UNIVERSITY OF CALIFORNIA, BERKELEY — Mechanical Engineering
ME140 Combustion Processes, Fall 2004 — Prof. Fernandez-Pello

FINAL EXAM (Dec. 15th, 2004)

- Put your name on each page
- Open book and open notes
- Four problems: 35, 25, 25 and 15, respectively
- You have 3 hours
- Indicate your assumptions
- Write your answers in **clear handwriting**
- Use the back of the pages to write if needed

Name: _____

PROBLEM 1:_____

PROBLEM 2:_____

PROBLEM 3:_____

PROBLEM 4:_____

Name_____

1. Consider a turbine combustor that uses kerosene (hexadecane) as fuel, premixed with 150% theoretical air. The kerosene is injected at 25°C and 1 atm, and the air enters the combustor at 500°C and 1 atm. In addition, liquid water at 25°C is also injected with the reactants at a mole fraction of 0.05. The combustor is adiabatic.
    a. Calculate the temperature of the exhaust gases
    b. Compare this exhaust temperature with that when there is no water addition
    c. The water had been added at the suggestion of an engineer to reduce pollutants. However, other engineers are concerned that although some pollutants may decrease, others may increase. Explain which emissions may decrease and which may increase with the water addition and why.

NOTE: The enthalpy of formation of liquid water is -285.10 MJ/kmol.

Name_____

1. Consider a diesel engine. At the end of a piston's compression stroke, fine droplets of fuel (pentadecane) are injected into air at 500°C. The droplets are only evaporating, not burning, and have a constant velocity of 1 m/s. The gap between the injector and the piston is 20 mm.
    a. Calculate the maximum diameter of the droplets in order to avoid the droplets hitting the piston surface.
    b. Now, with the diameter you just calculated and if the fuel were to be gasoline (octane) instead of diesel, would the droplets hit the piston before evaporating?

    NOTE: Use properties at 1 atm of pentadecane for diesel and isooctane for gasoline. Assume the piston does not significantly move from the top dead center position. Assume the average Reynolds number is $\overline{\mathrm{Re}}=1$.

Name_____

1. The safety of two fuel-air mixtures as a function of their temperature is being studied. Considering safety from the point of view of the reactivity of the mixture, and with the information given below, determine:

a. The temperature Tc at which both fuels are equally safe (or equally dangerous).
b. Use a qualitative plot of the reaction-rate and show which mixture is safer as a function of temperature.

Assume an Arrhenius expression for the reaction-rate with the following properties:

Mixture 1. Preexponential factor $A_1=4x10^9 cm^3 s/mol$, Activation Energy $E_{01}=30kcal/mol$.

Mixture 2. Preexponential factor $A_2=2x10^{12} cm^3 s/mol$, Activation Energy $E_{02}=35kcal/mol$.

Name_____

1. Short questions (three of them). Express in your own words and with short answers in the space provided. Be qualitative and include formulas and plots.

a) Define knocking of an IC engine. When, why and in which engines does it happen? How is it prevented?

b) If two different premixed mixtures are such that the ratio of activation energies is 2 ($E_1/E_2=2$), determine how their flame speeds would differ.

c) - What are the parameters that determine the spontaneous ignition of a fuel-air mixture?.