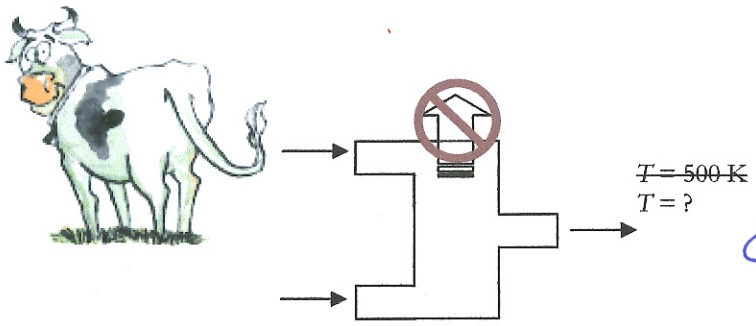
Example

Let us reconsider the dubious bovine flatulence energy source problem. As before, the proposed process combusts methane (CH_4) with air in a steady-state reaction chamber and produces 90% CO_2, 10% CO and no O_2 in the products. Both the methane and the air enter at 1 bar and 25°C.

This time, however, we will *not* assume that the products leave the chamber at 500 K and 1 bar. Rather, we will assume the chamber operates *adiabatically* and at constant pressure. You are to find the exit temperature of the products. That is, you are to find the

ADIABATIC FLAME TEMP

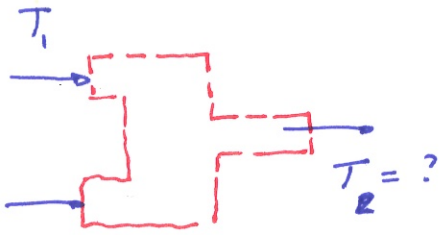
→ IS MAX ACHIEVABLE T



RECALL BALANCE RXN

$$CH_4 + 1.95\,O_2 + 7.332\,N_2 \longrightarrow$$

$$0.9\,CO_2 + 0.1\,CO + 2\,H_2O + 7.332\,N_2$$



Con. of energy

$$\dot{Q}_{CV} - \dot{W}_{CV} + \sum_{RXT} \dot{n}\bar{h} - \sum_{PROT} \dot{n}\bar{h}$$

RECALL

$$\bar{h}_i = \bar{h}^\circ_{f,i} + \bar{h}_i(T) - \bar{h}_i(298K)$$

→ IF $T = T_2$, UNKNOWN!

FOR 1 k-mol of CH_4 / 5

$$0 = (1)\bar{h}_{CH_4}\Big|_1 + (1.95)\bar{h}_{O_2}\Big|_1 + 7.332\,\bar{h}_{N_2}\Big|_1 - 0.9\,\bar{h}_{CO_2}\Big|_2$$
$$- 0.1\,\bar{h}_{CO}\Big|_2 - 2\,\bar{h}_{H_2O}\Big|_2 - 7.332\,\bar{h}_{N_2}\Big|_2 \qquad (1)$$

ITERATIVE SOL'N! GUESS T_2, FIND EACH $\bar{h}_i$, PLUG INTO (1) AND SEE IF $0=0$. IF NOT, GUESS AGAIN!

* TO GET US IN THE BALL PARK, ASSUME ALL PRDTS ARE N_2:

(1) BECOMES

$$0 = (1)\left[-74{,}850 \tfrac{kJ}{kmol}\right] + (1.95)(0) + (7.33)(0)$$
$$- (0.9)\left[-393{,}520 + \bar{h}_{N_2}(T_2) - 9364\right]$$
$$- (0.1)\left[-110{,}536 + \bar{h}_{N_2}(T_2) - 8669\right]$$
$$- (2)\left[-241{,}820 + \bar{h}_{N_2}(T_2) - 9904\right]$$
$$- (7.332)\left[0 + \bar{h}_{N_2}(T_2) - 8669\right]$$

$$\bar{h}_{N_2} = 83{,}897 \text{ kJ/kmol} \Rightarrow T_2 \approx 2500\text{K}$$

NOW ITERATE AGAIN STARTING W/ $T_2 = 2500$K, BUT USE REAL PRDT. ENTHALPIES. KEEP ITERATING!

.... $\boxed{T_2 = 2317\text{K}}$

FOR 1ST ITERATION, PRETEND PRDTS of N_2 FOR ALL.

i	T [K]	$\Delta\bar{h}^0_f$ [kJ/kmol]	$\bar{h}(T)$ [kJ/kmol]	$\bar{h}(298\text{K})$ [kJ/kmol]	$\bar{h}$ [kJ/kmol]
$CO_2)_2$	T_2=?	-393,520	$\bar{h}_{N_2}(T_2)$	9364	
$CO)_2$	T_2=?	-110,530	$\bar{h}_{N_2}(T_2)$	8669	
$H_2O)_2$	T_2=?	-241,820	$\bar{h}_{N_2}(T_2)$	9904	
$N_2)_2$	T_2=?	0	$\bar{h}_{N_2}(T_2)$	8669	
$CH_4)_1$	298	-74,850	~	SAME AS	-74,850
$O_2)_1$	298	0	~	"	0
$N_2)_1$	298	0	~	"	0

FIRST GUESS ONLY