~~Übungsblatt~~ 1 (1-2)

1.1. Wasser: $\Theta_f = 0\,°C$, $\Theta_v = 100.0\,°C$.

$T_f = 273.15\,K$, $T_v = 373.15\,K$.

$T_f^F = 32\,°F$

$T_v^F = 212\,°F$

Ethanol: $\Theta_f = -114.5\,°C$ $T_f = 158.65\,K$ $T_f^F = -174.1\,°F$

$\Theta_v = 78.33\,°C$ $T_v = 351.48\,K$ $T_v^F = 173.0\,°F$.

1.2. Lineal aus Eisen: $\Delta l = \alpha \Delta T l$ $l = 1\,m$, $\Delta T = -10\,K$, $\alpha = 12 \cdot 10^{-6}\,K^{-1}$

$\Delta l = 12 \cdot 10^{-6}\,K^{-1} \cdot (-10\,K) \cdot 1\,m = -1.2 \cdot 10^{-4}\,m = 0.1\,mm$

1.3. Brücke: $\Delta l = \alpha \Delta T l$ $l = 121\,m$, $\alpha = 12 \cdot 10^{-6}\,K^{-1}$, $\Delta T = 30\,°C - (-5\,°C) = 35\,K$.

$\Delta l = 12 \cdot 10^{-6}\,K^{-1} \cdot 35\,K \cdot 121\,m = 5.082 \cdot 10^{-2}\,m = 5.1\,cm$

1.4. Quecksilber:

$\Delta V = \gamma_{Hg} \Delta T V$

$= \pi r^2 h = \pi \left(\frac{d}{2}\right)^2 \Delta h$

$\Rightarrow \Delta h = \frac{\gamma V \Delta T}{\pi \left(\frac{d}{2}\right)^2} = \frac{4 \gamma V \Delta T}{\pi d^2}$

(besser: $1\,mm = d$)

↳ $18.5\,cm$

$\Delta h = \frac{4 \cdot 0.182 \cdot 10^{-3}\,K^{-1} \cdot 80\,K \cdot 10^{-5}\,m^3}{\pi (1 \cdot 10^{-3}\,m)^2}$

$= 4.6\,cm$

1.5. Aceton

$V = 150\,ml$

$\Theta_0 = 25\,°C$

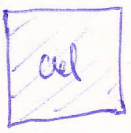
$\Theta_1 - \Theta_0 = 56.25\,°C$

$\Delta V = \gamma \Delta T V = \gamma (\Theta_1 - \Theta_0)$

$\Delta V = 1.49 \cdot 10^{-3}\,K^{-1} (56.25 - 25)\,K \cdot 150\,ml$

$= 6.98\,ml = 7.0\,ml$

1.6. Stahltank



$V = 20'000\,l$

$\Theta_0 = 20\,°C$

$\Theta_1 = 25\,°C$

$\alpha_{St} = 16 \cdot 10^{-6}\,K^{-1}$

$\gamma_{Öl} = 7.0\,K^{-1} \cdot 10^{-4}$

$\Delta V = (\gamma - 3\alpha) \cdot \Delta T \cdot V$

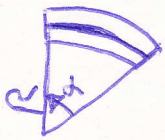
$\Delta V = (7.0 \cdot 10^{-4} - 3 \cdot 16 \cdot 10^{-6})\,K^{-1} \cdot 5\,K \cdot 2 \cdot 10^4\,l$

$= 65\,l$

1.7. Bimetall

$\Theta_0 = 20\,°C$ $\alpha_{Zn} = 26.3 \cdot 10^{-6}\,K^{-1}$ $d = 1\,mm$

$\Theta_1 = 100\,°C$ $\alpha_{Fe} = 12 \cdot 10^{-6}\,K^{-1}$



$\begin{cases} R\alpha = \alpha_1 \Delta T l + l \\ (R+d)\alpha = \alpha_2 \Delta T l + l \end{cases}$

$\frac{R+d}{R} = \frac{\Delta T \alpha_1 + 1}{\Delta T \alpha_2 + 1}$

$1 + \frac{d}{R} = \frac{\alpha_1 \Delta T + 1}{\alpha_2 \Delta T + 1}$

$\frac{d}{R} = \frac{\alpha_1 \Delta T + 1}{\alpha_2 \Delta T + 1} - 1$

$R^{-1} = \left(\frac{\alpha_1 \Delta T + 1}{\alpha_2 \Delta T + 1} - 1\right) d^{-1}$

$R^{+1} = \left(\frac{\alpha_1 \Delta T + 1}{\alpha_2 \Delta T + 1} - 1\right)^{-1} d$

$R = \left(\frac{26.3 \cdot 10^{-6}\,K^{-1} \cdot 80\,K + 1}{12 \cdot 10^{-6}\,K^{-1} \cdot 80\,K + 1} - 1\right)^{-1} 10^{-3}\,m = 8.75 \cdot 10^{-1}\,m = 87.5\,cm$

Wasser: $\Delta Q = cm\Delta T \Rightarrow m = \frac{\Delta Q}{c\Delta T}$ $\quad \Delta T = \Theta_1 - \Theta_0 = 100°C - 20°C = 80K$

2.1

$$m = \frac{1\,kWh}{4182\,\frac{J}{kgK}\cdot 80K} = \frac{10^3\cdot 3600\,J}{4182\cdot 80\,\frac{J}{kg}} = 10.\,kg$$

2.2. $m = 20kg$, $\Delta T = 100K$, $\Delta Q = 1.0\,kWh$

$\Delta Q = cm\Delta T \Rightarrow$ $\quad c_p = \frac{\Delta Q}{m\Delta T} = \frac{10^3\cdot 3600\,J}{20kg\cdot 100K} = 1.8\cdot 10^3\,\frac{J}{kgK}$

2.3 Wärmespeicher

(a) $c^{Fe} = 450\,\frac{J}{kgK}$ $\quad c^{H_2O} > c^{Fe}$ $\quad 10^3\,kg$ H_2O kann / mehr Liter Speichern! $10\times$

(b) $1\,\ell$ Eisen $\hat{=} 10^{-3}\,m^3\cdot \rho_{Eisen}$

$$c^{Fe}\cdot\rho_{Eisen} = 450\,\frac{J}{kgK}\cdot 7.86\cdot 10^3\,\frac{kg}{m^3} = 3.5\cdot 10^6\,\frac{J}{m^3K}$$

$$c^{H_2O}\cdot\rho_{H_2O} = 4182\,\frac{J}{kgK}\cdot 1000\,kg/m^3 = 4.2\cdot 10^6\,\frac{J}{m^3K}$$

C pro Volum ($H_2O > Fe$) aber nur rund $1.5\times$ grösser!

2.4. (i) $V = 120\,\ell$; $m = 120\,kg$ $\quad \Delta T = 38 - 6 = 32K$

$$\Delta Q = c_{H_2O}\,m\,\Delta T = 4182\,\frac{J}{kgK}\cdot 120kg\cdot 32K = 1.6\cdot 10^7\,J = 4.5\,kWh$$

(ii) Durchlauf $\varphi = 1\ell/8s = \frac{1}{8}\,\frac{10^{-3}m^3}{s} = \frac{10^{-3}}{8}\,m^3/s \hat{=} \frac{1}{8}\,\frac{kg}{s}$

$$\Delta t\cdot\varphi = m \Rightarrow \Delta t = \frac{m}{\varphi} \qquad \Delta t = \frac{120\,kg}{\frac{1}{8}\,\frac{kg}{s}} = 16\,min$$

(iii) $P = \frac{\Delta Q}{\Delta t} = \frac{c_{H_2O}\,m\,\Delta T}{m/\varphi} = c_{H_2O}\,\varphi\,\Delta T = 4182\,\frac{J}{kgK}\cdot 32K\cdot\frac{1}{8}\,\frac{kg}{s} = 17\,kW$

2.5. $m = 60kg$ $\quad \Delta t = 1.0\,min$

$P = \frac{\Delta Q}{\Delta t} = 1.0\,kW$

$\Delta Q = c_w\cdot m\,\Delta T = P\Delta t$

$$\Rightarrow \Delta T = \frac{P\Delta t}{c_w\cdot m} = \frac{1\,kW\cdot 60s}{4182\,\frac{J}{kgK}\cdot 60kg} = \frac{10^3}{4182}\,K = 0.24K$$

2.6. Mischung $m_{oel} = 100g$, $m_w = 350g$ $\quad c_p^{oel} = 1970\,J/kgK$ $\quad c_p^{w} = 4182\,J/kgK$ $\quad T_w = 15°C$, $T_{oel} = 95°C$ $\quad [T \to \Theta]$

$$\Delta Q = c_w\,m_w\,(T - T_w) + c_{oel}\,m_{oel}\,(T - T_{oel}) = 0$$

$$T(c_w m_w + c_{oel} m_{oel}) = c_w m_w T_w + c_{oel} m_{oel} T_{oel}$$

$$T = \frac{c_w m_w T_w + c_o m_o T_o}{c_w m_w + c_o m_o}$$

$$T = \frac{4182\,\frac{J}{kgK}\cdot 0.35kg\cdot 15K + 1970\,\frac{J}{kgK}\cdot 0.1kg\cdot 95K}{4182\,\frac{J}{kgK}\cdot 0.35kg + 1970\,\frac{J}{kgK}\cdot 0.1kg} = \frac{4.07\cdot 10^4 K}{1.66\cdot 10^3} = 24°C$$

2.7. Zinnbecher

$m_{Sn} = 100\,g$, $\Theta_{Sn} = -18\,°C$, $c_{Sn} = 227\,\frac{J}{kgK}$

$m_W = 100\,g$, $\Theta_W = 24\,°C$, $c_W = 4182\,\frac{J}{kgK}$

$$\Delta Q = m_{Sn}\, c_{Sn}\,(\Theta - \Theta_{Sn}) + m_W\, c_W\,(\Theta - \Theta_W) = 0$$

$$\Rightarrow \quad \Theta = \frac{m_{Sn}\, c_{Sn}\, \Theta_{Sn} + m_W\, c_W\, \Theta_W}{m_{Sn}\, c_{Sn} + m_W\, c_W} =$$

$$\Theta = \frac{0.11\,kg \cdot 227\,\frac{J}{kgK} \cdot (-18\,K) + 0.1\,kg \cdot 4182\,\frac{J}{kgK} \cdot (24\,K)}{0.11\,kg \cdot 227\,\frac{J}{kgK} + 0.1\,kg \cdot 4182\,\frac{J}{kgK}}$$

$$= \frac{9.59 \cdot 10^3\,K}{4.43 \cdot 10^2} = 21.63\,K = \underline{22\,K}$$