

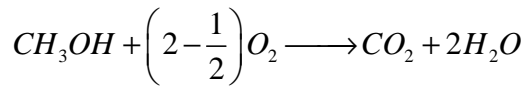
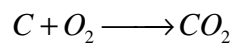
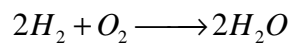
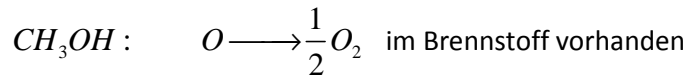
Lösung 10.1

geg.: $\dot{n}_{CH_3OH,I} = 1 \frac{\text{kmol}}{\text{s}}$ $\dot{n}_{L,I} = 10 \frac{\text{kmol}}{\text{s}}$
 $\psi_{O_2,II} = 0,21$ $\psi_{N_2,II} = 0,79$

ges.: $\dot{n}_{CO_2}, \dot{n}_{H_2O,II}, \dot{n}_{O_2,II}, \dot{n}_{N_2,II}, \lambda, \chi$

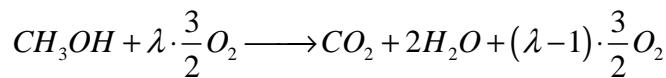
1. Schritt:

$\lambda = 1$ Oxidator: O_2



2. Schritt:

$\lambda > 1$ Oxidator: O_2



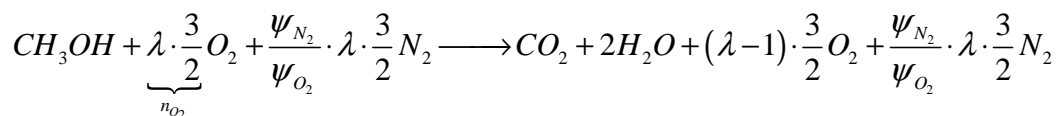
3. Schritt:

$\lambda > 1$ Oxidator: Luft $\psi_{N_2,I}, \psi_{O_2,I}$

$\dot{n}_{L,I} = \dot{n}_{O_2,I} + \dot{n}_{N_2,I}$

$\psi_{O_2,I} = \frac{\dot{n}_{O_2,I}}{\dot{n}_{L,I}} \Rightarrow \dot{n}_{L,I} = \frac{\dot{n}_{O_2,I}}{\psi_{O_2,I}}$

$\psi_{N_2,I} = \frac{\dot{n}_{N_2,I}}{\dot{n}_{L,I}} \Rightarrow \dot{n}_{N_2,I} = \psi_{N_2,I} \cdot \dot{n}_{L,I} = \frac{\psi_{N_2,I}}{\psi_{O_2,I}} \cdot \dot{n}_{O_2,I}$



4. Schritt:

$\dot{n}_{O_2,I} = \psi_{O_2,I} \cdot \dot{n}_{L,I} = 0,21 \cdot 10 \frac{\text{kmol}}{\text{s}} = 2,1 \frac{\text{kmol}}{\text{s}}$

$\dot{n}_{N_2,I} = \psi_{N_2,I} \cdot \dot{n}_{L,I} = 0,79 \cdot 10 \frac{\text{kmol}}{\text{s}} = 7,9 \frac{\text{kmol}}{\text{s}}$

aus der Reaktionsgleichung folgt:

$\dot{n}_{O_2,I} = \frac{3}{2} \cdot \lambda \cdot \dot{n}_{CH_3OH,I} = 2,1 \frac{\text{kmol}}{\text{s}} \Rightarrow \lambda = 1,4$

$\psi_{CO_2,II} = 0,087$

$\dot{n}_{CO_2,II} = \dot{n}_{CH_3OH,I} = 1 \frac{\text{kmol}}{\text{s}}$

$\psi_{H_2O,II} = 0,174$

$\dot{n}_{H_2O,II} = 2 \cdot \dot{n}_{CH_3OH,I} = 2 \frac{\text{kmol}}{\text{s}}$

$\psi_{O_2,II} = 0,052$

$$\dot{n}_{O_2,II} = (\lambda - 1) \cdot \frac{3}{2} \cdot \dot{n}_{CH_3OH,I} = 0,6 \frac{\text{kmol}}{\text{s}}$$

$$\psi_{N_2,II} = 0,687$$

$$\dot{n}_{N_2,II} = \dot{n}_{N_2,I} = 7,9 \frac{\text{kmol}}{\text{s}}$$

Verbrennungsverhältnis:

$$\chi = \frac{\left(\sum_j \dot{n}_{II,j} \right)_{\text{gasf. ,stöch.}}}{\left(\sum_j \dot{n}_{II,j} \right)_{\text{gasförmig}}}$$

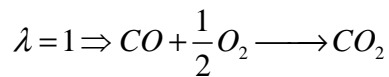
$$\chi = \frac{1 \frac{\text{kmol}_{CO_2}}{\text{s}} + 2 \frac{\text{kmol}_{H_2O}}{\text{s}} + \frac{3/2}{0,21} \cdot 0,79 \frac{\text{kmol}_{H_2O}}{\text{s}}}{1 \frac{\text{kmol}_{CO_2}}{\text{s}} + 2 \frac{\text{kmol}_{H_2O}}{\text{s}} + 0,6 \frac{\text{kmol}_{O_2}}{\text{s}} + 7,9 \frac{\text{kmol}_{N_2}}{\text{s}}} = 0,752$$

Lösung 10.3

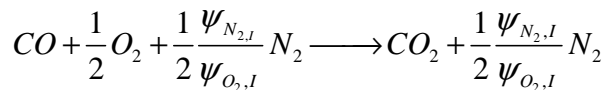
geg.: Zustandsänderungen

Kühlluft	$I \longrightarrow II$	isobare Wärmezufuhr durch Reaktion von CO mit Luft		
CO , Luft	$I \longrightarrow II$	Reaktion mit isobarer Wärmeabfuhr an die Kühlluft		
	$II \longrightarrow III$	adiabate, isobare Mischung von Kühlluft und Abgas		
$\dot{m}_{CO,I} = 1 \frac{\text{kg}}{\text{s}}$	$\psi_{O_2,I} = 0,21$	$\psi_{N_2,I} = 0,79$	$M_{CO} = 28 \frac{\text{kg}}{\text{kmol}}$	
$\Delta e_a = 0$	$T_I = 298,15 \text{ K}$	$T_{A,II} = 900 \text{ K}$	$T_{K,II} = 450 \text{ K}$	
$\lambda = 1$	$p_I = p_{II} = p_{III} = 1 \text{ bar}$		$\dot{Q}_{ul,II} = \dot{Q}_{ul,III} = 0$	

a) $\dot{Q}_{I,II}$



$$\dot{n}_{N_2,I} = \psi_{N_2,I} \cdot \dot{n}_{L,I} = \psi_{N_2,I} \cdot \frac{\dot{n}_{O_2,I}}{\psi_{O_2,I}} = \frac{\psi_{N_2,I}}{\psi_{O_2,I}} \cdot \dot{n}_{O_2,I}$$



$$\dot{n}_{CO,I} = \frac{\dot{m}_{CO,I}}{M_{CO}} = 0,0357 \frac{\text{kmol}}{\text{s}} \quad \dot{n}_{O_2,I} = \frac{1}{2} \cdot \dot{n}_{CO,I}$$

$$\dot{n}_{N_2,I} = \dot{n}_{N_2,II} = \frac{1}{2} \cdot \frac{\psi_{N_2,I}}{\psi_{O_2,I}} \cdot \dot{n}_{CO,I} \quad \dot{n}_{CO_2,II} = \dot{n}_{CO,I}$$

$$\begin{aligned} \dot{Q}_{I,II} &= \dot{H}_{II} - \dot{H}_I = \dot{H}_{CO_2,II} + \dot{H}_{N_2,II} - \dot{H}_{CO,I} - \dot{H}_{O_2,I} - \dot{H}_{N_2,I} \\ &= \dot{n}_{CO,I} \cdot \left(h_{m_{CO_2,II}} + \frac{1}{2} \cdot \frac{\psi_{N_2,I}}{\psi_{O_2,I}} \cdot h_{m_{N_2,II}} - h_{m_{N_2,II}} - \frac{1}{2} \cdot h_{m_{O_2,I}} - \frac{1}{2} \cdot \frac{\psi_{N_2,I}}{\psi_{O_2,I}} \cdot h_{m_{N_2,I}} \right) \\ &= -7,88 \frac{\text{MJ}}{\text{s}} \end{aligned}$$

b) $\dot{m}_{L,K}$, \dot{m}_L

1. Hauptsatz für das Kühlsystem

$$\dot{Q}_{I,II_B} + \dot{Q}_{I,II_K} = 0$$

$$\dot{Q}_{I,II_K} + \underbrace{\dot{W}_{t_{I,II_K}}}_{=0} = \dot{H}_{II_K} - \dot{H}_{I_K} + \underbrace{\Delta E_{a_{I,II_K}}}_{=0}$$

$$\dot{Q}_{I,II_K} = \dot{m}_{L,K} \cdot c_{pL} \cdot (T_{II_K} - T_I)$$

$$\Rightarrow \dot{m}_{L,K} = \frac{\dot{Q}_{I,II_K}}{c_{pL} \cdot (T_{II_K} - T_I)} = - \frac{\dot{Q}_{I,II_B}}{c_{pL} \cdot (T_{II_K} - T_I)} = 51,7 \frac{\text{kg}}{\text{s}}$$

$$\dot{m}_L = \dot{m}_{L,K} + \dot{m}_{L,V} = \dot{m}_{L,K} + \dot{n}_{N_2,I} \cdot M_{N_2} + \dot{n}_{O_2,I} \cdot M_{O_2}$$

$$\dot{n}_{L,I} = \frac{1}{2 \cdot \psi_{O_2}} \cdot \dot{n}_{CO,I}$$

$$\Rightarrow \dot{n}_{N_2,I} = \dot{n}_{N_2,II} = \psi_{N_2,I} \cdot \dot{n}_{L,I} = \frac{0,79}{0,21 \cdot 2} \cdot 0,0357 \frac{\text{kmol}}{\text{s}} = 0,0672 \frac{\text{kmol}}{\text{s}}$$

$$\Rightarrow \dot{m}_L = (51,7 + 0,0672 \cdot 28 + 0,01785 \cdot 32) \frac{\text{kg}}{\text{s}} = 54,153 \frac{\text{kg}}{\text{s}}$$

c) $\psi_{CO_2,III}$, $\psi_{O_2,III}$, $\psi_{N_2,III}$

$$M_L = \psi_{N_2,I} \cdot M_{N_2} + \psi_{O_2,I} \cdot M_{O_2} = 28,95 \frac{\text{kg}}{\text{kmol}}$$

$$\dot{n}_{CO_2,III} = \dot{n}_{CO_2,II} = \dot{n}_{CO,I} = 0,0357 \frac{\text{kmol}}{\text{s}}$$

$$\dot{n}_{O_2,III} = \psi_{O_2,I} \cdot \frac{\dot{m}_{L,K}}{M_L} = 0,3749 \frac{\text{kmol}}{\text{s}}$$

$$\dot{n}_{N_2,III} = \psi_{N_2,I} \cdot \frac{\dot{m}_L}{M_L} = 1,4772 \frac{\text{kmol}}{\text{s}}$$

$$\Rightarrow \dot{n}_{III} = (0,0357 + 0,3749 + 1,4772) \frac{\text{kmol}}{\text{s}} = 1,8878 \frac{\text{kmol}}{\text{s}}$$

$$\psi_{CO_2,III} = \frac{\dot{n}_{CO_2,III}}{\dot{n}_{III}} = \frac{0,0357}{1,8878} = 0,0189$$

$$\psi_{O_2,III} = \frac{\dot{n}_{O_2,III}}{\dot{n}_{III}} = \frac{0,3749}{1,8878} = 0,1986$$

$$\psi_{N_2,III} = \frac{\dot{n}_{N_2,III}}{\dot{n}_{III}} = \frac{1,4772}{1,8878} = 0,7825$$