The vapor compositions are

$$y_1 = \frac{x_1 P_1^{\text{sat}}}{P} = 0.448,$$
$$y_2 = 1 - y_1 = 0.552.$$

Dew pressure. In this case the given mole fractions give the composition of the vapor. Solving Raoult's law for the liquid mole fractions we obtain

$$x_1 = \frac{y_1 P}{P_1^{\text{sat}}},$$
$$x_2 = \frac{y_2 P}{P_2^{\text{sat}}}.$$

Adding the two equations we obtain an equation for the unknown pressure:

$$P = \frac{1}{\dfrac{y_1}{P_1^{\text{sat}}} + \dfrac{y_2}{P_2^{\text{sat}}}} = 0.587 \text{ bar}.$$

The corresponding composition of the liquid is

$$x_1 = \frac{y_1 P}{P_1^{\text{sat}}} = 0.185,$$
$$x_2 = 1 - x_1 = 0.815.$$

Comments Each of the above calculations has resulted in the points that define one tie line:

Bubble P: $T = 80\ ^\circ\text{C}$ $P = 0.639$ bar $x_1 = 0.3$ $y_1 = 0.448$,
Dew P: $T = 80\ ^\circ\text{C}$ $P = 0.587$ bar $x_1 = 0.185$ $y_1 = 0.3$.

These tie lines, which are shown on the Pxy graph in Figure 11-1, correspond to the same overall composition $z_1 = 0.3$. In the bubble P calculation, this refers to the composition of the liquid; in the dew P calculation, it refers to the composition of the vapor.

Example 11.5: Raoult's Law and Fugacity

Calculate the fugacity and fugacity coefficient of the ~~all~~ components in the liquid and the vapor ~~for~~ vapor-liquid system of acetonitrile and nitromethane at 80 °C that contains 30% by mol acetonitrile in the liquid.

for a

Solution The system is at the bubble point of the solution, which was determined in the previous example:

$$T = 80\ ^\circ\text{C}, \quad P = 0.639 \text{ bar}, \quad x_1 = 0.3, \quad y_1 = 0.448.$$