A1

[redacted]

1a ~~1. HS Am Kühlmantel:~~

$$\cancel{\frac{dE}{dt} = \frac{dU}{dt} = \dot{Q}_{aus} \;,\; \Delta U = Q_{aus}}$$

$$\cancel{\Delta U = \int_{T_{KF\,ein}}^{T_{KF\,aus}} c^{if}\,dT = Q_{aus} \;,\; Q_{aus} = c^{if}(10K)}$$

1b $$\cancel{\overline{T}_{KF} = \frac{\int_e^a T\,ds}{s_a - s_e}}$$

1a 1. HS Um Kessel:

$$0 = \dot{m}_{ein}(h_{ein} - h_{aus}) + \dot{Q}_R - \dot{Q}_{aus}$$

$$h_{ein}\,(\text{TAB A2}) = 292.98\ \frac{kJ}{kg}$$

$$h_{aus}\,(\text{TAB A2}) = 419.04\ \frac{kJ}{kg}$$

$$\dot{Q}_{aus} = \dot{m}_{ein}(h_{ein} - h_{aus}) + \dot{Q}_R = \underline{\underline{62.2\,kW}}$$

1b Hier kann das arithmetische Mittel verwendet werden:

$$T_{KF} = \frac{T_{KF\,a} + T_{KF\,e}}{2} = \underline{\underline{293.15\,K}}$$

1c $\quad$ gs: $\dot{S}_{erz}$ Reaktor / kM

$$0 = \dot{M}\left(s_{ein} - s_{aus}\right) + \frac{\dot{Q}_{aus}}{T_{KF}} + \frac{\dot{Q}_R}{\cancel{T}_{100°C}} + \dot{S}_{erz}$$

$$\dot{S}_{erz} = 2\dot{M}\left(s_{aus} - s_{ein}\right) + \frac{\dot{Q}_{aus}}{T_{KF}} - \frac{\dot{Q}_R}{373{,}15K}$$

$s_{aus} \Rightarrow TAB\,A2 = 1.3069\ \frac{kJ}{kgK}$

$s_{ein} \Rightarrow TAB\,A2 = 0.9549\ \frac{kJ}{kgK}$

$\dot{S}_{erz} = 26.4\ \frac{kW}{K}$

1d $\quad \Delta U = \Delta M\left(h_{ein\,A2}\right) + 35MJ$

$\Delta U = M_{ges}\left(u_2 - u_1\right)$, $u_2 = x_D u_g + (1 - x_D) u_f$

$u_2 \Rightarrow TAB\,A2 = 303.83\ \frac{kJ}{kg}$

$u_1 \Rightarrow TAB\,A2 = 429.38\ \frac{kJ}{kg}$

$-693.8\,MJ = \Delta M\, h_{ein\,A2} + 35MJ$

$h_{ein\,A2} \Rightarrow TAB\,AC = 2454.1\ \frac{kJ}{kg}$

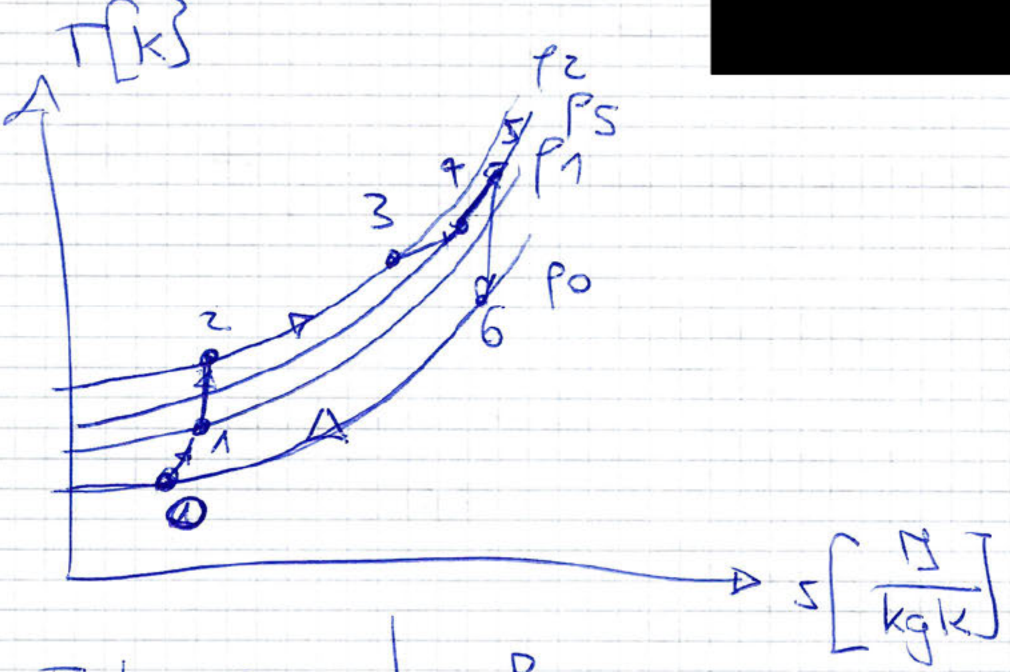
$\left|-728.8\,MJ\right| = \Delta M \cdot 2454.1\ \frac{kJ}{kg} = \Delta M \cdot \frac{2.454\,MJ}{kg}$

$\Delta M_{A2} = 296.99\,kg$

[redacted]

A2

2a



Zst	T	s	p
1	-30°C	s_1	p_0
2		$s_2 = s_1$	$p_2 > p_0$
3		$s_3 > s_2$	$p_3 = p_2$
4		$s_4 > s_3$	$p_4 < p_3$
5	431,9K		$0{,}5bar = p_4 = p_5$
6		$s_6 = s_5$	p_0

same

same

same

2b

ges: ω_6, T_6

~~Isentrope Schubdüse, ω_5, p_5, T_5 bekannt~~

$$\cancel{0 = \dot{m}\left(h_5 - h_6 + \frac{\omega_5^2 - \omega_6^2}{2}\right) - \omega_v}$$

$$\cancel{\dot{m} = \dot{m}_{ges}}$$

Exergiebilanz:

$$0 = \dot{m}_{ges}\left(h_5 - h_6 + \Delta ke\right), \quad \Delta ke = \frac{\omega_5^2 - \omega_6^2}{2}$$

$$h_5 \Rightarrow \text{TAB A22} = h(430K) + \frac{h(440K) - h(430K)}{10K} \cdot 1{,}9K$$

2b $h_5 = 953.36\ \frac{kJ}{kg}$

Isentrope Zst. änd.: $T_6 = T_5 \left(\frac{p_6}{p_5}\right)^{\frac{n-1}{n}}$

$$\underline{\underline{T_6 = 328.075K}}$$

$$h_6 = h(325K) + \frac{h(330K) - h(325K)}{5K} \cdot (3.075K)$$

$$h_6 = 333.93\ \frac{kJ}{kg}$$

$$0 = \dot{m}_{ges}\left((h_5 - h_6) + \frac{\omega_5^2 - \omega_6^2}{2}\right)$$

$$\cancel{\dot{m}_{ges}} 2(h_6 - h_5) = \cancel{\dot{m}_{ges}} \frac{\omega_5^2 - \omega_6^2}{\cancel{2}}, \quad -\omega_6^2 = 2(h_6 - h_5) - \omega_5^2$$

$$\omega_6^2 = 2(h_5 - h_6) + \omega_5^2, \quad \underline{\underline{\omega_6 = 498.26\ \frac{m}{s}}}$$

2c $e_{x\,str6} - e_{x\,str0} = \dot{m}_{ges}\left(h_6 - h_0 - T_0(s_6 - s_0) + \Delta ke\right)$

$$h_6 = 333.93\ \frac{kJ}{kg}, \quad h_0 = h(263.15K)$$

$$s_6 = s(T_6), \quad s_0 = s(T_0) \quad \Delta ke = \frac{\omega_6^2 - \omega_0^2}{2}$$

$$s_6(T_6) \approx 1.79\ \frac{kJ}{kgK}, \quad s_0 \approx 1.56\ \frac{kJ}{kgK}$$

$$h_0 \approx 263\ \frac{kJ}{kg}$$

TAB A22

$$\underline{\underline{\Delta e_{x\,str}}} = \frac{e_{x\,str}}{\dot{m}_{ges}} = \cancel{109.14\ \frac{kJ}{kg}} \quad \underline{\underline{119.09\ \frac{kJ}{kg}}}$$

A3 [redacted]

3a $p_{g,1} = p_{amb} + p_{EW} + p_{M_K}$

$$p_{EW} = \frac{m_{EW} g}{\pi \left(\frac{D}{2}\right)^2}, \quad p_{M_K} = \frac{M_K g}{\pi \left(\frac{D}{2}\right)^2}$$

$p_{g,1} = 1 bar \cancel{+ ...Pa} + 124.91 Pa + 39969.97 Pa$

$\underline{p_{g,1} = 1.4 bar}$

m_g: $p_{g1} V_{g1} = m_g R T_{g1}$, $R = \frac{\bar{R}}{M} = \frac{8.314 \frac{J}{mol K}}{50 \frac{kg}{kmol}}$

$$m_g = \frac{p_{g1} V_{g1}}{R T_{g1}} = 0.00342 kg \quad R = 166.28 \frac{J}{K kg}$$

$\underline{m_g = 3.42 g}$

3b $x_{Eis,2} > 0$, ges: $T_{g,2}$, $p_{g,2}$

Zust 2: Thermodyn. GGw zwischen EW und Gas, heisst kein Wärmestrom, heisst gleiche Temperatur.

$$\cancel{T = \frac{p_{2g} V}{} \frac{p_{g,2} V_{g,1}}{m_g R} = \frac{p_{EW} V_{EW}}{m_{EW}}}$$

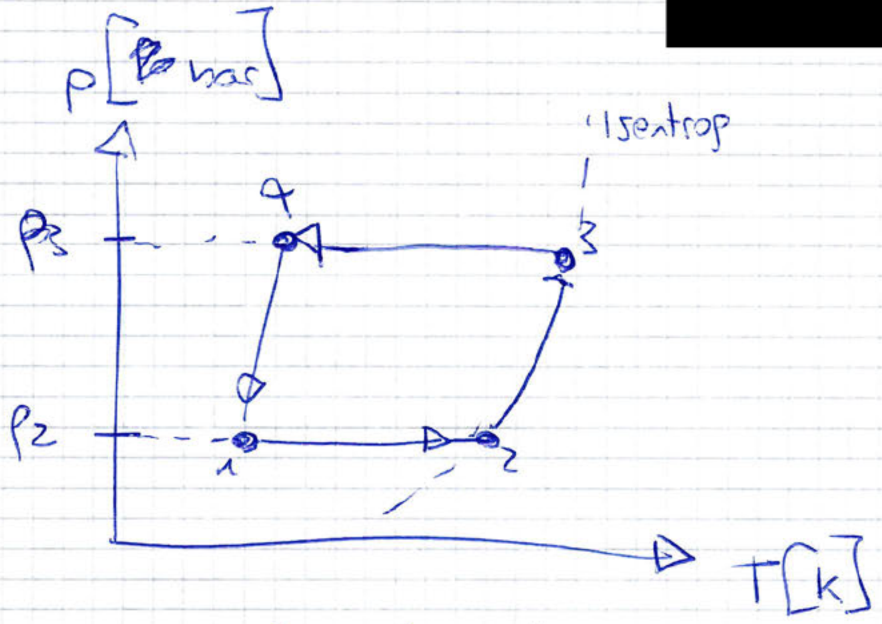
$\underline{T_{g,2} = T_{EW,2}}$, $p_{g,2} =$

3c

[redacted]

A4

4a



1-2 ~~Isentro~~ 2-3 Isentrop

1-2 Isobar

3-4 Isobar

4-1 Druckminderung

4b

$$0 = \dot{m}_{R134a}(h_1 - h_2) + \dot{Q}_K$$

$$\cancel{h_2} = T_{verdampfer} = T_i - 6K = -6K$$

$$h_1 = h_f(-6K), \quad h_2 = h_g(-6K)$$

4c

$$x_1 = \frac{s - s_f}{s_g - s_f}$$