CANKAYA UNIVERSITY
FACULTY OF ENGINEERING AND ARCHITECTURE
MECHANICAL ENGINEERING DEPARTMENT
ME 212 THERMODYNAMICS II

CHAPTER 13

EXAMPLES

1) One hundred kmol of propane (C_3H_8) together with 3572 kmol of air enter a furnace per unit of time. Carbon dioxide, carbon monoxide, and unburned fuel appear in the products of combustion exiting the furnace. Determine the percent excess or deficiency of air, whichever is appropriate.

2) Propane (C_3H_8) is burned with air. For each case, obtain the balanced reaction equation for complete combustion.
- **a)** with the theoretical amount of air.
- **b)** with 20% excess air.
- **c)** with 20% excess air, but only 90% of the propane being consumed in the reaction.

3) A fuel mixture with the molar analysis 70% CH_4, 20% CO, 5% O_2, and 5% N_2 burns completely with 20% excess air. Determine:
- **a)** the balanced reaction equation.
- **b)** The air-fuel ratio, both on a molar and mass basis.

4) A fuel mixture with the molar analysis 94.4% CH_4, 3.4% C_2H_6, 0.6% C_3H_8, 0.5% C_4H_{10}, 1.1% N_2 burns completely with 20% excess air in a reactor operating at steady state. If the molar flow rate of the fuel is 0.1 kmol/h, determine the molar flow rate of the air, in kmol/h.

5) Dodecane ($C_{12}H_{26}$) burns completely with 150% of theoretical air. Determine:
- **a)** the air-fuel ratio on a molar and mass basis.
- **b)** The dew point temperature of the combustion products, in ^oC, when cooled at 1 atm.

6) Carbon burns with 80%theoretical air yielding CO_2, CO, and N_2 only. Determine:
- **a)** the balanced reaction equation.
- **b)** the air-fuel ratio on a mass basis.
- **c)** The analysis of the products on a molar basis.

7) Liquid methanol (CH_3OH) burns with air. The product gas is analyzed and the laboratory report gives only the following percentages on a dry molar basis: 7.1% CO_2, 2.4% CO, and 0.84% CH_3OH. Assuming the balance consists of O_2 and N_2, determine:

a) the percentage of O_2 and N_2 in the dry molar analysis.
b) the percent excess air.

8) Benzene gas (C_6H_6) at 25°C, 1 atm enters a combustion chamber operating at steady state and burns with 95% theoretical air entering at 25°C, 1 atm. The combustion products exit at 1000 K and include only CO_2, CO, H_2O, and N_2. Determine the mass flow rate of the fuel, in kg/s, to provide heat transfer at a rate of 100 kW.

9) A closed, rigid vessel initially contains a gaseous mixture of 1 kmol of octane (C_8H_{18}) and 300% of theoretical air at 25°C, 1 atm. If the mixture burns completely, determine the heat transfer from the vessel, in kJ, and the final pressure, in atm, for a final temperature of 1000 K.

10) Determine the enthalpy of combustion for gaseous butane (C_4H_{10}), in kJ per kmol of fuel and kJ per kg of fuel, at 25°C, 1 atm, determine:
a) water vapor in the products.
b) liquid vapor in the products.

11) Determine the higher heating value, in kJ per kmol of fuel and in kJ per kg of fuel, at 25°C, 1 atm for
a) liquid octane (C_8H_{18}).
b) gaseous hydrogen (H_2).
c) liquid methanol (CH_3OH).
d) gaseous butane (C_4H_{10}).

12) For each of the following fuels, determine the adiabatic flame temperature, in K, for complete combustion with 200% of theoretical air in a combustor operating at steady state. The reactants enter at 25°C, 1 atm.
a) carbon
b) hydrogen (H_2).
c) liquid octane (C_8H_{18}).

13) Methane (CH_4) at 25°C 1 atm enters an insulated reactor operating at steady state and burns with the theoretical amount of air entering at 25°C, 1 atm. Determine the temperature of the exiting combustion products if:
a) combustion is complete.
b) 90% of the carbon in the fuel burns to CO_2 and the rest burns to CO.
Neglect kinetic and potential energy effects.