

CHE 251A: Introduction to Chemical Engineering and Process Calculations

Mid Semester Paper-2 (September 16, 2021)

Time: 9:00 AM to 10:00 AM
(includes time for submission)

Total Questions: 2 Max. Marks: 35

Instructions: (i) All questions are compulsory (ii) Figures to right indicate full marks (iii) Solve all the sub-questions within the same question together (iv) Start a new question from the fresh page (v) Cheating is completely forbidden. If anyone is found cheating at any stage (even after the exam), he/she will be suitably punished. If two people found involved in cheating, both will be punished

•Please make a box across the final answers for each step and follow a structured approach while solving i.e. Flow Chart, DoF, Material Balance to attain full credit•

Q1: Ethane can undergo combustion in air, if and only if, its mole % is between 3% and 13%. A mixture consisting of 11 mol % ethane in air has a flowrate of 500 mol/hr. Pure air is added to the mixture to bring ethane concentration to the lower limit of combustion. The resulting mix is fed to a reactor, where all methane gets converted to carbon-dioxide.

- A. Draw the detailed flowsheet and perform DoF [2+1]
B. Calculate the amount of pure air added. [4]
C. Calculate the mass % of Oxygen gas in the final product. (You can assume air to be made up of 21 mol % O₂ and 79 mol % N₂ with an average molecular weight of 29.0 g/mol.) [9]
D. Calculate the amount of CO₂ produced as the product if 300 mol/hr of pure ethane is additionally added to the reactor. [4]

Q2: Liquid coming out of the bottom of the distillation column is 55% vaporized in a partial reboiler. The boil up (vapor produced in the reboiler) is recycled and the residual reboiler liquid is taken out in the form of the final product stream. The compositions of boilup and residual liquid are governed by the relation given below:

$$[y_B/(1-y_B)]/[x_B(1-x_B)] = 2.30$$

Where, y_B and x_B are mole fractions of benzene in vapor and liquid streams respectively.

Vapor leaving the top of the distillation column comprises 95 mol% benzene and is fed to a condenser for total condensation. One-sixth of the condensed liquid is taken off as the final overhead product stream which contains 86.4% of the benzene in the feed of the column, while the rest is recycled to the column.

Using 100 mol of feed as a basis:

- A. Draw a Process Flow Chart and mention all variables at each stream with values, if provided. [2+1]
- B. Perform DOF analysis over the entire column. [1]
- C. Find out the mole fraction of benzene in the overhead product. [3]
- D. What is the total amount of overhead and bottoms product stream? [3]
- E. Calculate the mole fraction of benzene in the recycle stream leaving the reboiler. [3]
- F. What is the percentage recovery of toluene in the bottom's product [2]