

10.32
Spring 2005

Problem Set 2
Due Wednesday, February 23, 2005

Problem 1

A distillation column is fed two feed streams containing components A and B, each at a flow rate of 100 mol/hr. Stream 1 is a saturated liquid containing 40 mole percent A and Stream 2 is a saturated liquid containing 60 mole per cent A. The distillate should contain 99 mol percent of component A and the bottom product should contain one mol percent A. The relative volatility of A to B is 2.5, independent of temperature. You are asked to consider two cases:

Case 1. The two streams are mixed together and introduced to the column at the optimal location. After mixing, the feed to the column may be assumed to be a saturated liquid. The column has a partial reboiler and a total condenser.

- a) Find the minimum number of stages and the minimum reflux ratio.
- b) If the column is operated at a reflux ratio 1.2 times the minimum reflux ratio, what number of theoretical stages are required and where should the feed be added?

Case 2. The two streams are added to the column, each at its optimal location.

- c) The column is operated at the same reflux ratio used in part b. How many theoretical stages are required and at what stage should each feed stream be introduced?

Problem 2

The vapor-liquid equilibrium data for mixtures of ethanol and water at one atmosphere are shown in the attached figure.

- a) What are the maximum and minimum ethanol concentrations, in mole fraction, that can be obtained by continuous distillation of an ethanol and water mixture at one atmosphere pressure.

A distillation column is fed a saturated liquid feed stream of 30 mol percent ethanol in water. The bottoms stream contains two percent ethanol and the distillate should contain 96 percent of the ethanol in the feed stream.

- b) Find the flow rate of the two product streams.
- c) Find the minimum reflux ratio and the minimum number of stages for this distillation column.
- d) Find the percent ethanol in the feed that we can recover if the composition of the distillate approaches the azeotrope. (Please comment on the sensitivity of the percentage of ethanol recovered to the mole fraction of ethanol in the distillate).

Ethanol-Water, $P = 1 \text{ atm}$

