

is expressed either in **mole fraction** or in **mole percentage**. The mole fraction is defined as follows:

$$\text{Mole fraction A} = N_A = \frac{\text{Mole A}}{\text{Moles A} + \text{Moles B}}$$

$$\text{Mole Fraction B} = N_B = \frac{\text{Moles B}}{\text{Moles A} + \text{Moles B}}$$

$$N_A + N_B = 1$$

$$\text{Mole percentage A} = N_A \times 100$$

$$\text{Mole percentage B} = N_B \times 100$$

The horizontal and vertical lines shown in Figure 15.3 represent the processes that occur during a fractional distillation. Each of the **horizontal lines** (L_1V_1 , L_2V_2 , and so on) represents both the **vaporization** step of a given vaporization–condensation cycle and the composition of the vapor in equilibrium with liquid at a given temperature. For example, at 63°C a liquid with a composition of 50% A (L_3 on the diagram) would yield vapor of composition 80% A (V_3 on diagram) at equilibrium. The vapor is richer in the lower-boiling component A than the original liquid was.

Each of the **vertical lines** (V_1L_2 , V_2L_3 , and so on) represents the **condensation** step of a given vaporization–condensation cycle. The composition does not change as the temperature drops on condensation. The vapor at V_3 , for example, condenses to give a liquid (L_4 on the diagram) of composition 80% A with a drop in temperature from 63°C to 53°C.

In the example shown in Figure 15.3, pure A boils at 50°C, and pure B boils at 90°C. These two boiling points are represented at the left- and right-hand edges of the diagram, respectively. Now consider a solution that contains only 5% of A but 95% of B (Remember that these are *mole percentages*.) This solution is heated (following the dashed line) until it is observed to boil at L_1 (87°C). The resulting vapor has composition V_1 (20% A, 80% B). The vapor is richer in A than the original liquid was, but it is by no means pure A. In a simple distillation apparatus, this vapor would be condensed and passed into the receiver in a very impure state. However,

