3. Klausur [redacted] 07

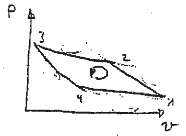
Theorie

a) thermisches Gleichgewicht $\Sigma=1$

b) Prozessgrößen → ZÄ (z.B. Arbeit)
Zustandsgrößen → Zustand (z.B. T) $\Sigma=2$

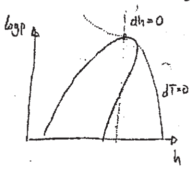
c) Nein. Id. Prozessführung ≠ id. Arbeitsmedium $\Sigma=2$

d)



$\Sigma=3$

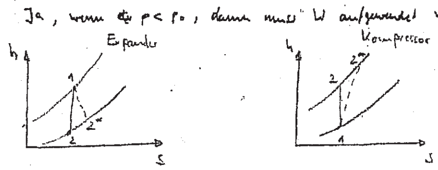
e)



$\Sigma=3$

f) Ja, wenn $p < p_0$, dann muss W aufgewendet werden um ins GG zu kommen. $\Sigma=2$

g)



$\Sigma=5$

h) $\frac{1}{k} = \frac{1}{25} + \frac{0{,}2}{0{,}4} + \frac{1}{10} \Rightarrow k = 1{,}5625\ \frac{W}{m^2K}$

$\Rightarrow \dot{Q} = k \cdot A \cdot \Delta T = 1{,}5625\ \frac{W}{m^2K} \cdot 1\,m^2 \cdot 15\,K = 23{,}44\ W$ $\Sigma=2$

geschl. System

a) $v_E = \frac{V_E}{m_E} = \frac{V_{AI} + V_{AII}}{m_{AI} + m_{AII}} = \frac{m_{AI}\,v_{AI} + m_{AII}\,v_{AII}}{m_{AI} + m_{AII}}$

mit $v_{AI} \overset{h,s\text{-Diagramm}}{=} 5{,}404\ \frac{m^3}{kg} \Rightarrow V_{AI} = 54{,}01\ m^3$

$v_{AII} = 1{,}937\ \frac{m^3}{kg} \Rightarrow V_{AII} = 38{,}74\ m^3$

$\Rightarrow v_E = 3{,}09\ \frac{m^3}{kg}$

$p_E \overset{h,s\text{-Diagr.}}{=} p(v_E, T_E) = 0{,}54\ bar$

$h_E \overset{h,s\text{-Diagr.}}{=} h(v_E, T_E) = 2662\ \frac{kJ}{kg}$ $\Sigma=7$

b) $\frac{dU}{dt} = \dot{Q} + \dot{W}_{=0} \Rightarrow Q = U_E - U_A$

$U_A = U_{AI} + U_{AII}$

mit $h_{AI} = 2646\ \frac{kJ}{kg}$ und $h_{AII} = 2777\ \frac{kJ}{kg}$

$\Rightarrow H_{AI} = 26460\ kJ$ $\quad H_{AII} = 55540\ kJ$

$U_{AI} = H_{AI} - p_{AI} \cdot V_{AI} = 26460\ kJ - 0{,}5 \cdot 10^2\ \frac{kN}{m^2} \cdot 54{,}01\ m^3 = 23839{,}7\ kJ$

$U_{AII} = 55540\ kJ - 1 \cdot 10^2\ \frac{kN}{m^2} \cdot 38{,}74\ m^3 = 79436\ kJ$ 51666 kJ

$\Rightarrow U_A = 76505{,}7\ kJ$

$U_E = 79860\ kJ - 0{,}54 \cdot 10^2\ \frac{kN}{m^2} \cdot 92{,}75\ m^3 = 74851{,}5\ kJ$

$\Rightarrow Q = 16542\ kJ$ $\Sigma=7$

c) $\frac{dS}{dt} = \frac{\dot{Q}}{T} + \dot{S}_{gen} \Rightarrow S_{gen} = S_E - S_A - \frac{Q}{T}$ $\quad S_E = 7{,}60\ \frac{kJ}{kgK} = 228\ \frac{kJ}{K}$

$S_A = m_{AI} \cdot s_{AI} + m_{AII} \cdot s_{AII} = 10\,kg \cdot 7{,}829\ \frac{kJ}{kgK} + 20\,kg \cdot 7{,}615\ \frac{kJ}{kgK} = 230{,}59\ \frac{kJ}{K}$

$\Rightarrow S_{gen} = 228\ \frac{kJ}{K} - 306{,}74\ \frac{kJ}{K} - \frac{-16542\ kJ}{293{,}15\ K} = 3{,}05\ \frac{kJ}{K}$ $\Sigma=6$

Feuchte Luft

a) Den Anteil eines Stoffes am Gesamtdruck einer Mischung

b) id. Gas: $p_{wd} \cdot V = m_{wd} \cdot \frac{\bar{R}}{M_{wd}} \cdot T$; $p_L \cdot V = m_L \cdot \frac{\bar{R}}{M_L} \cdot T$

$\Rightarrow m_{wd} = \frac{p_{wd} \cdot V}{\frac{\bar{R}}{M_{wd}} \cdot T}$ mit $M_{wd} = 18\ \frac{kg}{kmol}$ und $p_{wd} = \varphi_1 \cdot p_{w,s}(T_1)$

$p_{wd} = 1 \cdot 0{,}0317\ bar = 0{,}0317\ bar$

$\Rightarrow m_{wd} = \frac{0{,}0317 \cdot 10^2\ \frac{kN}{m^2} \cdot 10\,m^3}{\frac{8{,}314\ \frac{kJ}{kmol\,K}}{18\ \frac{kg}{kmol}} \cdot 298{,}15\,K} = 0{,}23\ kg$

$m_{Luft} = \frac{(p_1 - p_{wd}) \cdot V_1}{\frac{\bar{R}}{M_{Luft}} \cdot T_1} = 11{,}27\ kg$ $\Sigma=8$

c) $\varphi = \frac{p_{wd}}{p_{w,s}(T)}$; mit $\frac{V}{T} = konst \Rightarrow \frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow T_2 = \frac{V_2}{V_1} \cdot T_1$

$\Rightarrow T_2 \uparrow \Rightarrow p_{w,s}(T_2) \uparrow \Rightarrow \varphi \downarrow$ $\Sigma=2$

d) $W_{12} = -\int_1^2 p\,dV = -p \cdot (V_2 - V_1) = -1 \cdot 10^2\ \frac{kN}{m^2} \cdot 10\,m^3 = -1000\ kJ$ $\Sigma=2$

e) $\frac{dU}{dt} = \dot{Q} + \dot{W} \Rightarrow Q_{12} = U_2 - U_1 - W_{12}$ mit $U_2 = H_2 - p_2 V_2$ und $U_1 = H_1 - p_1 V_1$

$H_2 = m_L \cdot h_{1+x,2} = m_L \cdot [c_{pL} \cdot t_2 + x_2 \cdot (r_0 + c_{p,wd} \cdot t_2)]$

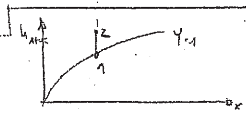
mit $T_2 = \frac{V_2}{V_1} \cdot T_1 = 596{,}3\ K \Rightarrow 323{,}15\ °C = t_2$; $x_2 = \frac{m_w}{m_L} = 0{,}0204$

$\Rightarrow H_2 = 11{,}27\ kg \cdot [1{,}004 \cdot 323{,}15\ \frac{kJ}{kg} + 0{,}0204 \cdot (2500\ \frac{kJ}{kg} + 1{,}86 \cdot 323{,}15\ \frac{kJ}{kg})]$
$= 4369{,}4\ kJ$

$H_1 = 868{,}33\ kJ$

$Q_{12} = (4369{,}4\ kJ - 1 \cdot 10^2\ \frac{kN}{m^2} \cdot 20\,m^3) - (868{,}33\ kJ - 1 \cdot 10^2\ \frac{kN}{m^2} \cdot 10\,m^3) - (-1000\ kJ)$
$= 3501{,}07$ $\Sigma=6$

f)



$\Sigma=2$

g) $E_D = T_0 \cdot S_{gen} = 293{,}15\ K \cdot 3{,}05\ \frac{kJ}{K} = 894{,}12\ kJ$ $\Sigma=2$

Verbrennung

a) $1\ H_2 + \frac{1}{2}\ O_2 \longrightarrow 1\ H_2O$ - stöchiometrisch

$\Rightarrow \dot{n}_{O_2} = 5 \cdot \frac{1}{2} \frac{kmol}{s} = \frac{5}{2} \frac{kmol}{s};\ \dot{n}_{H_2O} = 1 \frac{kmol}{s};\ \dot{n}_{O_2,Abgas} = 2 \frac{kmol}{s}$

$\boxed{\Sigma = 5}$

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b) $\frac{dU}{dT} = 0 = \dot{Q} + \dot{W} + \dot{H}_{H_2} + \dot{H}_{O_2} - \dot{H}_{Abgas}$ (mit $\dot{Q} \to 0$, $\dot{W} \to 0$)

$\dot{H}_{H_2} = 1 \frac{kmol}{s} \cdot 0 \frac{kJ}{kmol} = 0\ kW;\quad \dot{H}_{O_2} = \frac{5}{2} \frac{kmol}{s} \cdot 0 \frac{kJ}{kmol} = 0\ kW$

$\dot{H}_{Abgas} = \dot{n}_{O_2} \cdot \bar{h}_{O_2} + \dot{n}_{H_2O} \cdot \bar{h}_{H_2O} = 0$

$\Rightarrow 0 = 2 \frac{kmol}{s} \cdot \left(38{,}84 \frac{kJ}{kmol\ °C} \cdot t - 8181 \frac{kJ}{kmol}\right) + 1 \frac{kmol}{s} \cdot (53{,}3 \cdot t - 261963)$

$\Rightarrow 278325 = 130{,}98 \cdot t \Rightarrow t = 2125\ °C$

$\boxed{\Sigma = 6}$

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c) $p_{H_2O,3\,max} = p_s(t = t_3) = 0{,}0317\ bar$

$\boxed{\Sigma = 2}$

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d) $p_3 = 1\ bar \qquad p_{H_2O,3} = y_{O_2,3} \cdot p_3 = \frac{1}{3} \cdot 1\ bar = 0{,}\bar{3}\ bar$

$\boxed{\Sigma = 3}$

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e) Nein

id. Gas (MB)

$\frac{dU}{dT} = \dot{Q} + \dot{W} \Rightarrow Q_{12} = U_2 - U_1 - W_{12}$

$= m \cdot c_v \cdot (T_2 - T_1) - W_{12} = \ldots$

$\frac{c_p}{c_v} = \kappa \qquad c_p = c_v + \frac{R}{M}$

$c_v + \frac{R}{M} = \kappa \cdot c_v \Rightarrow c_v + \frac{R}{M} = c_v \cdot \kappa$

$\Rightarrow \frac{R}{M} = c_v (\kappa - 1)$

$\Rightarrow c_v = \frac{R/M}{\kappa - 1}$ [illegible]

$T_2 = \frac{V_2}{V_1} \cdot T_1$?