

$$i = \frac{I}{A} = env_D$$

where I - current, A - cross-section of the wire, e - elementary charge, n - density of electrons, v_D - drift velocity of the electrons. With N_A as the Avogadro's constant, we obtain:

$$A = \pi r^2 = 3.1 \cdot 10^{-4}\ \text{m}^2$$

$$n = \frac{N_A \cdot \rho_M}{M_A} = 8.5 \cdot 10^{28}\ \text{m}^{-3}$$

$$v_D = \frac{I}{enA} = \frac{IM_A}{eN_A\rho_M\pi r^2} = 2.3 \cdot 10^{-5}\ \text{m}\cdot\text{s}^{-1}$$

$$t_{Drift} = \frac{l}{v_D} = \frac{leN_A\rho_M\pi r^2}{IM_A} = 4.3 \cdot 10^8\ \text{s} \approx 14\ \text{Jahre}$$

Exercise 14.

Mol-mass of NaCl: $M = 58.5$ g/mol. Also 9 g NaCl in 1000 g H_2O represent 0.154 mol/l, which corresponds to a concentration of charge carriers of

$$\begin{aligned} n &= 0.154 \,\frac{\text{mol}}{l} \times 6.022 \cdot 10^{23} \,\frac{1}{\text{mol}} \\ &= 9.27 \cdot 10^{22} \,\frac{1}{l} \\ n &= 9.27 \cdot 10^{25} \,\frac{1}{\text{m}^3} \end{aligned}$$

a) Script page 306-10 and following pages:

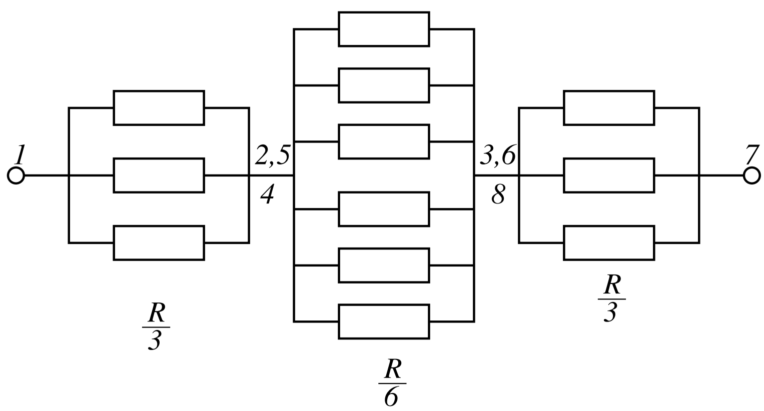
$$\begin{aligned} \sigma &= e(n^+ b^+ + n^- b^-) \\ &= 1.6 \cdot 10^{-19}\text{C} \times 9.27 \cdot 10^{25} \frac{1}{\text{m}^3} \times (4.6 + 6.85) \cdot 10^{-8} \frac{\text{m}^2}{\text{Vs}} \\ \sigma &= 1.7 \frac{1}{\Omega\text{m}} \end{aligned}$$

b) $R = \dfrac{l}{\sigma A} = 882\ \Omega.$

c) $U = IR = 88$ V.

Exercise 15.

Taking into account the symmetry of the problem, it follows immediately that the points 2,4,5 and 3,6,8 are all at the same potential. If we connect these points by a resistance-free wire, then we get the simplified circuit diagram:

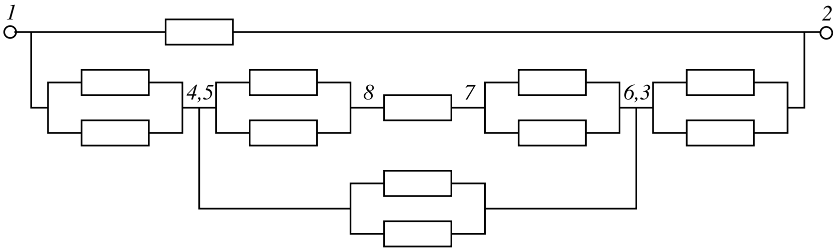


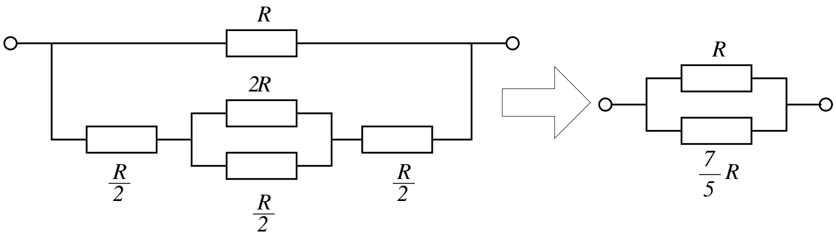
and therefore:

$$R_{ers} = \frac{R}{3} + \frac{R}{6} + \frac{R}{3} = \frac{5}{6} R$$

Exercise 16.

1 to 2: Using the same principle as in Exercise 15:

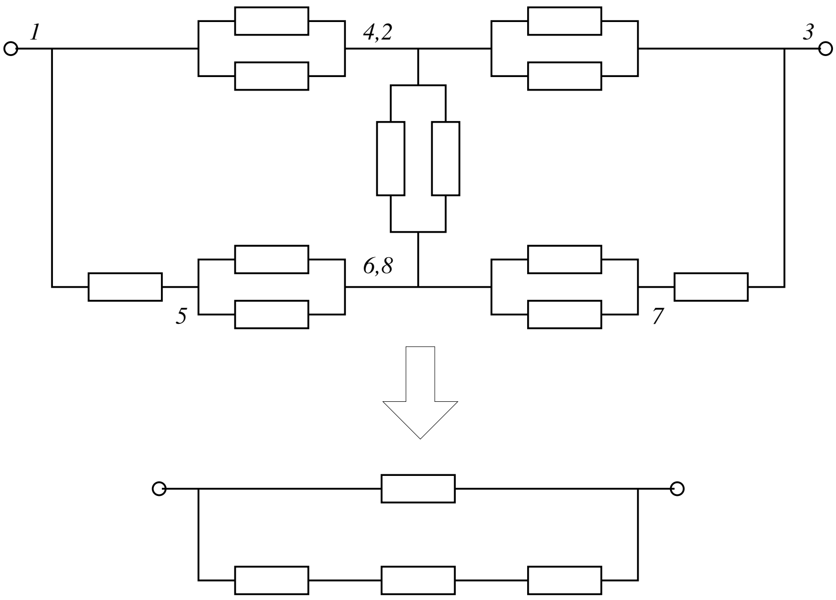




finally:

$$\frac{1}{R_{ers}} = \frac{1}{R} + \frac{5}{7R} \Rightarrow R_{ers} = \frac{7}{12}R$$

1 to 3:



Due to symmetry, no current goes between points 4,2 and 6,8.

$$\frac{1}{R_{ers}} = \frac{1}{R} + \frac{1}{3R} \Rightarrow R_{ers} = \frac{3}{4}R$$