Q.1

One hundred mol/h of butane (C_4H_{10}) and 5000 mol/h of air are fed into a combustion reactor. Calculate the percent excess air.

Q.2

Ammonia is burned to form nitric oxide in the following reaction:

$$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$$

(a) Calculate the ratio (lb-mole O_2 react/lb-mole NO formed).

(b) If ammonia is fed to a continuous reactor at a rate of 100.0 kmol NH_3/h, what oxygen feed rate (kmol/h) would correspond to 40.0% excess O_2?

(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.

Q.3

Ethylene oxide is produced by the catalytic oxidation of ethylene:

$$2C_2H_4 + O_2 \longrightarrow 2C_2H_4O$$

An undesired competing reaction is the combustion of ethylene:

$$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$$

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 of ethylene is 20%, and for every 100 moles of ethylene consumed in the reactor, 90 moles of ethylene oxide emerges in the reactor products. A multiple-unit process is used to separate the products: ethylene and oxygen are recycled to the reactor, ethylene oxide is sold as a product, and carbon dioxide and water are discarded.

Calculate the molar flow rates of ethylene and oxygen in the fresh feed needed to produce 1 ton per hour of ethylene oxide.

Q.4

Five liters of liquid *n*-hexane and 4 liters of liquid *n*-heptane are mixed and burned with 4000 gram-moles of air. Not all of the hydrocarbons are burned in the furnace, and both CO and CO_2 are formed. If it is possible to do so without additional information, calculate the percent excess air supplied to the furnace; if more information is needed, state what it is and outline the calculation of the percent excess air.

Rxns:

$$\begin{cases} C_6H_{14} + \frac{19}{2}O_2 \rightarrow 6CO_2 + 7H_2O \\ C_6H_{14} + \frac{13}{2}O_2 \rightarrow 6CO + 7H_2O \end{cases}$$

$$\begin{cases} C_7H_{16} + 11O_2 \longrightarrow 7CO_2 + 8H_2O \\ C_7H_{16} + \frac{15}{2}O_2 \rightarrow 7CO + 8H_2O \end{cases}$$

Q.5

Butane is burned with air. No carbon monoxide is present in the combustion products. Calculate the molar composition of the product gas for each of the following three cases: (i) theoretical air supplied, 100% conversion of butane; (ii) 20% excess air, 100% conversion of butane; and (iii) 20% excess air, 90% conversion of butane.

Q.6

Liquid methanol is fed to a space heater at a rate of 12.0 L/h and burned with excess air. The product gas is analyzed and the following dry-basis mole percentages are determined: CH_3OH = 0.45%, CO_2 = 9.03%, and CO = 1.81%.

(a) Draw and label a flowchart and verify that the system has zero degrees of freedom.

(b) Calculate the fractional conversion of methanol, the percentage excess air fed, and the mole fraction of water in the product gas.