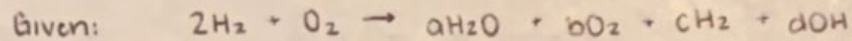


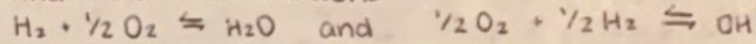
Name:

Veronica Loomis

Problem 5.4



And dissociation reactions



Find: Balanced chemical equation, molecular weight, characteristic velocity,
and specific heat ratio, and adiabatic flame temp

Assumptions: Reactants are at 298 K & $P = 50 \text{ atm}$

Include temp dependent C_p data from T5.3

Using Purdue's K_p table

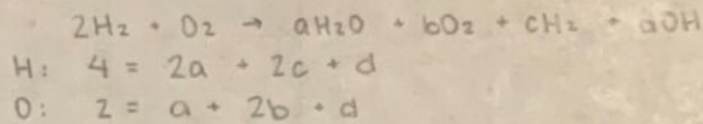
Basic Equations:

$$H = h^0 + \int C_p dT$$

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

$$C^* = \sqrt{\frac{R_u T_c}{\gamma M}}$$

Analysis:



$$d = 2 - a - 2b$$

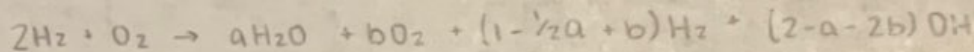
Sub into H's

$$4 = 2a + 2c + 2 - a - 2b$$

$$2c = 2 - a + 2b$$

$$c = 1 - \frac{1}{2}a + b$$

Rewrite chemical eq



So, the total number of moles is

$$n = a + b + 1 - \frac{1}{2}a + b + 2 - a - 2b$$

$$n = -\frac{1}{2}a + 3$$

We also have

$$K_{p,3} = \frac{x_{\text{OH}}}{\sqrt{x_{\text{O}_2} x_{\text{H}_2}}} P^{(1 - \frac{1}{2} - \frac{1}{2})}$$

$$K_{p,4} = \frac{x_{\text{H}_2\text{O}}}{x_{\text{H}_2} \sqrt{x_{\text{O}_2}}} P^{(1 - 1 - \frac{1}{2})}$$

$$x_{\text{H}_2\text{O}} = \frac{a}{-\frac{1}{2}a + 3}, \quad x_{\text{H}_2} = \frac{1 - \frac{1}{2}a + b}{-\frac{1}{2}a + 3}, \quad x_{\text{O}_2} = \frac{b}{-\frac{1}{2}a + 3}, \quad x_{\text{OH}} = \frac{2 - a - 2b}{-\frac{1}{2}a + 3}$$

$$K_{p,3} = \frac{\frac{2 - a - 2b}{-\frac{1}{2}a + 3}}{\left(\frac{b}{-\frac{1}{2}a + 3}\right)^{1/2} \left(\frac{1 - \frac{1}{2}a + b}{-\frac{1}{2}a + 3}\right)^{1/2}} = \frac{2 - a - 2b}{(b + b^2 - \frac{1}{2}ab)^{1/2}}$$

$$K_{p,4} = \frac{\frac{a}{-\frac{1}{2}a + 3}}{\left(\frac{1 - \frac{1}{2}a + b}{-\frac{1}{2}a + 3}\right) \left(\frac{b}{-\frac{1}{2}a + 3}\right)^{1/2}} P^{-1/2} = \frac{a(-\frac{1}{2}a + 3)^{1/2}}{b^{1/2}(1 - \frac{1}{2}a + b)} P^{-1/2}$$

Reactants = 0 since $h^\circ = 0$ for both H_2 & O_2 and they are injected at 298K

Products:

$$0 = a \left[-57800 \frac{\text{cal}}{\text{mol}} (4.184) \frac{\text{J}}{\text{cal}} + \int_{298}^{T_c} c_p dT \right]_{\text{H}_2\text{O}} + b \left[\int_{298}^{T_c} c_p dT \right]_{\text{O}_2} + (1 - \frac{1}{2}a + b) \left[\int_{298}^{T_c} c_p dT \right]_{\text{H}_2} + (2 - a - 2b) \left[10060 \frac{\text{cal}}{\text{mol}} (4.184) \frac{\text{J}}{\text{cal}} + \int_{298}^{T_c} c_p dT \right]_{\text{OH}}$$

$$C_{p H_2O} = 29.182 + 14.503 (T/1000) - 2.0235 (T/1000)^2$$

$$C_{p O_2} = 28.186 + 6.3011 (T/1000) - 0.74486 (T/1000)^2$$

$$C_{p H_2} = 26.896 + 4.3501 (T/1000) - 0.32674 (T/1000)^2$$

$$C_{p OH} = 81.55 - 15 (T)^{1/4} + 0.313 (T)^{3/4} - 0.02 (T)$$

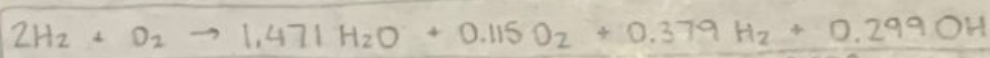
$\frac{J}{g \cdot mol \cdot K}$

Plug these in to enthalpy balance, guess T_c , check K_p , get a & b , determine $H_1 = H_2$. Iterate & repeat

For $P = 50 \text{ atm}$,

$$T_c = 3584.517 \text{ K}$$

$$a = 1.471, b = 0.115, c = 0.379, d = 0.299$$



$$M = \frac{1.471}{\frac{1}{2}(1.471)+3} (18) + \frac{0.115}{\frac{1}{2}(1.471)+3} (32) + \frac{0.379}{\frac{1}{2}(1.471)+3} (2) + \frac{0.299}{\frac{1}{2}(1.471)+3} (17)$$

$$M = 15.898 \text{ g/mol}$$

Specific heat ratio

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

$$C_{p \text{ total (excl)}} = 142.517 \text{ J/gmolK}$$

$$\gamma = \frac{142.5}{142.5 - 8.317}$$

$$\gamma = 1.06195$$

Char vel

$$C^* = \sqrt{\frac{R_u T_c}{\gamma M}} = \sqrt{\frac{8.314 \text{ Nm/gmolK} \cdot 3584.5 \text{ K} \times 1000 \text{ g/kg}}{1.06195 \times 15.898 \text{ g/mol}}}$$

$$C^* = 1328.6 \text{ m/s}$$