Exam 2
October 4, 2001
Open Books/Open Notes

Name: _____________________________________________   Box No._________

1. A gas mixture of 12 mol% propylene (C\textsubscript{3}H\textsubscript{6}), 14 mol% ammonia (NH\textsubscript{3}) and 74 mol% air is fed to a reactor to produce acrylonitrile (C\textsubscript{3}H\textsubscript{3}N) via the reaction

\[
\text{C}_3\text{H}_6 + \text{NH}_3 + (3/2) \text{O}_2 \rightarrow \text{C}_3\text{H}_3\text{N} + 3\text{H}_2\text{O}
\]

The product coming out of the reactor was analyzed to have 57 mol% N\textsubscript{2}.

a) (10 pts) Determine the limiting reactant

b) (20 pts) Determine the composition (in mole fractions) of the product stream.

c) (Bonus: 10 pts) Calculate the yield of acrylonitrile.

2. (35 pts) Fresh feed containing 30 mol% ethylene, 40 mol% water and 30 mol% inerts are mixed with a recycle stream. The mixture is then fed into a reactor to produce ethanol

\[
\text{C}_2\text{H}_4 + \text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_5\text{OH} \quad RXN_1
\]

with a side reaction that converts some of the ethanol produced to diethyl ether

\[
2 \text{C}_2\text{H}_5\text{OH} \rightarrow (\text{C}_2\text{H}_5)_2\text{O} + \text{H}_2\text{O} \quad RXN_2
\]

The reactor effluent is then passed to a separator in which the product is removed at the bottom of the separator. The product stream contains only all of the ethanol and diethyl ether generated. The selectivity of ethanol with respect to diethyl ether in the product stream is 4.0 mol ethanol/mol diethyl ether. The overall conversion of ethylene is 33.33%. The other stream flowing out of the separator is further split into a purge stream and a recycle stream. The purge contains only inerts, unreacted C\textsubscript{2}H\textsubscript{4} and water. The recycle to fresh feed ratio is 5.0 mol recycle/mol fresh feed.

Evaluate the single pass conversion of C\textsubscript{2}H\textsubscript{4} in the reactor.

3. (35 pts) Butane is fed to the furnace with 30 % excess air. Of the butane fed, 40% proceeded to complete combustion, 20% went towards partial combustion and the rest did not react. Calculate the composition of the stack gas under dry basis.