

Chapter 3: Single-Stage Distillation: Material Balances

These problems ask you to analyze single-stage, partial evaporators and condensers. No information about the feed is required other than the flow rate and composition. The thermodynamic state of the feed is not needed unless the required energy for the operation is needed (hold that thought for Chapter 4!). This leaves 6 variables for a two-component system: T , P , V , y , L , and x . Given the value of two variables (or process specifications) you can calculate the rest with two mole balances and two phase equilibrium relationships.

3.1 50 mol/s of an equimolar liquid mixture of benzene and toluene is fed to a partial evaporator operating at 97°C and 1 atm. Calculate all unknown product flow rates and compositions.

3.2 100 mol/s of a liquid containing 20.0 mol% ethanol and 80.0 mol% water is fed to a partial evaporator operating at 1 atm. The product vapor is 40.0 mol% ethanol. Determine all unknown flowrates, compositions, and the temperature.

3.3 1,000 kmol/h of a vapor consisting of 80 mol% water and 20 mol% isopropanol is fed to a partial condenser operating at 1 atm. 60 mol% of the isopropanol fed to the process is in the liquid product. Calculate all unknown product flow rates, compositions, and the temperature.

3.4 200 mol/s of an n-hexane (30 mol%) and n-octane (70 mol%) liquid mixture is fed to a partial evaporator operating at 1000 mm Hg. 80 mol% of the n-hexane fed is in the vapor product. Calculate the unknown temperature, flow rates, and compositions.

3.5 100 mol/s of an equimolar mixture of styrene and ethylbenzene is fed to a partial evaporator operating under vacuum at 100 mm Hg, producing a 50/50 split of vapor and liquid. Determine all unknown flowrates, compositions, and temperatures.

3.6 100 mol/s of a liquid containing water (60 mol%) and methanol (40 mol%) is fed to a partial evaporator operating at 1 atm. Calculate the unknown temperature, flow rates, and compositions. You will find there is one degree of freedom. Choose an additional specification (see Example 3.1 in the book). Calculate the unknown temperature, flow rates, and compositions. Explore the problem by choosing other process specifications.

3.7 10 gal/h of a 20-proof ethanol in water mixture is to be concentrated to 90-proof in a partial evaporator operating at 1 atm. Determine all flow rates, compositions, and temperature. Expect a little front-end work to convert volumetric flow rate and proof to molar flow rate and mole fractions.

3.8 1.0 m^3 (STP)/s of a vapor containing 40 mol% n-butane and balance n-hexane is fed to a partial condenser operating at 2 atm. 40 mol% of the feed is condensed. Calculate all unknown temperatures, flow rates, and compositions.

3.9 100 mol/s of a liquid containing equimolar amounts of benzene and chlorobenzene is fed to a partial evaporator operating at atmospheric pressure. The liquid product should contain 80 mol% of the chlorobenzene fed to the process. Calculate all unknown temperatures, flowrates, and compositions.

3.10 1000 kmol/day of a 50 mol% acetone - 50 mol% isopropanol mixture is separated in a partial evaporator operating at atmospheric pressure. Twice as much vapor is produced as liquid. Find the temperature, flow rates, and compositions of the products.