Assignment-1

1. Estimate the adiabatic flame temperature of a constant pressure reactor burning a stoichiometric mixture of H_2 and air at STP at the inlet. Use the following three approaches and determine the adiabatic flame temperature.
   a. Assume a constant (average) C_p at 1500 K.
   b. Conduct an iterative enthalpy balance so that the enthalpy of reactants at STP becomes equal to the enthalpy of the products at the adiabatic flame temperature and at 1atm pressure.
   c. Use any adiabatic flame temperature calculation software (for example, GASEQ, STANJAN or CANTERA) to determine the adiabatic flame temperature.

2. Consider the combustion of propane in air at STP. Use any of the above softwares or any other computer program to carry out the thermochemical calculations for the equilibrium compositions and flame temperature for equivalence ratios varying between 0.3 to 1.4 (with increment of 0.1). Plot the adiabatic flame temperature and the mole fractions of CO_2, H_2O, N_2, O_2, CO, OH, O, H, H_2 and NO versus equivalence ratio. Discuss the trend of the species at different equivalence ratios. Also, discuss the reasons for the observed trend of adiabatic flame temperature with equivalence ratio. Use any open computer software for this analysis i.e., thermochemical calculations for the equilibrium compositions and flame temperatures for equivalence ratios varying between 0.3 to 1.4.

3. Consider a spark ignition engine whose combustion process has been idealized as a constant volume process. Determine the effect of dilution of the fuel with CO_2 (like for no dilution case consider n number of moles (air+fuel) are being fed, now 10% CO_2 dilution is 0.9n will be the air + fuel and 0.1n will be CO_2) on the adiabatic flame temperature by varying the dilution from 0 to 50% with an increment of 10%. Discuss the trend of adiabatic flame temperature with the CO_2 dilution. The pressure and temperature of the reactants are fixed at 500 K and 25 bar respectively. The fuel is iso-octane, and the equivalence ratio is unity. List down all the assumptions. Hint: Use GASEQ software to perform the calculations.

4. Using appropriate software and hand calculations, determine the fuel among CH_4, C_2H_2, C_2H_6, C_3H_8 that gives the highest temperature when burned completely in a constant volume chamber with the theoretical amount of air. Assume reactants are at the standard reference state.

5. Using an appropriate software, study the effect of varying percent excess air during the steady-flow combustion of hydrogen at a pressure of 1 atm. At what temperature will 97% of H_2 burn into H_2O? Assume the equilibrium mixture consists of H_2O, H_2, O_2 and N_2. Also prove it by hand calculation.