

$$1.) \quad \overline{T_L} = \frac{37,92^\circ\text{C} + 24,51^\circ\text{C}}{2} = \underline{31,22^\circ\text{C}}$$

$$2.) \quad \dot{V}_L = \dot{V}_{L,N} \cdot \frac{T_L}{T_{L,N}} = 25,5 \frac{\text{Nm}^3}{\text{h}} \cdot \frac{(273+31,22)\text{K}}{273\text{K}} \\ = \underline{28,4 \frac{\text{Nm}^3}{\text{h}}}$$

$$3.) \quad \dot{m}_L = \frac{\dot{V}_L \cdot p}{R_{sp} \cdot T} = \frac{28,42 \frac{\text{Nm}^3}{\text{h}} \cdot 101325 \text{Pa}}{0,29 \frac{\text{J}}{\text{g} \cdot \text{K}} \cdot (31,22+273)\text{K}} \\ = \underline{9,07 \cdot 10^{-3} \frac{\text{kg}}{\text{s}}}$$

$$4.) \quad \dot{Q} = \dot{m}_L \cdot c_{p,L} \cdot \Delta T_L \\ = 9,07 \cdot 10^{-3} \frac{\text{kg}}{\text{s}} \cdot 1005 \frac{\text{J}}{\text{kg} \cdot \text{K}} \cdot (37,92 - 24,51)\text{K} \\ = \underline{122,2 \text{ W}}$$

$$5.) \quad \rho_{\text{H}_2\text{O}}(T_{\text{H}_2\text{O}}) = 1005,7 - 0,375 \cdot T [^\circ\text{C}] \\ \rho_{\text{H}_2\text{O}}(30,7^\circ\text{C}) = 1005,7 - 0,375 \cdot 30,7 \\ = \underline{995,1 \frac{\text{kg}}{\text{m}^3}}$$

$$6.) \quad \dot{m}_{\text{H}_2\text{O}} = \rho_{\text{H}_2\text{O}} \cdot \dot{V}_{\text{H}_2\text{O}} \\ = 995,1 \frac{\text{kg}}{\text{m}^3} \cdot 0,385 \frac{\text{m}^3}{\text{h}} \\ = \underline{0,11 \frac{\text{kg}}{\text{s}}}$$

$$7.) \Delta T_{H_2O} = \frac{\dot{Q}}{\dot{m}_{H_2O} \cdot c_{p_{H_2O}}} = \frac{122,2 \text{ W}}{0,11 \frac{\text{kg}}{\text{s}} \cdot 4185 \frac{\text{J}}{\text{kg} \cdot \text{K}}} = \underline{0,27 \text{ K}}$$

$$8.) T_{\alpha H_2O} = T_{w H_2O} + \Delta T_{H_2O} = 54,5 \text{ K} + 0,27 \text{ K} \\ = \underline{54,77 \text{ K}}$$

$$\hookrightarrow \bar{T}_{H_2O} = \frac{T_{\alpha H_2O} + T_{w H_2O}}{2} = \frac{54,5 \text{ K} + 54,77 \text{ K}}{2} = \underline{54,64 \text{ K}}$$

$$9.) LNTD = \frac{\Delta T_A - \Delta T_B}{\ln\left(\frac{\Delta T_A}{\Delta T_B}\right)} = \frac{(54,5^\circ\text{C} - 24,5^\circ\text{C}) - (54,77^\circ\text{C} - 37,92^\circ\text{C})}{\ln\left(\frac{54,5^\circ\text{C} - 24,5^\circ\text{C}}{54,77^\circ\text{C} - 37,92^\circ\text{C}}\right)} \\ = \underline{22,79 \text{ K}}$$

$$10.) U_a = \frac{Q}{LNTD \cdot A} = \frac{122,2 \text{ W}}{22,79 \text{ K} \cdot 0,8 \text{ m} \cdot \pi \cdot 0,0213 \text{ m}} \\ = \underline{100,123 \frac{\text{W}}{\text{m}^2 \cdot \text{K}}}$$

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$$11.) \quad d_H = D_i - d_a = 0,0237 \text{ m} - 0,0213 \text{ m} \\ = \underline{0,0084 \text{ m}}$$

$$12.) \quad A_{\text{H}_2\text{O}}(\text{Ringfläche}) = \frac{\pi}{4} \cdot (D_i^2 - d_a^2) = \frac{\pi}{4} \cdot (0,0237^2 - 0,0213^2) \\ = \underline{3,36 \cdot 10^{-4} \text{ m}^2}$$

$$13.) \quad w_{\text{H}_2\text{O}} = \frac{\dot{V}_{\text{H}_2\text{O}}}{A_{\text{H}_2\text{O}}} = \frac{0,385 \frac{\text{m}^3}{\text{s}}}{3,36 \cdot 10^{-4} \text{ m}^2} = \underline{0,32 \frac{\text{m}}{\text{s}}}$$

$$14.) \quad v_{\text{H}_2\text{O}}(T) = \exp(-13,2883 - 902806 \cdot T + 1,123 \cdot 10^{-4} \cdot T^2) \\ v_{\text{H}_2\text{O}}(54,64^\circ\text{C}) = \underline{5,11 \cdot 10^{-7} \frac{\text{m}^2}{\text{s}}}$$

$$15.) \quad Re_{\text{H}_2} = \frac{d_H \cdot w_{\text{H}_2\text{O}}}{v_{\text{H}_2\text{O}}} = \frac{0,0084 \text{ m} \cdot 0,32 \frac{\text{m}}{\text{s}}}{5,11 \cdot 10^{-7} \frac{\text{m}^2}{\text{s}}} = \underline{5,22 \cdot 10^3}$$

$$16.) \quad \lambda_{\text{H}_2\text{O}}(54,64^\circ\text{C}) = \underline{986,1 \frac{\text{W}}{\text{m} \cdot \text{K}}}$$

$$17.) \quad \alpha_{\text{H}_2\text{O}}(T) = 2,0107 + 0,00761 \cdot T + 3,347 \cdot 10^{-5} \cdot T^2 \\ \alpha_{\text{H}_2\text{O}}(54,64^\circ\text{C}) = \underline{0,65 \frac{\text{W}}{\text{m}^2 \cdot \text{K}}}$$

$$\begin{aligned}
 18.) \quad P_{\text{H}_2\text{O}} &= \frac{c_{\text{H}_2\text{O}} \cdot \dot{V}_{\text{H}_2\text{O}} \cdot \rho_{\text{H}_2\text{O}}}{\lambda_{\text{H}_2\text{O}}} \\
 &= \frac{4185 \frac{\text{J}}{\text{kg} \cdot \text{K}} \cdot 5,11 \cdot 10^{-7} \frac{\text{m}^3}{\text{s}} \cdot 986,1 \frac{\text{kg}}{\text{m}^3}}{0,65 \frac{\text{W}}{\text{m} \cdot \text{K}}} \\
 &= \underline{3,27}
 \end{aligned}$$

$$\begin{aligned}
 19.) \quad Nu_{\text{H}_2\text{O}} &= 0,023 \cdot (Re^2 \cdot Pr)^{0,4} \\
 &= 0,023 \cdot (5,22 \cdot 10^3)^2 \cdot 3,27^{0,4} \\
 &= \underline{35}
 \end{aligned}$$

$$\begin{aligned}
 20.) \quad \alpha_{\text{H}_2\text{O},a} &= \frac{Nu_{\text{H}_2\text{O}}}{d_H \cdot \lambda_{\text{H}_2\text{O}}} = \frac{35}{0,008 \text{ m}} \cdot 0,65 \frac{\text{W}}{\text{m} \cdot \text{K}} \\
 &= \underline{2677 \frac{\text{W}}{\text{m}^2 \cdot \text{K}}}
 \end{aligned}$$

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$$\begin{aligned}
 21.) \quad A_L \text{ (Kreisflächen)} &= \frac{\pi}{4} \cdot d_i^2 = \frac{\pi}{4} \cdot (0,0173 \text{ m})^2 \\
 &= \underline{2,35 \cdot 10^{-4} \text{ m}^2}
 \end{aligned}$$

$$22.) \quad w_L = \frac{\dot{V}_L}{A_L} = \frac{28,42 \frac{\text{m}^3}{\text{s}}}{2,35 \cdot 10^{-4} \text{ m}^2} = \underline{33,58 \frac{\text{m}}{\text{s}}}$$

23.)

$$v_2(T) = 13323 \cdot 10^{-5} + 8,71 \cdot 10^{-8} \cdot T + 1,02 \cdot 10^{-10} \cdot T^2$$

$$v_L(37,22^\circ\text{C}) = \underline{1,614 \cdot 10^{-5} \frac{\text{m}^2}{\text{s}}}$$

$$24.) Re_L = \frac{d_i \cdot w_L}{\nu_L} = \frac{0,0173m \cdot 33,58 \frac{m}{s}}{1,614 \cdot 10^{-5} \frac{m^2}{s}} = 3,60 \cdot 10^4$$

$$25.) f_L(T) = \frac{p}{R_{sp} \cdot T} = \frac{101325 Pa}{0,29 \frac{kg}{m^3} \cdot (31,22 + 273)K} = 1,149 \frac{kg}{m^3}$$

$$26.) \lambda_L(T) = 0,0876 + 2,46 \cdot 10^{-4} \cdot T + 1,12 \cdot 10^{-7} \cdot T^2$$

$$\lambda_L(31,22^\circ C) = 0,0265 \frac{W}{m \cdot K}$$

$$27.) Pr_L = \frac{c_{p,L} \cdot \nu_L \cdot f_L}{\lambda_L} = \frac{1005 \frac{J}{kg \cdot K} \cdot 1,614 \cdot 10^{-5} \frac{m^2}{s} \cdot 1,149 \frac{kg}{m^3}}{0,0265 \frac{W}{m \cdot K}} = 0,70$$

$$28.) \alpha_{di} = \left[\left(\frac{1}{Nu_a} - \frac{d_a}{2 \cdot \lambda_{st}} \cdot \ln \left[\frac{d_a}{d_i} \right] - \frac{1}{\alpha_{a,40}} \right) \cdot \frac{d_i}{d_a} \right]^{-1}$$

$$= \left[\left(\frac{1}{100 \frac{W}{m^2 \cdot K}} - \frac{0,0213m}{2 \cdot 15,6 \frac{W}{m \cdot K}} \cdot \ln \left[\frac{0,0213m}{0,0173m} \right] - \frac{1}{2677 \frac{W}{m^2 \cdot K}} \right) \cdot \frac{0,0173m}{0,0213m} \right]^{-1}$$

$$= 130 \frac{W}{m^2 \cdot K}$$

$$29.) Nu_L = \frac{\alpha_{di} \cdot d_i}{\lambda_L} = \frac{130 \frac{W}{m^2 \cdot K} \cdot 0,0173m}{0,0265 \frac{W}{m \cdot K}} = \underline{\underline{85}}$$

$$30.) \ln(Re_x^2 \cdot Pr_x) = \ln([3,6 \cdot 10^4]^2 \cdot 0,7) = \underline{20,63}$$

$$\ln(Nu_x) = \ln(85) = \underline{4,44}$$