

Chapter 4: Single-Stage Distillation: Energy Balances

These problems ask you to calculate the heat requirement for the scenarios described in the Chapter 3 problems. This requires that the thermodynamic state of the feed be specified. This leaves one more unknown than the original problems - Q (heat). This requires one more equation - the enthalpy balance.

4.1 50 mol/s of a saturated liquid at 1 atm and containing an equimolar mixture of benzene and toluene is fed to a partial evaporator operating at 97°C and 1 atm. In Problem 3.1, you calculated all unknown product flow rates and compositions. Now calculate the heat required for this process.

4.2 100 mol/s of a liquid at 70°C, 1 atm, and 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. In Problem 3.2, you determined all unknown flowrates, compositions, and the temperature. Now calculate the heat required for this process.

4.3 1,000 kmol/h of a vapor at 120°C, 1 atm, and 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. In Problem 3.3, you calculated all unknown product flow rates, compositions, and the temperature. Now calculate the heat removed for this process.

4.4 200 mol/s of an n-hexane (30 mol%) and n-octane (70 mol%) saturated 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. In Problem 3.4, you calculated the unknown temperature, flow rates, and compositions. Now calculate the heat required for this process.

4.5 100 mol/s of an equimolar mixture of styrene and ethylbenzene at 75°C and 1 atm is fed to a partial evaporator operating under vacuum at 100 mm Hg, producing a 50/50 split of vapor and liquid. In Problem 3.5, you determined all unknown flowrates, compositions, and temperatures. Now calculate the heat required for this process.

4.6 100 mol/s of a liquid containing water (60 mol%) and methanol (40 mol%) at 20°C and 1 atm is fed to a partial evaporator operating at 1 atm. In Problem 3.6, you calculated the unknown temperature, flow rates, and compositions after choosing one more process specification. Now calculate the heat required for this process.

4.7 10 gal/h of a 20-proof ethanol in water mixture at room temperature (20°C) and 1 atm is to be concentrated to 90-proof in a partial evaporator operating at 1 atm. In Problem 3.7, you determined all flow rates, compositions, and temperature. Now calculate the heat required for this process.

4.8 1.0 m^3 (STP)/s of 40 mol% n-butane and balance n-hexane at 30°C and 2 bar is fed to a partial condenser operating at 2 bar (absolute). 40 mol% of the feed is condensed. In Problem 3.8, you calculated all unknown temperatures, flow rates, and compositions. Now calculate the heat removed for this process.

4.9 100 mol/s of a liquid containing equimolar amounts of benzene and chlorobenzene at 50°C and 1 atm is fed to a partial evaporator. The vapor product should contain 20 mol% of the chlorobenzene fed to the process. In Problem 3.9, you calculated all unknown temperatures, flowrates, and compositions. Now calculate the heat required for this process.

4.10 1,000 kmol/day of saturated liquid at 1 atm consisting of equimolar acetone and isopropanol is separated in a partial evaporator operating at atmospheric pressure. The vapor product flow rate is twice that of the liquid. In Problem 3.10, you found the temperature, flow rates, and compositions of the products. Now calculate the heat required for this process.