MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mechanical Engineering

2.61 INTERNAL COMBUSTION ENGINES

Homework Set #3

Problems:

1) The NO_X emission from automobiles is a mixture of NO and NO_2. At high temperatures, the mixture is mostly NO, and at low temperatures, mostly NO_2. Consider a mixture with elemental composition of 1 mole of nitrogen atom and 2 moles of oxygen atoms at a fixed pressure of 1 atmosphere. Plot the equilibrium mole fraction of NO as a function of temperature in the 600 to 1000 K range. (The actual exhaust gas is not in equilibrium; therefore, the equilibrium value of NO is a lower bound.) Note that at equilibrium above 1000 K, most of the gas is NO.

   (Note: you have to solve a non-linear equation. Use Matlab or Excel.)

   The equilibrium constants from the JANAF table are:

T(K)	$Log_{10}K_p$ for NO	$Log_{10}K_p$ for NO_2
600	-7.210	-6.111
700	-6.086	-5.714
800	-5.243	-5.417
900	-4.587	-5.185
1000	-4.062	-5.000

2) Problem 3.8 of text

   In part (c), the equilibrium constant should be $10^{10.2}$ instead of 10.2. Also, assume that there is no dissociation of the N_2 and H_2O.

   Hint: in solving for the amount of CO, assume that the amount is negligibly small compare to the amount of CO_2. Justify posteriori.

3) Problem 4.1 of text.

   Calculation of exhaust composition under fuel rich condition is a tedious exercise which is usually computerized. You can use the exhaust composition program on the web (under "good stuff"). Look at the source listing to see what is involved. If you want to, you can set K=3.5 instead of 3.7; it does not make that much difference. You can also do it using the information on p. 104-105 of the text, especially table 4-3. Then you have to solve the quadratic equation 4.6 yourselves — the Matlab program on the web, exhaust_compo, essentially does that. You have to supply the input variable in the calling program to solve the problem.)

4) Problem 4.9 of text

   Hint: using the exhaust composition, write the stoichiometric equation for the reaction.

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