

ME 456  
Examination 2  
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1. Consider a reactive gas which is ideal and calorically perfect. The gas undergoes a one-step irreversible exothermic reaction dictated by standard Arrhenius kinetics. The properties of the products and reactants have the same molecular weight,  $\mathcal{M}$ , and specific heat at constant volume,  $c_v$ . The universal gas constant is  $\mathfrak{R}$ . The reaction occurs in a piston-cylinder arrangement in which the pressure is maintained at a constant value of  $P_o$ . The cylinder has radius  $R$ . At  $t = 0$ , the cylinder has height  $z_o$ , the gas has temperature  $T_o$ . The heat released in the reaction per unit mass is  $q$ .
  - (a) What is the final temperature and density of the gas assuming adiabatic combustion?
  - (b) What is the final height of the cylinder assuming adiabatic combustion?
  - (c) Formulate the smallest number of differential equations and initial conditions which model the time-dependent behavior of this system, assuming adiabatic combustion.
  - (d) Formulate the smallest number of differential equations and initial conditions which model the time-dependent behavior of this system, assuming convective heat transfer occurs with the environment, with the heat transfer coefficient of  $h$  and far field temperature of  $T_\infty$ .
2. Propane gas ( $C_3H_8$ ) is burned in air. Find the air-fuel ratio ( $AFR$ ) (taken to be on a *mass* basis) and equivalence ratio  $\phi \equiv AFR|_{stoichiometric} / AFR|_{actual}$  for the cases
  - (a) when just enough air is present for complete combustion, and
  - (b) 1.5 times the necessary air for complete combustion is present.