AS – 568 High Temperature Gas Dynamics
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Supplementary Exercise – 1
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1. Plot the absolute enthalpy per unit mole as a function of T for the following species on a single plot. Interpret the differences. (Need not use every data row given in the tables!) Species of interest: H2, H, H2O(g), H2O(l), O, O2, N2, Air, CO, CO2.

2. (a) Derive mass fraction of a species in terms of mole fractions of all the species in the mixture of gases.
(b) Derive mole fraction of a species in terms of mass fractions of all the species in the mixture of gases.
(c) Derive molecular weight of a mixture of gases in terms of (a) mole fraction, (b) mass fraction of the component species ni the mixture.

3. Consider two reactions:

(i) $H_2 + O_2 \rightarrow H_2O + \frac{1}{2} O_2$

(ii) $H_2 + CO_2 \rightarrow H_2O + CO$

(a) Find the heat of reaction of each of the above reactions at T=298.15 K, P=1 atm.
(b) Find the heat of reaction of each of the above reactions at T=1000 K, P=1 atm.
(c) Find the heat of reaction of each of the above reactions at T=3500 K, P=2 atm.

4. Find the Heats of formation of H2O and CO2 at 2000K, 1 atm (without using direct data from tables) and compare the results from the data tables. Explain the difference if any.

5. Do the above for ΔG_f^o and explain the differences if any.

6. Do the above for $Kp,_f$ and explain the differences if any.

7. Write the expression for the Kp of reaction for the reaction (ii) given in problem 3, and express it in terms of the $Kp,_f$ of the individual gases. Show that both the expressions are the same.

8. Is the reaction 3(ii) exothermic or endothermic? Prove it. Does the answer depend on the temperature at which reaction will take place? Explain.

9. If reaction CH4 is burnt with stoichiometric proportion of air, calculate the higher and lower heating values for the fuel gas.

10. Assuming complete combustion occurs, find the adiabatic flame temperature for CH4-Air system for equivalence ratios ranging from 0.75 to 1.5. Explain the trends.

11. If H2 at 400K is mixed with Air at 800K, find the adiabatic flame temperature using the plots obtained in problem 1. Also perform the hand calculations and compare the results.