Aufgabe 1

a) $0 = \dot{m}[h_e - h_a] + \sum \dot{Q}_j - \sum \dot{W}_{b,in}^{\to 0}$ $\quad \sum \dot{Q}_j = \dot{Q}_R + \dot{Q}_{aus}$

$= \dot{Q}_R + \dot{Q}_{aus}$

$h_a = 419.04 + 0.005(2676.1 - 419.04) = 430.33 \frac{kJ}{kg}$

$h_e = 292.98 + 0.005(2626.8 - 292.98) = 304.65 \frac{kJ}{kg}$

$\dot{Q}_{aus} = 0.3[304.65 - 430.33] + 100 = +62.30\,kW$

Aufgabe 1

[redacted]

b) $\bar{T} = \frac{\int_e^a T\,ds}{s_a - s_e} = \frac{\int_e^a T\,ds}{\int_{T_{ein}}^{T_{aus}} \frac{c_i f(T)}{T}\,dT} =$

Aufgabe 1

c) $\dot{Q}_{aus} = 65\,kW \quad \bar{T}_{KF} = 295\,K$

$$0 = \dot{m}[s_e - s_a] + \sum_j \frac{\dot{Q}_j}{\bar{T}_j} + \dot{s}_{erz} \qquad \bar{T}_{Reaktor} = 100°C = 373.15\,K$$

→ Bilanz im Reaktor

$$\dot{s}_{erz} = \dot{m}[s_a - s_e] - \frac{\dot{Q}_{aus}}{\bar{T}_{Reaktor}}$$

$s_a = 1.3069 + 0.005(7.3549 - 1.3069) = 1.34 \frac{kJ}{kg \cdot K}$

$s_e = 0.9549 + 0.005(7.7553 - 0.9549) = 0.99 \frac{kJ}{kg \cdot K}$

$\dot{s}_{erz} = 0.3[1.34 - 0.99] - \frac{-65\,kW}{373.15\,K} = 0.29 \frac{kW}{kg \cdot K}$

Aufgabe 1

d) $\Delta E = \sum_i \Delta m_i [h_i] + \sum_j Q_j = m_2 u_2 - m_1 u_1 = (m_1 + \Delta m_{12}) u_2 - m_1 u_1$

$m_1 u_2 + \Delta m_{12} u_2 - m_1 u_1 = \Delta m_{12} [h_{12}] + Q_{R,12}$

$\Delta m_{12} = \underbrace{m_1 u_2 - m_1 u_1 + Q_{R,12}}_{h_{12}} + \Delta m_1$

$\Delta m_{12}(1 - u_2) = \underbrace{m_1 u_2 - m_1 u_1 - Q_{R,12}}_{h_{12}}$

$u_1 = 418.94 + 0.005(2506.5 - 418.94) = 429.38 \frac{kJ}{kg}$

$u_2 = u_f(70°C) = 292.95 \frac{kJ}{kg}$

$h_{12} = h_f(20°C) = 83.96 \frac{kJ}{kg}$

$\Delta m_{12} = \frac{5755\,kg \cdot 292.95 \frac{kJ}{kg} - 5755\,kg \cdot 429.38 \frac{kJ}{kg} - 35'000\,kJ}{83.96 \frac{kJ}{kg} - 83.96 \frac{kJ}{kg}, 292.95 \frac{kJ}{kg}}$

$= 33.46\,kg$

e) $\Delta S = m_2 s_2 - m_1 s_1 \qquad \Delta m_{12} = 3600\,kg$

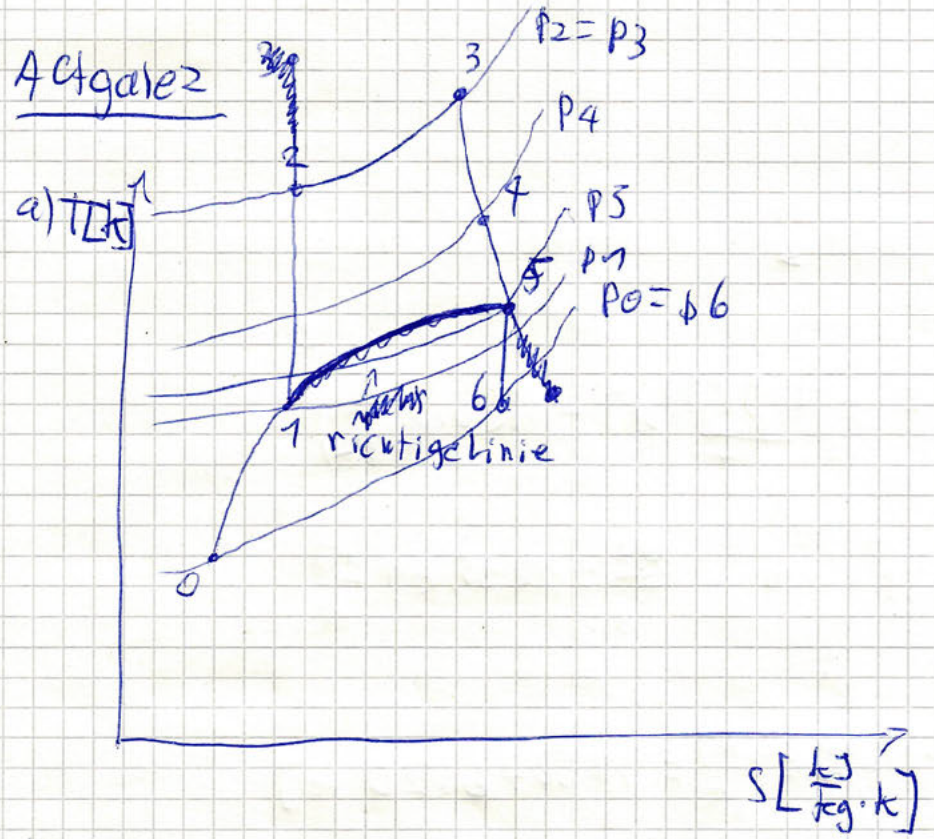
$s_1 = 1.3069 + 0.005(1.354 - 1.3069) = 1.34 \frac{kJ}{kg \cdot K}$

$s_2 = s_f(70°C) = 1.0155 \frac{kJ}{kg \cdot K}$

$\Delta S = (5755\,kg + 3600\,kg)\, 1.02 \frac{kJ}{kg \cdot K} - 5755\,kg \cdot 1.34 \frac{kJ}{kg \cdot K} = 1830.4 \frac{kJ}{kg \cdot K}$

Aufgabe 2

a)



b) $0 = \dot{m}\left[h_e - h_a + \frac{(w_e^2 - w_a^2)}{2}\right] + \sum \dot{Q}_j - \sum \dot{W}_t$

$$\frac{T_6}{T_5} = \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}} \qquad T_0 = T_5 \left(\frac{p_0}{p_5}\right)^{\frac{1.4-1}{1.4}} = 328.07\,K$$

$p_0 = p_6 = 0.191\,bar$

c) $e_{x,str} = e_{x,str,6} - e_{x,str,0}$ $\quad T_6 = 340\,K$ $\quad w_6 = 510\,\frac{m}{s}$ $\quad T_0 = 243.15\,K$

$$\dot{E}_{x,str} = \dot{m} e_{x,str} = \dot{m}\left[h - h_0 - T_0(S - S_0) + ke + pe\right]$$

$$e_{x,str,6} = h_6 - h_0 - T_0(S - S_0) + ke = \int_{T_0}^{T_6} c_p^{ig}(T)\,dT - T_0 \int_{T_0}^{T_6} \frac{c_p^{ig}(T)}{T}\,dT + ke$$

$$e_{x,str,0} = h_0 - h_0 - T_0(S_0 - S_0) + ke$$

$$e_{x,str,6} = c_p^{ig}(T_6 - T_0) - T_0 c_p^{ig} \ln\left(\frac{T_6}{T_0}\right) + \frac{1}{2} \cdot w_6^2 = 130065.42$$

$$e_{x,str,0} = \frac{1}{2} \cdot w_0^2 = 20'000$$

$$e_{x,str} = 130065.42 - 20000 = 110065.42\,\frac{kJ}{kg}$$

d) $E_{x,verl} = T_0 \cdot \dot{S}_{erz}$

$$0 = \dot{m}[s_e - s_a] + \frac{\dot{Q}_j}{T_j} + \dot{S}_{erz}$$

$$\frac{\dot{S}_{erz}}{\dot{m}} = s_a - s_e - \frac{Q_B}{T_B} = \int_{T_2}^{T_3} \frac{c_p^{ig}(T)}{T} dT - R \ln\left(\frac{p_3}{p_2}\right)^{0}$$

$$= c_p^{ig} \cdot \ln\left(\frac{T_3}{T_2}\right) - \frac{Q_B}{T_B} = 1295.81 \frac{kJ}{K}$$

$$E_{x,verl} = 243.13K \cdot 1295.81 \frac{kJ}{K} = 315076.20\,kJ$$

Aufgabe 3

[redacted]

a) $m = \frac{p \cdot V}{R T}$

$R = \frac{\bar{R}}{M} = \frac{8{,}314\ \frac{J}{mol \cdot K}}{50{,}000\ \frac{g}{mol}} = 0.000166\ \frac{J}{kg \cdot K}$

$p = \frac{R T}{v}$

b) $p_{g,1} = 1{,}5\,bar \quad m_g = 3{,}6\,g$

$T_{g,2} = 0°C \qquad \frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}}$

$n = \frac{c_p^{ig}}{c_v^{ig}} = \frac{0{,}63316}{0{,}6} =$

$\left(p_2\right)^{\frac{n-1}{n}} = \frac{T_2}{T_1} \cdot (p_1)^{\frac{n-1}{n}}$

$p_2 = \left(\frac{T_2}{T_1}\right)^{\frac{n}{n-1}} \cdot p_1$

$R = c_p^{ig} - c_v^{ig} \quad c_p^{ig} = R + c_v^{ig}$

$c_p^{ig} = 0{,}63316$

$n = \frac{0{,}63316}{0{,}633} = 1{,}00025$

gas

Die Temp ist gleich wie des Eis, da die Eis Temp sich nicht verändern kann mit $x_1 \geq 0$

c) $\Delta E = E_2 - E_1 = \sum_j Q_j - \sum_n W_{tn}$ durch einschließen des Gemisch wird $W = 0$

$m(u_2 - u_1) = Q_{12} = m \int_{T_1}^{T_2} c_v^{ig}\, dT = m c_v^{ig} (T_2 - T_1) =$

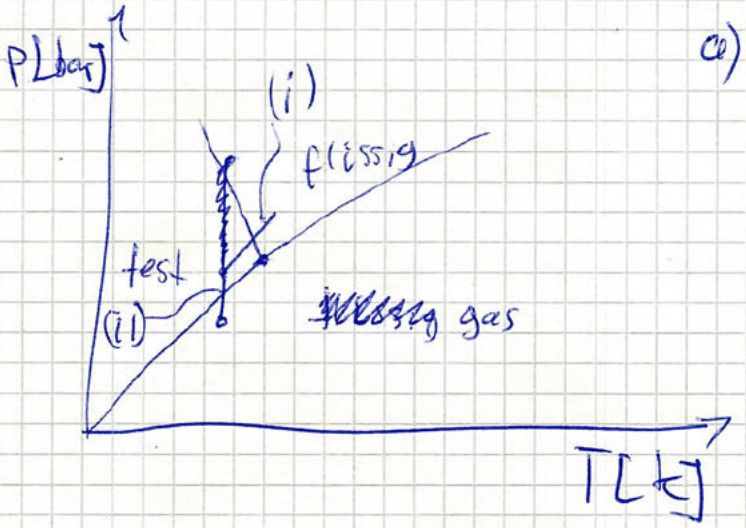
$T_2 = 0.003°C = 273.153K$

$= -1.14kJ$

$Q_{12} = 1140J$

a)

Aufgabe 4



a)

b)

	T	p	x
1		$p_1 = p_2$	
2	−10°C	$p_2 = p_1$	
3	−40°C	8 bar	
4		8 bar	0

$T_1 = -10°C \rightarrow T_1 = T_2 = -40°C$

2-3 Prozess

$0 = \dot{m}[h_e - h_a] + \dot{Q}_{23}^{\nearrow 0} - \dot{W}_t \qquad \dot{m} = \frac{\dot{W}_t}{h_e - h_a}$

$h_e = h_g(-40°C) = 244.9 \frac{kJ}{kg}$

$h_a =$

c) $s_1 = s_4 = s_f(8\,bar) = 0.459 \frac{kJ}{kg \cdot K}$ da $p_3 = p_4$

$x_1 = \frac{s_4 - s_f(-40°C)}{s_g(-40°C) - s_f(-40°C)} = 0.23$

a) $e_k = \frac{Q_{za}}{Q_{ob} - Q_{za}} =$