11.6 Summary

The ideal solution is a useful idealization that simplifies VLE calculations of systems composed of molecules whose cross interactions are nearly identical the to their self interactions. It is an idealization because such similarity is encountered only in an approximate sense. It is very useful because several real systems are actually well approximated by ideal solutions. When this is the case, a property of the mixture can be calculated *solely* from the properties of the pure components and the amounts of components. The VLE problem, in particular, is very straightforward and reduces to Raoult's law. Compared to calculations that are based on equations of state, calculations with ideal solutions are very simple and require no interaction parameters or mixing rules. This simplicity comes with the limitation that ideal-solution theory works with a small number of systems whose self- and cross-interactions are similar. The true value of the ideal solution is that it provides the basis for treating more complex solutions through the introduction of residual properties. This approach is discussed in the next chapter.

11.7 Problems

Problem 11.1: A vapor mixture of acetone (1) and nitromethane (2) ($y_1 = 0.7$) initially at $P = 1$ bar and 110 °C is to be liquified by compression under constant temperature.
a) At what pressure does the system fully become a liquid?
b) Calculate the composition of the last bubble that condenses.
c) What is the fugacity of nitromethane in the liquid when the system is at the conditions of part (a)?
Assume that the system behaves according to Raoult's law. The saturation pressures of pure acetone and nitromethane at 110 °C are 463 kPa, and 132.4 kPa respectively.

Problem 11.2: A mixture contains n-pentane, n-hexane, and n-heptane at equal mole fractions. The temperature is 55 °C.
a) Calculate the bubble and dew pressure at 55 °C.
b) What is the phase of the system at 1.7 bar, 55 °C? If a two-phase system, calculate the amount and composition of each phase.
c) Repeat the previous part at 0.5 bar.
d) The pressure is adjusted so that 75% of the mixture is vapor while the temperature remains at 55 °C. Determine the pressure and the compositions of the two phases.
Additional data: At 55 °C the ~~vapor~~ saturation pressures of n-C_5, n-C_6, and n-C_7 are 1.903 bar, 0.644 bar, and 0.231 bar respectively.

Problem 11.3: a) Calculate the enthalpy, entropy, and volume of a solution that contains 37.5% by mole heptane in decane, at 15 °C, 1 bar.
b) Calculate the amount of heat needed to raise the temperature of the solution to 40 °C under constant pressure of 1 bar.
c) Calculate the entropy change of the solution in part b.
Additional data: You may assume that the components form an ideal solution. The following properties of the ~~pure components are known~~: pure components at 15 °C, 1 bar are known:

	C_7	C_{10}
ρ (mol/liter)	6.7823	~~6.7823~~ 5.1062
H (J/mol)	−17596	−52923
S (J/mol/K)	−52.632	−142.73
C_P (J/mol/K)	224.5	~~224.5~~ 311.96

Problem 11.4: Assuming normal heptane and normal octane to form ideal solutions, do the following:
a) Calculate the chemical potential of n-C_7(1) in solution with n-C_8(2) at 40 °C, 1 bar, $x_1 = 0.45$.
b) Calculate the fugacity of normal heptane at the conditions of part (a).
c) Calculate the bubble pressure of the solution ($x_1 = 0.45$) at 40 °C.
d) Calculate the dew pressure of the solution at 40 °C.
e) Calculate the bubble temperature at 1 bar.
f) Calculate the dew temperature at 1 bar.
g) Calculate the amount and composition of vapor and liquid when a solution with $z_1 = 0.45$ is flashed to 40 °C, 0.065 bar.

Problem 11.5: A tank that contains a mixture of normal heptane (1)/normal octane is delivered to you. The composition of the mixture is unknown but the tank labels state that the bubble temperature of the mixture at 1 bar is 103 °C.
a) What is the composition of the mixture?
b) What is the dew temperature at 1 bar?
c) The mixture is to be flashed at 120 °C, 1.5 bar. Determine the recovery of normal heptane in the vapor stream.
d) You are requested to flash the mixture so that the liquid stream is 85% of the inlet (by mol). If the pressure is 1.5 bar, what temperature should be used?
Additional data: The saturation pressures of the two components are given by the Antoine equation:

$$\ln P_i^{\text{sat}} = A_i - B_i/(C_i + t)$$

where P^{sat} is in mm Hg, t is in Kelvin, and the parameters A_i, B_i, C_i, are

	A	B	C
nC_8	15.9426	3120.29	−63.63
nC_7	15.8737	2911.32	−56.51