2021

1. a) $\dot{Q}_{aus}$:

$$\Rightarrow \dot{m}_{ein}(h_{aus} - h_{ein}) = \dot{Q}_R - \dot{Q}_{aus}$$

$h_{aus} \hat{=} h_f(100°C) = 419.04 kJ/kg$ (from TA-2)

$h_{ein} \hat{=} h_f(70°C) = 292.99 kJ/kg$

$$\Rightarrow \dot{Q}_{aus} = \dot{Q}_R + \dot{m}_{ein}(h_{ein} - h_{aus}) = 100kW + 0.3kg/s(292.99 - 419.04)kJ/kg$$

$$= \underline{62.19kW}$$

b) $\bar{T}_{KF}$:

$p_{KF} = const. \Rightarrow \bar{T}_{KF} = \frac{T_{kaus} + T_{kein}}{2} = \frac{293.15K + 283.15K}{2}$

$$\underline{\bar{T}_{KF} = 293.15K}$$

c) $\dot{S}_{erz}$:

$$\dot{S}_{erz} = -\frac{\dot{Q}_{aus}}{\bar{T}_{KF}} = -\frac{62.15kW}{293.15K} = \underline{-212W/K}$$

ΔQ_{1+t}

$$(m_1 + \Delta m_{12}) \cdot u_2 - m_1 \cdot u_1 = \Delta m_{12} \cdot h_w(20°C) - Q_{R,12}$$

$u_2 = 252.55 + 0.005 \cdot (2469.6 - 252.55) = 303.93 kJ/kg$ (TA-2)

$u_1 = 419.54 + 0.005 \cdot (2506.5 - 419.54) = 429.99 kJ/kg$

$h_f(20°C) = 83.96 kJ/kg$

$m_1 u_2 + \Delta m h_2 - m_1 u_1 = \Delta m h - Q_R$

$\Delta m(h_2 - h) = m_1 u_1 - Q_R - m_1 u_2$

$$\Delta m_{12} = \frac{m_1 \cdot u_1 - Q_R - m_1 \cdot u_2}{u_2 - h_w} = \frac{5755kJ(429.99 - 303.93)kJ/kg - 55000kJ}{(303.93 - 83.96)kJ/kg}$$

$$\underline{\Delta m_{12} = 3127kg}$$

1. d) $\Delta J_{12} = \Delta M_{12} \cdot S_W(20°C) - \frac{Q_{abk.12}}{T_{KF}}$

$\Rightarrow S_W(20°C) = 0.2566\,kJ/kg\,K$ (TA-2)

$\Delta J_{12} = 3127\,kg \cdot 0.2566\,kJ/kg\,K - \frac{3500\,kJ}{293.15\,K} = \underline{808.1\,kJ/K}$

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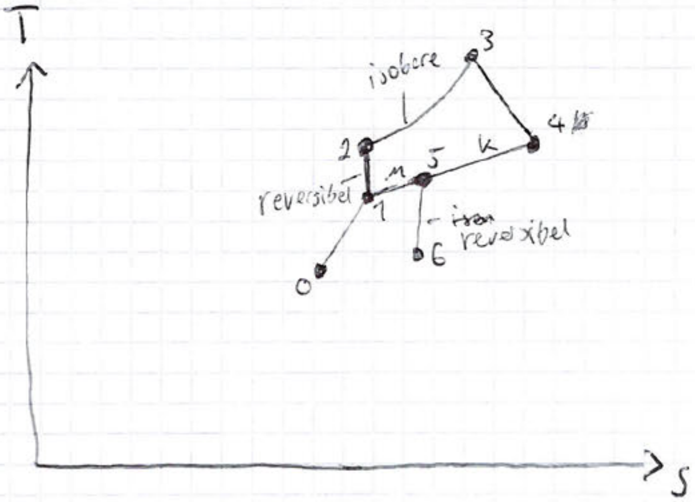
2.

a)



b) T_6, w_6

reversibel: $s_5 = s_6$

$$\Rightarrow 0 = c_p \cdot \ln\left(\frac{T_6}{T_5}\right) - \frac{\bar{R}}{M_L} \cdot \ln\left(\frac{p_6}{p_5}\right)$$

$$\Rightarrow \ln(\Delta T) = \frac{\bar{R}}{c_p M_L} \cdot \ln\left(\frac{p_6}{p_5}\right) \Big| \Rightarrow T_6 = T_5 \cdot \exp\left(\frac{\bar{R}}{c_p \cdot M_L} \cdot \ln\left(\frac{p_6}{p_5}\right)\right)$$

$$T_6 = 431.5\,K \cdot \exp\left(\frac{8.314\,J/molK}{1.006\,kJ/kgK \cdot 28.97\,g/mol} \cdot \ln\left(\frac{0.1516\,bar}{0.5\,bar}\right)\right)$$

$$= \underline{\underline{328.2\,K}}$$

Temperaturtafel $\Rightarrow T_6$: $h_{L5}(431.5\,K) = 431.43 + \frac{1.5}{10} \cdot (441.61 - 431.43) = 433.36\,kJ/kg$

$$h_{L6}(328.2\,K) = 325.31 + \frac{3.2}{5} \cdot (330.34 - 325.31) = 328.53\,kJ/kg$$

$$\Rightarrow \dot{m}\left(h_5 + w_5^2/2\right) = \dot{m}\left(h_6 + w_6^2/2\right)$$

$$\Rightarrow w_6 = \sqrt{2 \cdot \left(h_5 + \frac{w_5^2}{2} - h_6\right)} = \sqrt{2 \cdot \left(433.36\,kJ/kg + \frac{(220\,m/s)^2}{2} - 328.53\,kJ/kg\right)}$$

$$= \underline{507.9\,m/s}$$

3. p_{S1} , m_S

a) $\frac{m_K \cdot g}{A} + \frac{m_{EW} \cdot g}{A} + p_0 = p_{S1}$ | $A = \frac{D^2}{4} \cdot \pi$

$\Rightarrow p_{S1} = p_{amb} + g/A\,(m_K + m_{EW}) = 1\,bar + \frac{4 \cdot 9.81\,m/s^2}{(10 \cdot 10^{-2})^2\,m^2 \cdot \pi}\,(32 + 0.1)\,kg$

$p_{S1} = 1.401\,bar$

$m_S = \frac{pV}{RT} = \frac{p_{S1} \cdot V_{S1} \cdot M_S}{\bar{R} \cdot T_{S1}} = \frac{1.401\,bar \cdot 3.14 \cdot 10^{-3}\,m^3 \cdot 50\,g/mol}{8.314\,J/mol\,K \cdot (50 + 273.15)\,K}$

$m_S = 3.42\,g$

b) T_2 , p_2

$\Rightarrow p_2 \doteq p_1$ | da das Kräfte / Druck-Gleichgewicht immer noch das gleiche bleibt

$p_{g2} = 1.401\,bar$

Da $x_{Ei} > 0$, muss die Temperatur von EW immernoch bei 0°C liegen.

da bei Zustand 2 $Q_{ab} = 0$ ist, muss auch $T_{S2} = 0°C$ sein.

c) $Q_{12} = c_p \cdot m_S \cdot (T_2 - T_1)$ | $c_p = \frac{\bar{R}}{M_S} + c_v$

$= \left(\frac{\bar{R}}{M_S} + c_v\right) \cdot m_S\,(T_2 - T_1) = \left(\frac{8.314\,J/mol\,K}{50\,g/mol} + 0.637\,kJ/kg\,K\right) \cdot 3.42\,g \cdot (500\,K)$

$= 1366.8\,J$

d) $u_{fE} m_{ges} \cdot 0.6 + m_{ges} \cdot 0.4 \cdot u_{fL} - Q_{12} = u_{fE} \cdot x \cdot m_{S1} + u_{fL} \cdot (1-x) \cdot m_{S1}$

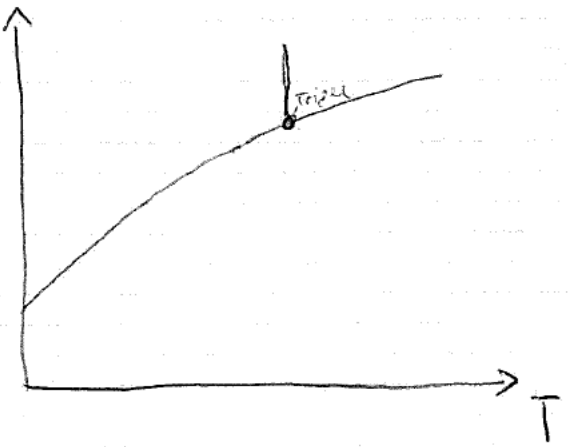
u_{fE}: 0°C (Zustand 1); x: 0°C (Zustand 2); $x_2\,(u_{fE} - u_{fL})$

$\Rightarrow u_{fE} \cdot 0.6 + 0.4\,u_{fL} - Q_{12}/m_{S1} = x_2 \cdot u_{fE} + u_{fL} - x\,u_{fL}$

$\Rightarrow x_2 = \frac{0.6\,u_{fE} + 0.4\,u_{fL} - Q_{12}/m_{S1} - u_{fL}}{u_{fE} - u_{fL}} = \frac{0.6 \cdot (333.458)\,kJ/kg + 0.4 \cdot 0 - 0.045) - \frac{1366.8}{3.42}}{(-333.458) - 0.045)\,kJ/kg}$

$x_2 = 0.560$

4. a)



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4.

~~b) ... T_2 ... $= 22°C$~~

~~c) ...~~

b) $0 = \dot{m}_R (h_2 - h_3) - \dot{W}_K$ | $T_2 = T_1 - 6\,K$; $T_1 = T_5 + 10\,K$

T_5 ($T_{Ver} = -25°C + 5 = -20°C$

$h_2(-20°C, x_2 = 1) = 24.26$ kJ/kg (TA-10)

$h_3 = 93.42$ kJ/kg (TA-11)

$$\dot{m}_R = \frac{\dot{W}_K}{h_2 - h_3}$$