

$$12.1 \quad m = 30 \text{ kg } H_2O$$

$$T_k = 12^\circ C \Rightarrow \text{Thete kalt}$$

$$T_w = 80^\circ C \quad \text{warm}$$

$$\Delta T = T_w - T_k = 80 - 12 = 68^\circ C$$

$$Q = m \cdot c \cdot \Delta T = 30 \cdot 4,19 \frac{\text{kJ}}{\text{kg K}} \cdot 68 = 8547,6 \text{ kJ}$$

$$= 8,55 \text{ MJ}$$

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$$12.3 \quad m = 60 \text{ g} = 0,06 \text{ kg}$$

$$T_k = 18^\circ C$$

$$T_w = 350^\circ C$$

$$c = 0,39 \frac{\text{kJ}}{\text{kg K}}$$

$$\Delta T = T_w - T_k = 350 - 18 = 332^\circ C$$

$$Q = m \cdot c \cdot \Delta T = 0,06 \cdot 0,39 \cdot 332 = 7,76 \text{ kJ}$$

$$12.4 \quad P = 2 \text{ kW} \\ t = 3 \text{ h}$$

$$W = P \cdot t = 2 \text{ k} \cdot 3 = 6 \text{ kWh} \\ = 6 \text{ kW} \cdot 3600 \text{ s} = 21.600 \text{ kWs} \\ = 21,6 \text{ MJ}$$

$$12.5 \quad P = 750 \text{ W} \quad t = 11' \\ m = 3 \text{ kg} \quad \Delta \vartheta_k = 18^\circ \text{C} \\ \eta = 1 \quad (\text{keine Verluste})$$

$$W = P \cdot t = 750 \cdot 11 = 8250 \text{ Wmin} \\ = 495.000 \text{ Ws} \\ = 495 \text{ kJ}$$

$$Q = W \quad \text{bei } \eta = 100\%$$

$$\Delta \vartheta = \frac{Q}{c \cdot m} = \frac{495 \text{ kJ}}{4,19 \frac{\text{kJ}}{\text{kg K}} \cdot 3 \text{ kg}} = 39,4^\circ \text{C}$$

$$\vartheta_w = \vartheta_k + \Delta \vartheta = 18 + 39,4 = 57,4^\circ \text{C}$$

$$12.6 \quad \vartheta_u = 12^\circ\text{C} \quad \vartheta_w = 62^\circ\text{C}$$

$$m = 25 \text{ kg}$$

$$t = 5'$$

$$\eta = 97\%$$

$$\Delta\vartheta = \vartheta_w - \vartheta_u = 62 - 12 = 50^\circ\text{C}$$

$$Q = m \cdot c \cdot \Delta\vartheta = 25 \cdot 4,19 \cdot 50 = 5237 \text{ kJ}$$

$$W = \frac{Q}{\eta} = \frac{5237 \text{ kJ}}{0,97} = 5399,5 \text{ kJ}$$
$$= 5399,5 \text{ kWs}$$

$$P = \frac{W}{t} = \frac{5399,5 \text{ kWs}}{5 \cdot 60 \text{ s}} = 18 \text{ kW}$$

$$12.7 \quad R = 800 \Omega$$

$$U = 230 \text{ V}$$

$$t = 2 \text{ h}$$

$$P = \frac{U^2}{R} = \frac{230^2}{800} = 66,125 \text{ W}$$

$$\begin{aligned} W &= P \cdot t = 66,1 \cdot 2 = 132,2 \text{ Wh} \\ &= 132,2 \cdot 3600 \text{ Ws} = \\ &= 476 \text{ kJ} \end{aligned}$$

$$12.8 \quad m = 80 \text{ kg}$$

$$T_k = 14^\circ\text{C}$$

$$T_w = 85^\circ\text{C}$$

$$a) \quad \eta = 0,88$$

$$P = 1 \text{ kW}$$

$$b) \quad \eta = 0,94$$

$$P = 4 \text{ kW}$$

$$\Delta T = T_w - T_k = 85 - 14 = 71^\circ\text{C}$$

$$Q = m \cdot c \cdot \Delta T = 80 \cdot 4,19 \cdot 71 = 23,817 \text{ kJ}$$

$$W = \frac{Q}{\eta} = \frac{23,800 \text{ kJ}}{0,88} = 27,044 \text{ kJ}$$

$$t = \frac{W}{P} = \frac{27,044 \text{ kW s}}{1 \text{ kW}} = 27,044 \text{ s}$$

$$= 7,5 \text{ h}$$

$$W = \frac{Q}{\eta} = \frac{23,800 \text{ kJ}}{0,94} = 25,318 \text{ kJ}$$

$$t = \frac{W}{P} = \frac{25,318}{4} = 6329 \text{ s} = 1 \frac{3}{4} \text{ h}$$

$$12.9 \quad P = 2 \text{ kW} \quad m = 1,5 \text{ kg}$$
$$\quad \quad \quad \vartheta_k = 16^\circ \text{C} \quad \vartheta_w = 100^\circ \text{C}$$
$$\quad \quad \quad t = 6'$$

$$\Delta \vartheta = \vartheta_w - \vartheta_k = 100 - 16 = 84^\circ \text{C}$$

$$Q = m \cdot c \cdot \Delta \vartheta = 1,5 \cdot 4,19 \cdot 84 = 527,9 \text{ kJ}$$

$$W = P \cdot t = 2 \text{ kW} \cdot 6 \cdot 60'' = 720 \text{ kJ}$$

$$\eta = \frac{Q}{W} = \frac{527,9 \text{ kJ}}{720 \text{ kJ}} = 0,73$$
$$= 73\%$$

$$12.10 \quad U = 230V \quad I = 270mA$$
$$t = 45'$$

$$P = U \cdot I = 230 \cdot 0,27 = 62,1W$$

$$W = P \cdot t = 62,1 \cdot 0,75 = 46,6Wh$$

$$\begin{array}{l} \nearrow \\ 45' \\ \hline 60 \end{array} = \frac{3}{4}h$$

$$12.11 \quad P = 4 \text{ kW} \quad t = 2 \text{ h } 20'$$
$$m = 120 \text{ kg} \quad \eta = 90\%$$
$$\vartheta_K = 15^\circ\text{C}$$

$$W = P \cdot t = 4 \text{ kW} \cdot (2 \cdot 3600 + 20 \cdot 60) =$$
$$= 33.600 \text{ kW s} \quad \begin{matrix} 2 \text{ h} \\ 20' \end{matrix}$$

$$Q = W \cdot \eta = 33.600 \text{ kJ} \cdot 0,9 =$$
$$= 30.240 \text{ kJ}$$

$$\Delta \vartheta = \frac{Q}{m \cdot c} = \frac{30.240}{120 \cdot 4,19} = 60,1^\circ\text{C}$$

$$\vartheta_W = \vartheta_K + \Delta \vartheta = 15 + 60,1 = 75,1^\circ\text{C}$$

$$12.12 \quad U = 230V$$

$$t = 20'$$

$$m = 1 \text{ kg}$$

$$\eta = 77\%$$

$$\vartheta_n = 12^\circ\text{C}$$

$$\vartheta_w = 100^\circ\text{C}$$

$$\Delta\vartheta = \vartheta_w - \vartheta_n = 100 - 12 = 88^\circ\text{C}$$

$$Q = m \cdot c \cdot \Delta\vartheta = 1 \cdot 4,19 \cdot 88 = 368,720 \text{ kJ}$$

$$W = \frac{Q}{\eta} = \frac{368,720}{0,77} = 478,857 \text{ kWs}$$

$$P = \frac{W}{t} = \frac{478,857 \text{ kWs}}{20 \cdot 60 \text{ s}} = 0,399 \text{ kW}$$

$$I = \frac{P}{U} = \frac{399}{230} = 1,74 \text{ A}$$

$$R = \frac{U}{I} = \frac{230}{1,74} = 135 \Omega$$

$$12.13 \quad m = 200 \text{ kg} \quad U = 230 \text{ V}$$

$$t : 22:00 - 5:30 \Rightarrow 7,5 \text{ h}$$

$$\eta = 83\%$$

$$\vartheta_K = 12^\circ\text{C} \quad \vartheta_W = 80^\circ\text{C}$$

$$\Delta\vartheta = \vartheta_W - \vartheta_K = 80 - 12 = 68^\circ\text{C}$$

$$Q = m \cdot c \cdot \Delta\vartheta = 200 \cdot 4,19 \cdot 68 = 56.984 \text{ kJ}$$

$$W = \frac{Q}{\eta} = \frac{56.984 \text{ kWs}}{0,83} = 68.655 \text{ kWs}$$

$$P = \frac{W}{t} = \frac{68.655 \text{ kWs}}{7,5 \cdot 3600 \text{ s}} = 2,54 \text{ kW}$$

$$I = \frac{P}{U} = \frac{2,54 \text{ k}}{230} = 11 \text{ A}$$

$$12.14 \quad P = 2,1 \text{ kW}$$

$$m = 2,5 \text{ kg}$$

$$\vartheta_k = 16^\circ \text{C}$$

$$t = 11'$$

$$\vartheta_w = 100^\circ \text{C}$$

$$\Delta\vartheta = \vartheta_w - \vartheta_k = 100 - 16 = 84^\circ \text{C}$$

$$Q = m \cdot c \cdot \Delta\vartheta = 2,5 \cdot 4,19 \cdot 84 = 880 \text{ kJ}$$

$$W = P \cdot t = 2,1 \text{ kW} \cdot 11 \cdot 60 = 1386 \text{ kWs}$$

$$\eta = \frac{Q}{W} = \frac{880 \text{ kJ}}{1386 \text{ kJ}} = 0,63 = 63\%$$

$$12.15 \quad \vartheta_K = 14^\circ\text{C}$$

$$\vartheta_{W1} = 62^\circ\text{C}$$

$$\vartheta_{W2} = 40^\circ\text{C}$$

$$\vartheta_{W3} = 70^\circ\text{C}$$

$$k = 0,13 \frac{\text{€}}{\text{kWh}}$$

$$m_1 = 10 \text{ kg}$$

$$m_2 = 12 \text{ kg}$$

$$m_3 = 14 \text{ kg}$$

$$\Delta\vartheta_1 = \vartheta_{W1} - \vartheta_K = 62 - 14 = 48^\circ\text{C}$$

$$\Delta\vartheta_2 = \quad \quad \quad = 40 - 14 = 26^\circ\text{C}$$

$$\Delta\vartheta_3 = \quad \quad \quad = 70 - 14 = 56^\circ\text{C}$$

$$Q_1 = m_1 \cdot c \cdot \Delta\vartheta_1 = 10 \cdot 4,19 \cdot 48 = 2011 \text{ kJ}$$

$$Q_2 = \quad \quad \quad = 12 \cdot 4,19 \cdot 26 = 1307 \text{ kJ}$$

$$Q_3 = \quad \quad \quad = 14 \cdot 4,19 \cdot 56 = 3285 \text{ kJ}$$

$$Q = Q_1 + Q_2 + Q_3 = 2011 + 1307 + 3285 =$$

$$= 6603 \text{ kJ} = \text{kWh}$$

$$= 1,83 \text{ kWh}$$

360

$$K = k \cdot W = 0,13 \frac{\text{€}}{\text{kWh}} \cdot 1,83 \text{ kWh} = 0,24 \text{ €}$$

12.16

$$P = 600 \text{ W}$$

$$t = 10'$$

$$\vartheta_K = 20^\circ\text{C}$$

$$\vartheta_W = 240^\circ\text{C}$$

$$\eta = 72\%$$

$$c = 0,23 \frac{\text{kJ}}{\text{kg} \cdot \text{K}}$$

$$W = P \cdot t = 600 \text{ W} \cdot \underbrace{10 \cdot 60 \text{ s}}_{10'} = 360 \text{ kWs}$$

$$Q = W \cdot \eta = 360 \text{ k} \cdot 0,72 = 259,2 \text{ kJ}$$

$$\Delta\vartheta = \vartheta_W - \vartheta_K = 240 - 20 = 220^\circ\text{C}$$

$$m = \frac{Q}{c \cdot \Delta\vartheta} = \frac{259,2}{0,23 \cdot 220} = 5,12 \text{ kg}$$

$$\begin{aligned} 12.17 \quad V &= 200 \text{ l} & \rho &= 0,91 \frac{\text{kg}}{\text{dm}^3} \\ C &= 1,68 \frac{\text{kJ}}{\text{kg K}} & \eta &= 86\% \\ P &= 5 \text{ kW} & t &= 0,5 \text{ h} \\ \vartheta_K &= 18^\circ\text{C} \end{aligned}$$

$$m = V \cdot \rho = 200 \cdot 0,91 = 182 \text{ kg}$$

$$\begin{aligned} W &= P \cdot t = 5 \text{ kW} \cdot 0,5 \text{ h} = 2,5 \text{ kWh} = \\ &= 9000 \text{ kWs} \end{aligned}$$

$$Q = W \cdot \eta = 9000 \text{ k} \cdot 0,86 = 7740 \text{ kJ}$$

$$\Delta \vartheta = \frac{Q}{m \cdot C} = \frac{7740}{182 \cdot 1,68} = 25,3^\circ\text{C}$$

$$\vartheta_W = \vartheta_K + \Delta \vartheta = 18 + 25,3 = 43,3^\circ\text{C}$$

$$12.18 \quad \vartheta_1 = 14^\circ\text{C} \quad m_1 = 60 \text{ kg}$$

$$\vartheta_2 = 80^\circ\text{C} \quad m_2 = 20 \text{ kg}$$

$$m = m_1 + m_2 = 60 + 20 = 80 \text{ kg}$$

$$\vartheta_m = \frac{m_1 \cdot \vartheta_1 + m_2 \cdot \vartheta_2}{m} =$$

$$= \frac{60 \cdot 14 + 20 \cdot 80}{80} = 30,5^\circ\text{C}$$