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SP B

Given: $2H_2 + O_2 \rightarrow aH_2O + bO_2 + cH_2$

Find: a) Adiabatic flame temp, T_c
b) Coefficient of products, a
c) Molecular weight of products, M
d) Gamma of the products
e) Characteristic velocity of the products, C^*
f) Plot of specific heat of water, O_2, and H_2 as function of temp
g) Bonus: Plot of total enthalpy as function of temp

Schematic: Ø

Assumptions: Adiabatic combustion
No dissociation
Heat of formation from table 5.1
Specific heats from table 5.3
P = 1 atm
Reactant temp = 298 K
One dissociation reaction
equilibrium constants from Purdue

Equations:

$$h_{Ai} = \int_{T^\circ}^{T} C_{PAi}\, dT + h^\circ_{Ai}$$

$$\gamma_{mix} = \frac{c_{pmix}}{c_{pmix} - R_u}$$

$$C^* = \sqrt{\frac{R_u T_c}{\gamma M}} \left[2/(\gamma+1)\right]^{-(\gamma+1)/2(\gamma-1)}$$

$$K_p = a(6-a)^{1/2}/(2-a)^{3/2}$$

Analysis:

a)

$$a\left[-57800 \frac{cal}{mol} * 4.184 \frac{J}{cal} + \left[29.182T + \frac{14.503}{2} T(T/1000) - \frac{2.0235}{3} T(T/1000)^2\right]_{298}^{T_c}\right.$$
$$+ (2-a)\left[26.896T + \frac{4.35011}{2} T(T/1000) - \frac{0.32674}{3} T(T/1000)^2\right]_{298}^{T_c}$$
$$\left. + \frac{2-a}{2}\left[28.186T + \frac{6.3011}{2} T(T/1000) - \frac{0.74986}{3} T(T/1000)^2\right]_{298}^{T_c}\right] = 0$$

Solve in MATLAB

$T_c = 3500\,K$

b) $K_p = 10^{BT^3 + CT^2 + DT + E}$

$K_p = 4.3874$

B = -1.8559e-10
C = 2.3375e-6
D = -1.05e-2
E = 1.6715e1

$$K_p = \frac{a(6-a)^{1/2}}{(2-a)^{3/2}}$$

$a = 1.26606$

c) $2H_2 + O_2 \rightarrow 1.266\,H_2O + 0.367\,O_2 + 0.734\,H_2$

$M = 1.266(2.02 + 16) + 0.367(32) + 0.734(2.02)$ g/gmol

$M = 22.813 + 11.744 + 1.48268$ g/gmol

$\boxed{M = 36.04 \text{ g/gmol}}$

d) $C_p =$ oh boy

$C_{pH_2O} @ 3500K = 29.182 + 14.503(3500/1000) - 2.0235(3500/1000)^2 =$

$C_{pH_2} @ 3500K = 26.896 + 4.3501(3500/1000) - 0.32674(3500/1000)^2 =$

$C_{pO_2} @ 3500K = 28.186 + 6.3011(3500/1000) - 0.74986(3500/1000)^2 =$

$C_p = 134.3271$ J/gmol K

$\gamma = \frac{C_p}{C_p - R_u}$

$\gamma = \frac{134.3271}{134.3271 - 8.317}$

$\boxed{\gamma = 1.066}$

e) $c^* = \sqrt{\frac{8.317 \frac{Nm}{gmol\,K} \times 3500\,K \times 1000\,g/kg}{1.066 \times 36.04\,g/gmol}} \left[2/2.0666\right]^{-2.0666/2(0.666)}$

$\boxed{c^* = 1446.6 \text{ m/s}}$