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SPA

Given: $2H_2 + O_2 \rightarrow 2H_2O$
$\delta Q = 0$
$H_2 = H_i$

Find: a) Adiabatic flame temp, T_c
b) coefficient of the products, a
c) Molecular weight of products, M
d) The gamma of the products
e) Characteristic velocity of the products, c^*
f) Plot specific heat of water as function of temp
g) BONUS: Plot total enthalpy as function of temperature

Schematic: Ø

Assumptions: Adiabatic combustion
No dissociation
Heat of formation from Table 5.1
Specific heat fus Table 5.3
P = 1 atm
Reactants are 298 K

Equations:

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

$$M = \frac{i}{\sum_{i=1}^{N} y_i / M_i}$$

$$\gamma_{mix} = \frac{C_{pmix}}{C_{pmix} - R_{mix,u}}$$

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

Analysis:

a) $$2\left[h^\circ + \int_{298}^{T_c} C_p\, dT\right]_{H_2O} = 2\left[h^\circ + \int_{298}^{298} C_p\, dT\right]_{H_2} + \left[h^\circ + \int_{298}^{298} C_p\, dT\right]_{O_2}$$

$h^\circ_{H_2O} = -57.7979$ kcal/mole

$C_{pH_2O} = 29.182 + 14.503\,(T/1000) - 2.0235\,(T/1000)^2$ J/gmole K

$$\int C_{pH_2O} = 29.182\,T + \frac{14.503}{2}\,T(T/1000) - \frac{2.0235}{3}\,T\,(T/1000)^2$$

$$2\left\{-57.7979\ \frac{kcal}{mole} \times \frac{4184\ J}{kcal} + \left[29.182\,T + \frac{14.503}{2}\,T(T/1000) - \frac{2.0235}{3}\,T(T/1000)^2\right]_{298}^{T_c} \frac{J}{gmole\,K}\right\} = 0$$

calculated using MATLAB

$T_c = 5163.9956$ K

b) Since it's complete combustion, $\boxed{a = 2}$

c) $2H_2O$

H: $4(1.01) = 4.04$ g/gmol

O: $2(16) = 32$ g/gmol

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

d) $C_p = 29.182 + 14.503\left(\frac{5163.9956}{1000}\right) - 2.0235\left(\frac{5163.9956}{1000}\right)^2$

$C_p = 50.115$ J/gmol K

$Ru = 8.317 \frac{Nm}{gmol\,K}$

$\gamma = \frac{50.115 \frac{Nm}{gmol\,K}}{50.115 - 8.317 \frac{Nm}{gmol\,K}}$

$\boxed{\gamma = 1.194}$

e) $c^* = \sqrt{\frac{RuTc}{\gamma M}\,(2/(\gamma+1))^{-(\gamma+1)/2(\gamma-1)}}$

$c^* = \sqrt{\frac{(8.314)\frac{Nm}{gmol\,K}\,(5163.9956)\,K}{(1.194)(36.04)\,g/gmol} \times 1000\ g/kg}\,(2/(1.194+1))^{-2.194/2(0.194)}$

$\frac{Nm}{gmol}\,\frac{gmol}{g} = kg\frac{m}{s^2}\,\frac{m}{g} \times \frac{1000g}{kg}$

$\boxed{c^* = 1686 \text{ m/s}}$