

cross- and self-interactions are identical in magnitude. This situation arises when molecules are very similar in chemical nature and size, as in solutions of neighboring members of a homologous series. We call this special system an *ideal solution*. The ideal solution is defined by the following properties:

$$V^{\text{id}} = \sum x_i V_i \quad \Delta V_{\text{mix}}^{\text{id}} = 0, \quad (11.1)$$

$$H^{\text{id}} = \sum x_i H_i \quad \Delta H_{\text{mix}}^{\text{id}} = 0, \quad (11.2)$$

$$S^{\text{id}} = \sum x_i S_i - R \sum x_i \ln x_i \quad \Delta S_{\text{mix}}^{\text{id}} = -R \sum x_i \ln x_i, \quad (11.3)$$

where the superscript <sup>id</sup> is used to refer to “ideal solution.” Because molecules that form ideal solutions interact with each other in the same manner as among themselves, there is no change of volume or enthalpy when the pure components are mixed to form the solution. The entropy, on the other hand, does not remain constant but increases by exactly the same amount as when ideal gases mix. There is a close relationship between ideal solutions and ideal mixtures, but an important difference as well: in the ideal-gas mixture, self-interactions and cross-interactions are both zero; in ideal solution, self- and cross-interactions are of equal strength, but they are *not* zero. In fact, they are quite strong, as a result of the close proximity of molecules in the liquid. The ideal-gas mixture, therefore, should be thought of as a special case of ideal solution. It has the properties of the ideal-solution, eqs. (11.1)–(11.3) but also additional special properties (for example, it obeys the ideal-gas law) that the ideal solution does not have.

Equations (11.1)–(11.3) give the primary properties of mixing. All other properties may be obtained by their relationship to those given above. In particular, for the internal energy and Gibbs free energy we obtain

$$U^{\text{id}} = \sum_i x_i U_i, \quad (11.4)$$

$$G^{\text{id}} = \sum x_i G_i + RT \sum x_i \ln x_i, \quad (11.5)$$

which are obtained by writing  $U^{\text{id}} = H^{\text{id}} - PV^{\text{id}}$ , and  $G^{\text{id}} = H^{\text{id}} - TS^{\text{id}}$ . From these equations we may easily identify the corresponding partial molar properties:

$$\bar{V}_i = V_i, \quad (11.6)$$

$$\bar{H}_i = H_i, \quad (11.7)$$

$$\bar{S}_i = S_i - R \ln x_i. \quad (11.8)$$

remove extra T (leave the R)

The most important partial molar property is the chemical potential. It is the partial molar Gibbs free energy and is given by

$$\mu_i^{\text{id}} = G_i + RT \ln x_i. \quad (11.9)$$