Combining these results the lost work is,

T0/T

$$W_{\text{lost}} = T_0 \left(\Delta S_{\text{mix}} - \frac{\Delta H_{\text{mix}}}{T} \right) = -\frac{T}{T_0} \Delta G_{\text{mix}}. \tag{9.23}$$

In the special case that the heat bath is at the temperature of the system ($T_0 = T$), the lost work simplifies to

$$W_{\text{lost}} = -\Delta G_{\text{mix}}.$$

As we recall, the lost work is also equal to the minimum amount of work that must be done to reverse the process, in this case, to separate the components. Since the Gibbs free energy of mixing is always negative, the work for separation is positive. The more important conclusion is that the Gibbs free energy of mixing is a direct measure of the energy released when the mixture is formed, also equal (in absolute value) to the amount of energy that must be consumed to separate the mixture.

9.5 Mixtures in the Ideal-Gas State

The ideal-gas state for a mixture is reached by reducing pressure at constant temperature and constant composition. When this state is reached, molecules behave as point masses that exert no interactions. Neither the chemical nature of the gas, nor its composition (if mixture) has any effect on its volumetric properties. Therefore, the equation of state of the ideal-gas mixture is the same as for a pure fluid in the ideal-gas state:

$$PV^{\text{igm}} = RT. \tag{9.24}$$

Here the superscript $^{\text{igm}}$ is used to indicate ideal-gas *mixture*. It follows from this equation that when we form an ideal-gas mixture by mixing the pure components in the ideal-gas state at constant temperature and pressure, the volume of the mixture formed is equal to the volume of the pure components before mixing:[10]

$$V^{\text{igm}} = \sum_i x_i V_i^{\text{ig}}. \tag{9.25}$$

10. The proof is straightforward: multiply eq. (9.24) by $n = n_1 + n_2 + \cdots$, to obtain

$$nV^{\text{igm}} = n_1 \frac{RT}{P} + n_2 \frac{RT}{P} + \cdots,$$

On the left-hand side we have the total volume of the mixture, and on the right-hand side we have the sum of the volumes of the pure components.