Homework 3 Due date: 31-Jan-2007

1. (Chapter 4, Prob. 4.59) Ethylene oxide is produced by the catalytic oxidation of ethylene. An undesired competing reaction is the combustion of ethylene to carbon dioxide and water. The feed to the reactor (*not* the fresh feed to the process) contains 3 moles of ethylene per mole of oxygen. The single-pass conversion is 20%, and for every 100 moles of ethylene consumed in the reactor, 90 moles of ethylene oxide emerge in the reactor products. A multiple-unit process separates the products: ethylene and oxygen are recycled to the reactor, ethylene oxide is sold as the product and carbon dioxide and water are discarded.
    a) Assuming a quantity of reactor feed stream as a basis of calculation, draw and label the flowchart for the process.
    b) Calculate (i) the molar flow rates of ethylene and oxygen in the fresh feed, (ii) production rate of ethylene oxide and (iii) overall conversion of ethylene.
    c) Calculate the molar flow rates of ethylene and oxygen in the fresh feed needed to produce 1 ton per hour of ethylene oxide.
    d) Calculate the selectivity of ethylene oxide to carbon dioxide and yield of ethylene oxide.

2. (Chapter 4, Prob. 4.69) A mixture of 75 mole% propane and 25 mole% hydrogen is burned with 25% excess air. Fractional conversion of 90% of the propane and 85% of the hydrogen are achieved; of the propane that reacts, 95% forms CO_2 and the balance forms CO. The hot combustion product gas passes through a boiler in which heat transferred from the product gas converts boiler feedwater into steam.
    a) Calculate the concentration of CO (ppm) in the product gas
    b) The CO in the stack gas is a pollutant. Its concentration can be lowered by raising the percent excess air fed to the furnace. Think of at least two costs of doing so. (*Hint:* The heat released by the combustion goes into heating the combustion products, and the higher the combustion product temperature, the more steam is produced.)

3. Ammonia is burned with oxygen to form nitric oxide and water. Write the stoichiometric equation.
    a) Calculate the ratio (lb mole oxygen react/lb mole NO formed)
    b) If ammonia is fed to a continuous reactor at a rate of 100 kmol/h what oxygen feed rate (kmol/h) would correspond to 40.0% excess oxygen?
    c) If 50.0 kg of ammonia and 100.0 kg of oxygen are fed to a batch reactor, determine the limiting reactant, the percentage by which the other reactant is in excess, and the extent of reaction (mol) and mass of NO produced (kg) if the reaction proceeds to completion.

4. Do problem 3 of Tutorial 3.