ME410

Internal Combustion Engines

Fall 2002

Test 2 Sample

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Name_____

Box_____

Grade_____

Instructions

1. Closed text, notes, and neighbor.
2. Partial credit will be given as merited if you show your work.
3. If you are not sure what is being asked, be sure and check with me.
4. Refer as needed to the reference page attached.

1. A 4-cylinder laboratory test engine is supplied with isooctane fuel (C_8H_{18}) at a rate of 1.5×10^{-3} kg/sec. The fuel air equivalence ratio, ϕ, is 0.8.

   a) Is the mixture rich or lean?

   b) Calculate the air flow rate in kg/sec.

   c) Write and balance the chemical equation describing the combustion process.

   d) Calculate the mole fractions of each of the gases making up the exhaust.

   e) If we set $\phi = 1.3$, describe how this problem would be different and how you would solve it.

2. This is a continuation of the previous problem. The heating value of the fuel is 42000 kJ/kg. The mechanical efficiency is 0.83, the fuel conversion efficiency (based on brake work/power) is 0.34, and the combustion efficiency is 0.93. We estimate that 35% of the energy entering the engine in the fuel is transferred to the cooling system. Calculate in kW

   a) the brake power

   b) the friction power

   c) the indicated power

   d) the heat transfer

   e) the total power in the exhaust gas

   f) the rate at which chemical energy leaves the engine in the exhaust gas

In the space below, draw a control volume containing the engine and labeled with these energy rates.

3. A mixture which initially consists of 1 mole of CO_2 and 5 moles of O_2 at room temperature is taken to 2800 K and a pressure of 9 atmospheres. The gas CO_2 will disassociate into CO and O_2 according to the reaction

$$CO_2 = CO + 1/2\ O_2$$

until the three gases exist in a state of chemical equilibrium. Calculate the mole fractions of the component gases in such an equilibrium mixture if the equilibrium constant for the reaction is $K_p = 0.1502$. (Very substantial partial credit will be given for setting up the equations.)

4. For the following multiple choice question, one response is the best description of the answer. Identify it.

a) For constant pressure adiabatic combustion,
   i. the volume is constant
   ii. the enthalpy is constant
   iii. the internal energy is constant
   iv. the entropy is constant
   v. none of the above

b) In describing the compression stroke in an IC engine, we frequently assume that it ...
   i. takes place at constant pressure
   ii. is adiabatic
   iii. is reversible
   iv. is isentropic
   v. takes place at constant temperature

c) The study we have made of chemical equilibrium enables us to ...
   i. describe the composition of the unburned mixture at intake
   ii. describe the composition of the products of combustion at all temperatures
   iii. describe the composition of the products of combustion at low temperature
   iv. describe the composition of the products of combustion at high temperature
   v. describe the composition of the unburned mixture just before combustion is initiated

d) Which of the following statements best describes chemical equilibrium as we have studied it
   vi. the change in entropy as you go from reactants to products is 0.
   vii. the change in specific volume is zero
   viii. the enthalpy of the products is equal to the enthalpy of the reactants
   ix. the internal energy of the products is equal to the internal energy of the reactants
   x. the Gibbs Free Energy of the products is equal to the Gibbs Free Energy of the reactants