UNIVERSITY OF CALIFORNIA, BERKELEY — Mechanical Engineering
ME140/Fall 2002 Combustion Processes — Prof. Fernandez-Pello

# **FINAL EXAMINATION** (Dec. 12, 2002)

- Open book and open notes.
- Three problems: 40, 30 and 30 points respectively.
- Indicate clearly your assumptions, if any.
- Write your answers in clear handwriting.
- Put your name on top of each page.
- Use the back of the pages to write if needed

**Name:** _____

PROBLEM 1:_____

PROBLEM 2:_____

PROBLEM 3:_____

**Name**_____

**1.** Consider a combustor that uses kerosene (hexadecane) as fuel premixed with 150% theoretical air. The kerosene is injected at 25 C 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 behaves as adiabatic. **Note**: the enthalpy of formation of liquid water is -285.10 MJ/kmol

a) Assuming that there is complete combustion, calculate the exhaust temperature. (**15** points)
b) Compare the calculated exhaust temperature with that when there is no water addition. (**15** points)

**Note: the accuracy of the method used to calculate the exhaust temperature will be taken into account when grading the problem**.

The water had been added by the suggestion of an engineer to reduce pollutants. However, other engineers are concerned that although some pollutants may decrease, others may increase.

c) Considering that water addition may prevent complete combustion, explain which emissions may decrease and which emissions may increase with the water addition and why. (**10** points)

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**Name**_____

**1.** Consider a four-stroke spark ignition engine. Each cylinder has an internal diameter of 10 cm. When the piston is at the top dead center (TDC) there is a gap of 3 cm between its top surface and the cylinder upper wall. The engine works with a stoichiometric mixture of gasoline (octane or isooctane) and air. At the end of the compression stroke the pressure is 8 atm and the temperature 200 °C.

a) It is found that in some occasions the mixture is ignited by the spark but in others the mixture ignites uniformly before the spark activation. Determine for each case how long it will take for the mixture to burn totally. (**25** points)
b) If the engine was running at 4000 rpm, qualitatively describe what emissions would you expect (**5** points)

Note: For the calculation in a) assume that the volume and pressure remain constant during the combustion process.

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**Name**_____

**1.** In a combustion chamber, fine droplets of octane with diameter 500 μm are injected into an atmosphere of air at 500°C and 1 atm. It is observed that some droplets are evaporating and others are burning. It is also observed that some of the droplets are moving with the same velocity as the air and others have significant velocities relative to the air.

a) Calculate the life time of the evaporating droplets that are moving at the same velocity as the air (quiescent environment). (**10** points)
b) Calculate the life time of the evaporating droplets that are moving with a velocity of 10 m/s relative to the air. (**10** points)
c) Calculate the life time of the burning droplets that are moving at the same velocity as the air (quiescent environment). (**10** points)

NOTE: Assume that the thermal layer thickness and the flame stand-off distance are both equal to half the droplet diameter.

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