1. Calculate the rate of heat transfer in problem 5 of the previous set. You can assume complete combustion and a constant specific heat of the product stream equal to value of air at room temperature. Be sure to account for the effect of water condensation on the heat transfer.

2. Use the GASEQ software package to compute the adiabatic flame temperature of a methane/air flame as a function of equivalence ratio $\Phi$. Take the reactants to be at 298 K, 1 atm, and assume that the products consist of the major species plus dissociation compounds:

$$\text{CO}_2, \text{H}_2\text{O}, \text{O}_2, \text{N}_2, \text{CO}, \text{H}_2, \text{OH}, \text{O}, \text{H}, \text{NO}$$

Make the following plots:

(a) A plot of CO and NO mole fraction as a function of $\Phi$ for $\Phi$ between 0.5 and 2.

(b) A plot $T_{AFT}$ as a function of $\Phi$ for $\Phi$ between 0.5 and 2.

Discuss the trends in the mole fractions, and explain why the flame temperature does not peak at stoichiometric conditions.

3. A proposed method of producing hydrogen gas ($\text{H}_2$) from water is to heat water vapor to a sufficiently high temperature so that dissociation of the water molecule occurs, and then to separate the hydrogen from the mix. For such a scheme to be economically feasible, the heat source would have to be both cheap and capable of producing high temperatures; solar heat has such a potential. Consider a stream of water vapor that enters a heater at 298 K and 0.1 atm pressure, and leaves at the same pressure and a temperature $T_2$. Assuming that the product stream consists of an equilibrium mixture of water, molecular hydrogen, and molecular oxygen, calculate the amount of molecular hydrogen produced, and the required heat transfer, per kmole of water entering the reactor. Make a plot of the ratio of the hydrogen production to heat transfer as a function of $T$ for $T$ between 2000 and 4000 K. You can use whatever calculation tools are available (i.e., software or tabulated $K_P$ values).

4. Propane is burned with 30% excess air in an adiabatic reactor. Reactants enter at 298 K, and the pressure is 1 atm. Using $K_P$ data, estimate the mole fractions of CO and NO in the exhaust stream using the method discussed in class. Compare with the exact GASEQ result.