Distillation and Absorption

Problem 1: It is desired to separate propylene from trans-2-butene in a distillation column. The feed stream is available as saturated liquid at 15 bar, and has the following composition:

propylene	45 gmol/s
trans-2-butene	10 gmol/s
cis-2-butene	15 gmol/s
1-butene	6 gmol/s
ethylene	5 gmol/s
propane	4 gmol/s

It is desired to recover 99.5% of the propylene in the distillate and 99% of trans-2-butene in the bottom stream.

- Determine the temperature of the feed stream and the minimum number of plates that are required for the column.
- Determine the mole fraction composition of the distillate and the the bottoms.
- If cooling water at 100^{o}F is to be used in the condenser with $\Delta T_{min} = 10\ ^oC$, what would be the lowest pressures at which the column should operate if the distillate is obtained as either saturated liquid or saturated vapor? Also, for these two cases, what would be the maximum temperatures in a total reboiler?

Problem 2: Consider a distillation column with a feed of 10 gmol/s benzene, 20 gmol/s o-xylene and 15 gmol/s toluene at 1 atm and 230 ^{o}F.

- For a benzene recovery of 98%, what is the minimum number of trays if the ratio of benzene to o-xylene in the overhead is 100? Find the bottoms and tops compositions.
- Periodically a small amount of H_2S appears in the feed. Since it is undesirable to have this component in the product, explain *qualitatively* how you would design and operate this column to separate the H_2S.
- An overhead product of 55% benzene, 40% toluene and 5% o-xylene is recovered as saturated liquid. Can cooling water be used if the column operates at 2 bar?

Problem 3: It is proposed to use an absorption column to recover 99.2% of acetone from a gas stream at 2 bar, 300 K, that has the following composition: 94.3 gmol/s air, 5.0 gmol/s acetone, 0.7 gmol/s formaldehyde.

- If water is to be used as the solvent, estimate its required flowrate for the following conditions:

P column	T water
2 bar	300 K
2 bar	330 K
10 bar	300 K
10 bar	330 K

- Estimate the number of theoretical trays required for this column.
- Assuming that the absorber will operate at 2 bar, and with the temperature of water at 300 K, calculate the mass balance of the column, and estimate the temperature of the outlet liquid stream assuming that it comes out as a saturated liquid stream.

Problem 4: Given the following feed stream:

methane	20 lbmol/hr
methanol	70 lbmol/hr
water	60 lbmol/hr

at 10 atm and 350 K.

1. Design an absorber to recover 95% of the methanol using water as the solvent. Specify all the stream flowrates around the absorber.
2. Explain *qualitatively* how the column design will change in terms of number of stages and the solvent flowrate if a heavy oil solvent ($K_{oil}(350\ K) = 0.01$) is used for the same recovery specification of methanol.

Please search the literature to get the Antoine coefficients for the above problems.