

Solve each problem on a separate sheet of Engineering Computation paper. Carefully and neatly document your answers. Box your final answer, reporting it with the correct number of significant figures and units. Use plotting software for all plots.

1 NO!

One of the steps in the production of nitric acid is the oxidation of ammonia (NH_3) with O_2 to form nitric oxide and water.

1. (2 pts) Write a balanced equation for NH_3 oxidation.
2. (2 pts) How many lb-mole of O_2 does it take to completely react 10 lb-mole NH_3 ?
3. (2 pts) NH_3 flows into an oxidation reactor at a rate of 100 kmol/hr. What rate must oxygen be fed to maintain a 40% excess of O_2 ?
4. (4 pts) 50.0 kg/hr of NH_3 and 100.0 kg/hr O_2 are fed to a continuous reactor. Plot the mass flow rates of all the reactants and products as a function of the conversion of the limiting reagent.

2 Deacon Blues (Or an Ode to Wake Forest)

In the Deacon process, Cl_2 is made by oxidizing HCl with O_2 . Sufficient dry air is fed to provide 35% excess oxygen, and the conversion of HCl is 85%.

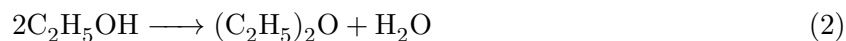
1. (2 pts) Write a balanced equation for the Deacon process.
2. (4 pts) Draw and label a flow chart for this process.
3. (4 pts) Use atomic species balances to determine the product stream composition, in mole fractions.
4. (4 pts) Use advancements to determine the product stream composition, in mole fractions.
5. (2 pts) The Deacon process could be run with pure O_2 rather than air. Speculate on one cost advantage and one cost disadvantage of doing so.

3 Commonly known as alcohol

Industrial ethanol can be produced by the hydration of ethylene:



Some of the product is converted to diethyl ether in a side reaction:



The reactor feed contains ethylene, steam, and an inert diluent. The reactor effluent is found to contain 43.3%(mol/mol) ethylene, 2.5% ethanol, 0.14% ether, 9.3% diluent, and balance H_2O .

1. (3 pts) Draw molecular representations of ethylene, ethanol, and diethyl ether. Pay attention to single, double, ..., bonds, as well as appropriate representations of bond angles and torsions.

Introduction to Chemical Engineering (CBE 20255)

Homework 4

Due February 22, 2016

2. (4 pts) Draw and label a process flow chart for this process, assuming a 100 mol/hr effluent basis.
3. (2 pts) Determine the number of degrees of freedom in the problem as stated.
4. (4 pts) Compute the composition and flow rate of the reactor feed.
5. (2 pts) Compute the ethylene conversion.
6. (2 pts) Compute the ethanol yield.
7. (2 pts) Compute the selectivity to ethanol over the ether.
8. (2 pts) What would you expect to happen to (a) the ethanol yield and (b) the selectivity if the reactor was run to higher conversion?

4 Reduce, reuse, recycle

Methanol is synthesized from carbon monoxide and hydrogen in a catalytic reactor. The fresh feed contains 32.0%(mol/mol) CO, 64.0%(mol/mol) H₂, and 4.0%(mol/mol) N₂. The fresh stream is mixed with a recycle stream in a 1:5 fresh:recycle mole ratio. As a result, the inlet to the reactor is 13.0% N₂. The reactor effluent goes to a condenser that separates a pure liquid stream of only methanol from a gas stream of CO, H₂, and N₂. Part of the gas stream is removed as a purge, while the remainder is recycled.

1. (2 pts) Write a balanced equation for methanol synthesis from CO and H₂.
2. (6 pts) Draw and fully label a process flow chart for this process.
3. (6 pts) Assuming a methanol production rate of 100 kmol/hr, calculate the required fresh feed rate, the composition of the purge stream, and the purge flow rate.
4. (2 pts) Compute the overall CO conversion.
5. (4 pts) Compute the single-pass reactor conversion.
6. (2 pts) What is the point of including (a) a recycle and (b) a purge in this process?