CHE 251A: Introduction to Chemical Engineering and Process Calculations

Mid Semester Paper-1 (September 17, 2021)

Time: 8 AM to 8:55 AM **Total Questions: 3** **Max. Marks: 45**
(includes time for submission)

Instructions: (i) All questions are compulsory. (ii) Figures to the 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 were found involved in cheating, both will be punished

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

Q1: AB_4 reacts with C_2 to produce AB_3C and BC. Once formed, AB_3C further react with C_2 to form AB_2C_2 and BC. Production process consists of a reactor, a condenser, a distillation column, and an absorption column. A gas stream containing 80.0 mole% AB_4 and the balance C_2 is fed to the reactor. In the reactor a single-pass C_2 conversion of essentially 100% is attained, the mole ratio of AB_3C to AB_2C_2 in the product is 5:1. The product stream flows to the condenser. Two streams emerge from the condenser: the liquid condensate, which contains essentially all of the AB_3C and AB_2C_2 as the reactor effluent, and a gas containing the AB_4 and BC. The condensate goes to the distillation column in which the two component species are separated. The gas leaving the condenser flows to the absorption column where it contacts an aqueous solution. The solution absorbs all of the BC and none of the AB_4 in the absorbers feed. Liquid leaving the absorber is pumped elsewhere in the plant for further processing, and AB_4 is recycled to join the fresh feed to the process. The combined stream is the feed to the reactor.

Draw a detailed flowsheet for the process and perform DOF analysis for the overall process. **[10]**

Q2: In a bio-incubator, we frequently use air conditioning to maintain specific temperature and humidity conditions. Air contains high amount of moisture which can be reduced by using an AC. Initially air having 80% relative humidity is cooled isobarically at 1 atm from from 70^{o}C to 30^{o}C.

Note: use linear interpolation while reading the attached tables

A. Estimate the dew point temperature. **[8]**
B. How much water is consumed per m^3 of feed gas? **[7]**
C. Air at 70^{o}C with 80% relative humidity is put in closed chamber containing a mirror. Pressure is raised at constant temperature until mist is formed on the mirror. At what pressure(atm) would the mist drops start to form? **[5]**

Q3: When ethylene reacts with oxygen, it forms ethylene oxide as the desired product and CO_2 as the undesired product.

Exit gases from an ethylene oxide reactor had the following analysis (mol% on dry basis)

Ethylene (C_2H_4) = 4.6%

Ethylene oxide(C_2H_4O) = 2.8%

Nitrogen (N_2) = 70.1%

Oxygen (O_2) = 12.3%

Carbon dioxide (CO_2) = 10.2%

Note: (i)Water is not considered in dry basis analysis, whereas in wet basis water is considered.

(ii) N_2 comes only by air and there is no water in the feed

Calculate the following using wet basis:-

A. The new gas composition on wet basis **[5]**
B. Percentage overall conversion of ethylene **[4]**
C. Percentage selectivity **[2]**
D. Air to ethylene mole ratio in feed mixture **[4]**

Separation of an equimolar mixture of benzene and toluene is carried out via distillation.

****The End****