This Homework Must Be Uploaded onto CANVAS to Receive Credit. Deadline: Shown in Syllabus

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Nama.		

General Instructions

- <u>Uploading Assignment:</u> The entire homework assignment must be uploaded in the CANVAS dropbox in <u>one file</u>. Use the filename *xxHW_Lastname_revxx.doc* when uploading to CANVAS. Your homework must be written neatly or typed. If you want to write it out, you can scan it or take pictures of it with your phone. I must be able to read the uploaded file. Submitting all solutions in one file is required.
- <u>Uploading spreadsheets or other programs</u>: If you use spreadsheets or other programs, put in
 screenshots of your graphs or pertinent tables into your homework file submission. You do
 not have to upload your spreadsheets, videos, or programs unless specifically requested in the
 assignment sheet. When using computer programs, be sure to document in your homework
 submission the basic equations and example calculations with units showing how the program
 works.
- Re-submitting homework: If you submit your package and then resubmit an update before the deadline, the newest submission will be graded.
- <u>Grading Rubric</u>: The homework grading rubric is shown on CANVAS. The completeness of the entire homework package is also a component of the homework grade.

Required Homework Format (See Example at end of this Syllabus)

In the solution of problems, you are required to:

- 1. **Name:** Provide name of the student.
- 2. **Given**: State briefly and concisely (in your own words) the information provided.
- 3. **Find:** State the information that you have to find.
- 4. **Schematic**: Draw a schematic representation of the system and control volume if applicable.
- 5. **Assumptions:** List the simplifying assumptions that are appropriate to the problem and implied by the equations used.
- 6. **Basic Equations**: Outline the basic equations needed to do the analysis. Use the proper symbol from the book where applicable.
- 7. **Analysis:** Manipulate the basic equations to the point where it is appropriate to substitute numerical values. Substitute numerical values (using a consistent set of units) to obtain a numerical answer. <u>Include appropriate units in calculations</u>. If multiple repetitive calculations are done on a spreadsheet for example, show at least one example calculation in detail, <u>including all units</u>. The significant figures in the answer should be consistent with the given data. Check the answer and the assumptions made in effecting the solution to make sure they are reasonable.
- 8. **Answer**. Label the answer(s) with a box and an arrow from the right-hand margin.
- 9. **Comment**: Write a comment at the end of the homework that reflects on the limitations of the solution, the reasonableness of the solution, or something that you learned by doing the problem.

All nine formatting elements must be specifically shown in Each HW to receive full credit unless otherwise specified.

Special Problem SP-03A-A

- 1. Name: Robert Frederick
- 2. Given: Example problem in textbook section 5.4.1:

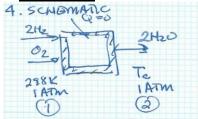
$$2H_2 + O_2 \rightarrow 2H_2O$$

Adiabatic, no dissociation, P = 1atm

3. Find:

- (a) Adiabatic flame temperature $T_{adiabatic}$
- (b) Coefficient of the products, a
- (c) Molecular weight of the products, $M_{product}$
- (d) Specific heat ratio of the products, \(\gamma_{product} \)
- (e) Characteristic velocity of the products, $c*_{products}$
- (f) Plot of specific heat of water as a function of temperature
- (e) Plot of total enthalpy as a function of temperature (+5 Points Bonus)

4. Schematic:



5. Assume:

- 1) Adiabatic combustion
- 2) No dissociation
- 3) Heats of Formation from Table 5.1
- 4) Specific heat fits from Table 5.3
- 5) Constant pressure, 1atm
- 6) Reactant temperature = 298 K
- 7) Steady state, No work, No $\triangle KE$, No $\triangle PE$

6. Basic Equations:

$$\Delta H = 0 = \sum_{i=1}^{n} b_{i} \left(\int_{T^{0}}^{T} C_{p_{B,i}} dT + h_{B,i}^{o} \right) - \sum_{j=1}^{n} a_{j} \left(\int_{T^{0}}^{T} C_{p_{A,i}} dT + h_{A,i}^{o} \right)$$

$$a_{1}A_{1} + a_{2}A_{2} \rightarrow b_{1}B_{1} \qquad \Leftrightarrow \qquad 2H_{2} + 1O_{2} \rightarrow 2H_{2}O$$

$$\bar{c}_{p} = a + b(T/1000) + c(T/1000)^{2} + d(T/1000)^{3} \qquad J/mol - K$$

$$H_{2}O \rightarrow a = 29.182, b = 14.503, c = -2.0235, d = 0 \qquad [Range = 273-3770K]$$

$$\Delta \bar{h}_{f,H_{2}}^{o} = 0 \qquad \Delta \bar{h}_{f,O_{2}}^{o} = 0 \qquad \Delta \bar{h}_{f,H_{2}O(g)}^{o} = -57.7979 kcal/mol$$

$$\Delta \bar{h}_{f,H_{2}O(v)}^{o} = -57.7979 \frac{kcal}{mole} \left(\frac{1000cal}{kcal} \right) \left(\frac{4.184}{cal} \right) = -241,826.41 J/mol$$

$$\gamma = \frac{\bar{c}_{p}}{\bar{c}_{p} - R_{u}} \qquad c^{*} = \frac{P_{c}A_{t}}{m} = \sqrt{\frac{R_{u}T_{c}}{\gamma M_{mix}}} \left(\frac{2}{\gamma + 1} \right)^{\frac{-(\gamma + 1)}{2(\gamma - 1)}} \qquad (4-29)$$

7. Analysis:

$$\begin{array}{c} \overline{2H_2 + 10_2} \rightarrow 2H_2O \\ a_1A_1 + a_2A_2 \rightarrow b_1B_1 \\ a_2 = 1 moles, A_1 = H_2 \\ b_1 = 2 moles, B_1 = H_2O \\ \\ \Delta H = H_2 - H_1 = 0 \\ \\ 0 = b_1 \left(\int_{T^0}^{T_2} C_{p_{B1}} dT + h_{B1}^o \right) - a_1 \left(\int_{T^0}^{T_1} C_{p_{A1}} dT + h_{A1}^o \right) - a_2 \left(\int_{T^0}^{T_1} C_{p_{A2}} dT + h_{A2}^o \right) \\ h_{H_2O(v)}^o = -57.7979 \frac{kcal}{mole} \left(\frac{1000cal}{kcal} \right) \left(\frac{4.184J}{cal} \right) = -241,826.41 \ J/mol \\ h_{H_2(g)}^o = 0 \\ h_{O_2(g)}^o = 0 \\ \text{Since } T_1 = T_0, \int_{T^0}^{T_1} C_{p_{A1}} dT = \int_{T^0}^{T_1} C_{p_{A2}} dT = 0 \ \text{ for the reactants} \\ C_{nH_2O} = a + b(T/1000) + c(T/1000)^2 + d(T/1000)^3 \end{array}$$

From Table 5.3 for $H_2O(gas)$, a = 29.182, b = 14.503, c = -2.0235, d = 0

So integrating first,

$$b_{1}\left\{\int_{T^{0}}^{T_{2}}\left[a+b(T/1000)+c(T/1000)^{2}\right]dT+h_{fH_{2}O}^{o}\right\}=0$$

$$b_{1}\left\{aT+\frac{bT}{2}\left(\frac{T}{1000}\right)+\frac{cT}{3}\left(\frac{T}{1000}\right)^{2}\right|_{T^{0}}^{T_{2}}+h_{fH_{2}O}^{o}\right\}=0$$

$$b_{1}\left\{\left[aT_{2}+\frac{bT_{2}}{2}\left(\frac{T_{2}}{1000}\right)+\frac{cT_{2}}{3}\left(\frac{T_{2}}{1000}\right)^{2}\right]-\left[aT^{0}+\frac{bT^{0}}{2}\left(\frac{T^{0}}{1000}\right)+\frac{cT^{0}}{3}\left(\frac{T^{0}}{1000}\right)^{2}\right]+h_{fH_{2}O}^{o}\right\}=0$$

$$H_2 - H_1 = 0$$

Sample Calculation

- 1. Put in coefficients
- 2. Guess T₂
- 3. Calculate $H_2 H_1$
- 4. Iterate on temperature until $H_2 H_1 = 0$

Example Guessing $T_2 = 3000$ K

$$2moles \left[29.182(3000) + \frac{14.503(3000)}{2} \left(\frac{3000}{1000} \right) + \frac{-2.0235(3000)}{3} \left(\frac{3000}{1000} \right)^{2} \right] J/mole$$

$$- 2moles \left[29.182(298) + \frac{14.503(298)}{2} \left(\frac{298}{1000} \right) + \frac{-2.0235(298)}{3} \left(\frac{298}{1000} \right)^{2} \right] J/mole$$

+
$$2moles\left[-241864\frac{J}{mol}\right] = H_2 - H_1$$

$$\Rightarrow$$
 2moles[87546 + 65263.5 - 18211.5] J/mole

+
$$2moles\left[-241826.41\frac{J}{mol}\right] = H_2 - H_1$$

$$\Rightarrow H_2 - H_1 = 269,196J - 18,644.7J - 483,652.8J = -233,101.5J$$

Comment: At the assumed product temperature of 3,000K, the change in enthalpy inside of the box assuming that H_2O is the only product is -233,202 J. This means that for the assumed product, we would have to take out 233kJ of heat from the control volume to get the gases to 3000K. The adiabatic temperature, Q = 0, is therefore much higher than 3000K.

Part a)

Iterating with spreadsheet,
$$T_{AF} = T_2 = 5163.24K$$

Part b)

$$b_1 = 2 moles$$

Part c)

$$M_{H_2O} = 16 \frac{kg}{mol} + 2 \frac{kg}{mol} = 18 \frac{kg}{mol}$$

$$\Rightarrow M_{H_2O} = 18 \frac{kg}{kmol}$$

Part d)

$$\begin{split} \gamma_{mix} &= \frac{\bar{c}_{p,mix}}{\bar{c}_{p,mix} - R_u} \\ \bar{c}_{p,mix} &= \bar{c}_p(5163.24K) = 29.182 + 14.503 \left(\frac{5163.24}{1000}\right) - 2.0235 \left(\frac{5163.24}{1000}\right)^2 = 50.12 \frac{J}{mol - K} \\ R_u &= 8317 \frac{J}{kmol - K} \frac{kmole}{1000mole - K} = 8.317 \frac{J}{mol - K} \end{split}$$

(Note the books value for R_u is incorrect. It should be $8,314.4598 \frac{J}{kmol-K}$)

$$\gamma_{mix} = \frac{50.12 \frac{J}{mol-K}}{50.12 \frac{J}{mol-K} - 8.317 \frac{J}{mol-K}} = 1.199 = 1.2$$

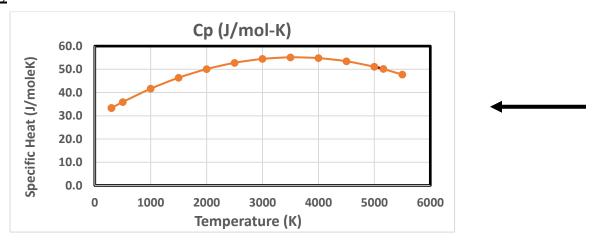
Part e)

$$c^* = \sqrt{\frac{8.317 \frac{J \quad 1000 mole}{mol - K \quad kmole} (5163.24K) (\frac{Nm}{J}) (\frac{kg \cdot m}{N \cdot s^2})}{1.199 * 18 \frac{kg}{kmol}}} \left(\frac{2}{1.199 + 1}\right)^{\frac{-(1.199 + 1)}{2(1.199 - 1)}}$$

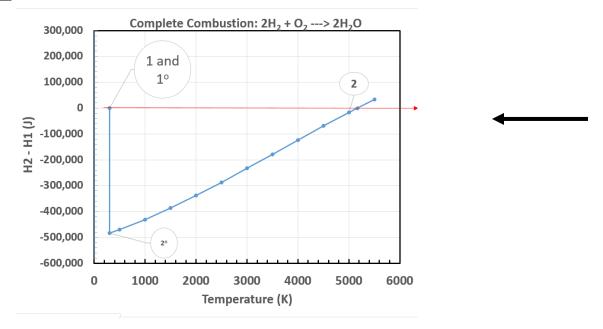
$$c^* = 2381m/s$$



Part f)



Part g)

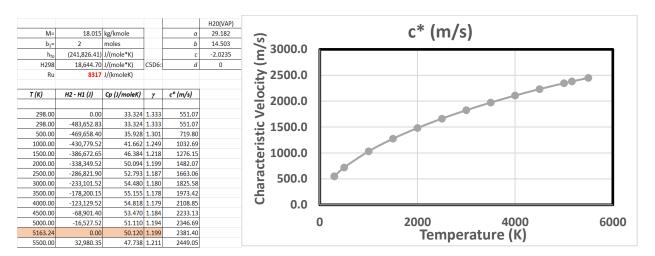


8. Answers:

- (a) $T_{AF} = 5163.24K$ (b) $b_1 = 2 \text{ moles}$
- (c) $M_{H_2O} = 18 \frac{kg}{kmol}$
- (d) $\gamma_{mix} = 1.2$ (e) $c^* = 2381m/s$

9. Comments:

Complete combustion greatly over-predicts the adiabatic flame temperature by not accounting for dissociation of the H_2O in the products.



Special Problem SP-03A-B

- 1. Name: Robert Frederick
- 2. Given: Gaseous hydrogen and oxygen at 1 atm and T = 298K with following reaction:

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

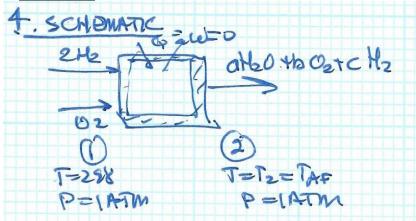
With the presumed products shown, considering the dissociation reaction:

$$H_2 + \frac{1}{2}O_2 \rightleftharpoons H_2O$$

3. **Find:**

- (a) Adiabatic flame temperature $T_{adiabatic}$
- (b) Coefficient of the products, a
- (c) Molecular weight of the products, $M_{product}$
- (d) Specific heat ratio of the products, \(\gamma_{product} \)
- (e) Characteristic velocity of the products, $c*_{products}$
- (f) Plot of specific heat of H_2O , O_2 and H_2 as a function of temperature
- (e) Plot of total enthalpy as a function of temperature (Bonus +5 Points)

4. Schematic:



5. Assume:

- 1) Adiabatic combustion
- 2) Limited dissociation
- 3) Heats of Formation from Table 5.1
- 4) Specific heat fits from Table 5.3
- 5) Constant pressure
- 6) Complete combustion
- 7) Steady state

6. Basic Equations:

$$a_1A_1 + a_2A_2 \rightarrow b_1B_1 + b_2B_2 + b_3B_3$$
 (5.28)

$$H_2 - H_1 = 0 = \sum_{i=1}^n b_i \left(\int_{T^0}^T C_{p_{B,i}} dT + h_{B,i}^o \right) - \sum_{j=1}^n a_j \left(\int_{T^0}^T C_{p_{A,i}} dT + h_{A,i}^o \right)$$
 (5.31)

$$K_p = \frac{X_{H_20}}{X_{H_2} X_{02}^{1/2}} p^{1-1-\frac{1}{2}} \qquad X_i = \frac{n_i}{\sum n_i}$$
 (5.48)

$$M_{mix} = \sum X_i M_i \tag{5.15}$$

$$\gamma_{mix} = \frac{\bar{c}_{p_{mix}}}{\bar{c}_{p_{mix}} - R_u} \tag{5.7}$$

$$\bar{C}_{p_{mix}} = \sum X_i \bar{C}_{p_i} \tag{5.16}$$

$$c^* = \frac{P_c A_t}{\dot{m}} = \sqrt{\frac{R_u T_c}{\gamma M_{mix}}} \left(\frac{2}{\gamma + 1}\right)^{\frac{-(\gamma + 1)}{2(\gamma - 1)}}$$
(4.29)

7. Analysis:

Setup

Atom Balance: $2H_2 + O_2 \rightarrow aH_2O + bO_2 + cH_2$

H:
$$2(2) = a(2) + b(2)$$

O: $(2) = a + b(2)$

$$2H_2 + O_2 \rightarrow aH_2O + \left(\frac{2-a}{2}\right)O_2 + (2-a)H_2$$

$$n = \sum n_i = a + \left(\frac{2-a}{2}\right) + (2-a) = \frac{6-a}{2}$$

Need additional equation from equilibrium constant,

$$H_{2} + \frac{1}{2}O_{2} \rightleftharpoons H_{2}O$$

$$K_{p}(T_{2}) = \frac{X_{H_{2}O}}{X_{H_{2}}X_{O_{2}}^{1/2}}p^{-1/2} \quad (Note \ Pressure \ is \ in \ Atmospheres)$$

$$X_{H_{2}O} = \frac{2a}{6-a}$$

$$X_{H_{2}O} = \frac{2a}{6-a} * 2$$

$$X_{O_{2}}^{1/2} = \frac{2a}{2} * \frac{2}{6-a} = \frac{2-a}{6-a}$$

$$p^{-1/2} = \left(\frac{1ATM}{1ATM}\right)^{-1/2} = 1$$

$$\Rightarrow K_{p}(T_{2}) = \frac{\frac{2a}{6-a}}{\frac{2-a}{6-a} \cdot 2*} \left(\frac{2-a}{6-a}\right)^{1/2} = \frac{a(6-a)^{1/2}}{(2-a)^{3/2}}$$

Lookup $K_p(T_2)$ in Table 5.2 [Column $K_{p,4}$ noting that $K_{p,4}$ at 4000K is incorrect in the table (should be 1.6623)]

So,
$$K_p(T_2) = \frac{a(6-a)^{1/2}}{(2-a)^{3/2}}$$
 with the unknowns T_2 , a

Energy equation now becomes,

Note the stoichiometric "a" and the curve fit "a" are different numbers

$$\begin{split} H_2 - H_1 &= a \left[\int_{298K}^{T_2} C_p dT + h_f^o \right]_{H_2O} + (2 - a) \left[\int_{298K}^{T_2} C_p dT + h_f^o \right]_{H_2} \\ &+ \left(\frac{2 - a}{2} \right) \left[\int_{298K}^{T_2} C_p dT + h_f^o \right]_{O_2} - 2 \left[\int_{298K}^{298K} C_p dT + h_f^o \right]_{H_2} - 1 \left[\int_{298K}^{298K} C_p dT + h_f^o \right]_{H_2} \\ \Rightarrow H_2 &= a \left[a \left(\frac{T}{1000} \right) + \frac{bT}{2} \left(\frac{T}{1000} \right)^2 + \frac{cT}{3} \left(\frac{T}{1000} \right)^3 + \frac{dT}{4} \left(\frac{T}{1000} \right)^4 \right]_{T^0}^{T_2} + a \Delta h_f^o \Big|_{H_2O} \\ &+ (2 - a) \left[a \left(\frac{T}{1000} \right) + \frac{bT}{2} \left(\frac{T}{1000} \right)^2 + \frac{cT}{3} \left(\frac{T}{1000} \right)^3 + \frac{dT}{4} \left(\frac{T}{1000} \right)^4 \right]_{T^0}^{T_2} \Big|_{O_2} \\ &+ \left(\frac{2 - a}{2} \right) \left[a \left(\frac{T}{1000} \right) + \frac{bT}{2} \left(\frac{T}{1000} \right)^2 + \frac{cT}{3} \left(\frac{T}{1000} \right)^3 + \frac{dT}{4} \left(\frac{T}{1000} \right)^4 \right]_{T^0}^{T_2} \Big|_{H_2O} \end{split}$$

Solution Technique

- 1. Guess T₂
- 2. Find K_p
- 3. Solve for a (Stoichiometric coefficient)
- 4. Put *a* in the energy equation
- 5. Solve for H_2
- 6. Check if $H_2 \approx 0$
- 7. Iterate on T_2 and repeat until the condition $H_2 \approx 0$ is true

Calculate,

$$\begin{split} &M_{mix} = \mathbf{X}_{H_2O} M_{H_2O} + \mathbf{X}_{H_2} M_{H_2} + \mathbf{X}_{O_2} M_{O_2} \\ &\bar{C}_{p_{mix}} = \mathbf{X}_{H_2O} \bar{C}_{H_2O} + \mathbf{X}_{H_2} \bar{C}_{H_2} + \mathbf{X}_{O_2} \bar{C}_{O_2} \\ &\gamma = \frac{\bar{c}_{p_{mix}}}{\bar{c}_{p_{mix}} - R_u} \\ &c^* = \sqrt{\frac{R_u T_c}{\gamma M_{mix}}} \left(\frac{2}{\gamma + 1}\right)^{\frac{-(\gamma + 1)}{2(\gamma - 1)}} \end{split}$$

Input
$$\Delta h_f^o \Big|_{H_2O} = -57.7879 \left(\frac{kcal}{mol-K} \right) \left(\frac{1000cal}{kcal} \right) \left(4.184 \frac{J}{cal} \right) = 241.785 \frac{J}{mol-K}$$

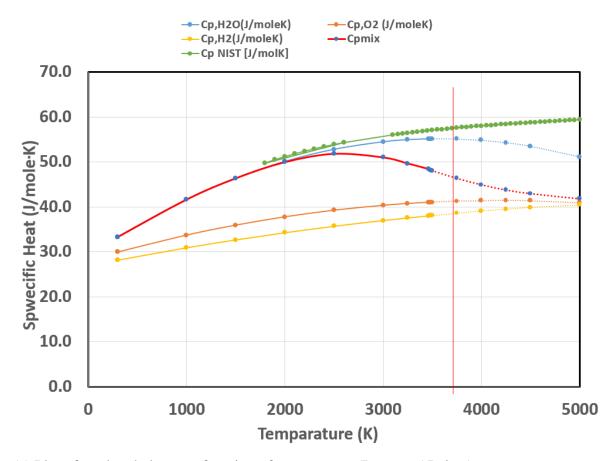
Assumed Specific Heat Curve Fit Coefficients (From Book)

	a	b	С	d
H ₂ O	29.182	14.503	-2.0235	0
H_2	26.896	4.3501	-0.32674	0
02	28.186	6.3011	-0.74986	0

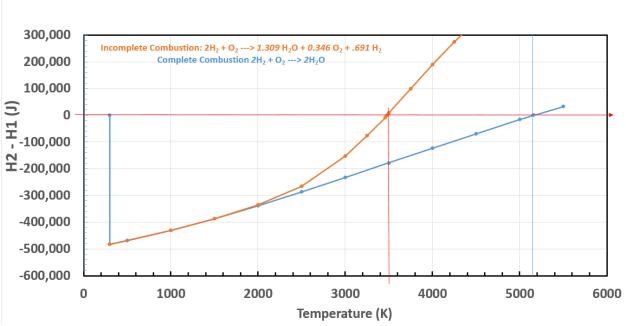
$$\bar{C}_p = \alpha \left(\frac{T}{1000}\right) + \frac{bT}{2} \left(\frac{T}{1000}\right)^2 + \frac{cT}{3} \left(\frac{T}{1000}\right)^3 \qquad \left[\frac{J}{mol - K}\right]$$

Perform calculations on spreadsheet to solve for required parameters.

(f) Plot of specific heat of H_2O , O_2 and H_2 as a function of temperature



(e) Plot of total enthalpy as a function of temperature (Bonus +5 Points)



8. Answers:

$$\overline{\text{(a)}} T_{AF} = 3500K$$

(b)
$$a = 1.309 \, moles$$

$$b = 0.3455 \, moles$$

$$c = 0.691 \, moles$$

(c)
$$M_{H_20} = 15.36 \frac{kg}{kmol}$$

(d)
$$\gamma_{mix} = 1.21$$

(e)
$$c^* = 2116.8 m/s$$

- (f) See below.
- (g) See below.

Answers will vary slightly depending on the tolerance on final enthalpy being zero. The solution I presented in class was 3500. The comment section shows a more precise iteration and the resulting properties.

9. Comments:

Temperature significantly lower than the complete combustion case because dissociation lowers the production of H_2O over 30% and hence less $\Delta h_{f,H_2O}^o$

The attached spreadsheet and graphs show the comparison between the complete combustion case and the limited dissociation case.

T (K)	KP4	а	Solve	b	С	Cp. _{Act} (I/moleR)	Cp.O2 (I/moleK)	Cp. se (I/moleK)	H(H2o)	H(Ho2)	H(He)	H2-H2 Mix	Cprole	Mmix	γ	c* (m/s) Incom	X0:20	X02	xH2			H20(VAP)	02	H2	Units
298.00	1.1143E+40	2.0000	0.00E+00	0.0000	0.0000	33.324	29.997	28.163	-483,652.83	0.00	0.00	-483,652.83	33.32	18.02	1.333	550.97	1.000	-			<u>a</u>	29.182	28.186	26.896	J/(mole*K)
298.00	1.1143E+40	2.0000	0.00E+00	0.0000	0.0000	33.324	29.997	28.163	-483,652.83	0.00	0.00	-483,652.83	33.32	18.02	1.333	550.97	1.000	-			<u>b</u>	14.503	6.3011	4.3501	J/(mole*K)
1000.00	1.1480E+10	1.9996	-1.15E+10	0.0002	0.0004	41.662	33.737	30.919	-430,696.18	4.39	9.66	-430,682.13	41.66	18.01	1.249	1032.54	1.000	0.000	0.000		£	-2.0235	-0.7499	-0.3267	J/(mole*K)
1500.00	5.2541E+05	1.9996	-1.99E-05	0.0002	0.0004	46.384	35.950	32.686	-386,597.84	7.87	15.92	-386,574.04	46.38	18.01	1.219	1275.97	1.000	0.000	0.000		d	0	0	0	J/(mole*K)
2000.00	3.3931E+03	1.9889	-7.54E-07	0.0056	0.0111	50.094	37.789	34.289	-336,466.90	335.53	649.78	-335,481.59	49.97	17.97	1.200	1483.61	0.992	0.003	0.006		h _{fo}	(241,826.41)	0	0	J/(mole*K)
2500.00	1.6127E+02	1.9168	-7.94E-06	0.0416	0.0832	52.793	39.252	35.729	-274,884.04	3,391.43	6,387.30	-265,105.31	51.82	17.65	1.191	1677.84	0.939	0.020	0.041		MW	18.015	31.999	2.016	kg/kmole
3000.00	2.0999E+01	1.6961	-9.31E-05	0.1520	0.3039	54.480	40.341	37.006	-197,677.29	15,841.26	29,226.86	-152,609.17	51.01	16.74	1.195	1884.94	0.788	0.071	0.141						
3250.00	9.5786E+00	1.5173	1.99E-04	0.2414	0.4827	54.944	40.744	37.583	-156,080.10	28,047.55	51,303.65	-76,728.90	49.68	16.08	1.201	1998.46	0.677	0.108	0.215						
3460.00	5.6734E+00	1.3571	4.17E-05	0.3214	0.6429	55.138	41.011	38.036	-123,914.98	40,682.45	73,925.98	-9,306.55	48.45	15.52	1.207	2094.67	0.585	0.138	0.277						
3481.55	5.2726E+00	1.3321	-6.97E-04	0.3340	0.6680	55.148	41.034	38.081	-120,041.17	42,630.50	77,415.70	5.03	48.24	15.44	1.208	2106.20	0.571	0.143	0.286						
3500.00	4.9295E+00	1.3085	-2.07E-05	0.3457	0.6915	55.155	41.054	38.119	-116,591.78	44,450.50	80,676.33	8,535.04	48.05	15.36	1.209	2116.46	0.558	0.147	0.295		8314.00	J/(kmoleK)			
3750.00	2.7498E+00	1.0853	5.63E-04	0.4573	0.9147	55.113	41.270	38.614	-81,736.13	64,635.67	116,479.11	99,378.66	46.40	14.66	1.218	2236.23	0.442	0.186	0.372						
4000.00	1.6623E+00	0.8756	1.56E-04	0.5622	1.1244	54.818	41.393	39.069	-53,906.35	86,847.20	155,481.70	188,422.54	44.96	14.06	1.227	2352.43	0.342	0.219	0.439]				
4250.00	1.0568E+00	0.6884	-4.99E-04	0.6558	1.3116	54.270	41.421	39.482	-32,992.10	110,185.87	196,065.62	273,259.39	43.79	13.57	1.234	2463.37	0.259	0.247	0.494						
4500.00	7.0307E-01	0.5338	-5.54E-05	0.7331	1.4662	53.470	41.356	39.855	-18,390.71	133,391.93	236,011.18	351,012.40	42.92	13.18	1.240	2567.01	0.195	0.268	0.536						
5000.00	3.55E-01	0.3234	2.35E-04	0.8383	1.6766	51.110	40.945	40.478	-2,672.24	176,897.93	309,756.00	483,981.69	41.83	12.69	1.248	2751.30	0.114	0.295	0.591						

