USING CHEMICAL THERMODYNAMICS
IN ENGINE ENERGY BALANCE ANALYSIS

Follow these steps to use heat of reaction concepts in your analysis of engine energy balance analysis…

PROBLEM: A 3.0 liter 4-stroke SI engine is run on ethanol (C2H5OH). For better emissions, the engine is run at an equivalence ratio of 0.75. The air and fuel enter at 25 C and 1 atm. The exhaust is at 727 C. In this situation, 320 $MJ/kmol_{fuel}$ leaves the engine via the cooling system. Assume 100% combustion efficiency and products consisting of only CO_2, H_2O, O_2, and N_2.

a) Find the specific work output of the engine in $MJ/kmol_{fuel}$.

- compute the excess air coefficient and write the reaction equation
- determine the LHV of ethanol based on reactants and products at STP
  => *use tabulated data from heat of reaction activity* (note that this is independent of equivalence ratio)
- determine the heat of reaction based on reactants at STP and products at the exhaust temperature
  => *use tabulated data from heat of reaction activity* (note that this depends on the equivalence ratio)
- the difference between these represents the cooling system heat rejection plus the specific work

b) Find the percent of fuel energy that leaves the engine via the cooling system, via specific work, and via sensible heat carried away in the exhaust.

- draw a diagram that relates the incoming fuel/air energy and these three exiting streams
- express these as a percentage of the LHV
- use the 1^{st} law to find the sensible heat carried away in the exhaust
- recognize that the specific work percentage is the arbitrary efficiency of the engine

c) Under highway driving conditions, the part throttle volumetric efficiency is 70% and the engine speed is 2000 RPM. Estimate the power output of the engine under these conditions.

- write the long equation for brake power output
- find the F/A ratio on a mass basis at the specified equivalence ratio
- express the heating value on a MJ/kg basis
- express the engine speed in proper units (rev/sec)
- assume an inlet air density
- use known engine geometry data
- apply the arbitrary efficiency value found above
- calculate the brake power output with the given volumetric efficiency