The partial molar volume of compound A in a mixture of A and B can be defined as

\[ V_A = \left( \frac{\partial V}{\partial n_A} \right)_{p,T,n_B} \]

Using this definition, a change in volume for the mixture can be described using the total differential of \( V \):

\[ dV = \left( \frac{\partial V}{\partial n_A} \right)_{p,T,n_B} dn_A + \left( \frac{\partial V}{\partial n_B} \right)_{p,T,n_A} dn_B \]

or

\[ dV = V_a \ dn_A + V_b \ dn_B \]

and integration yields

\[ V = \int_0^{n_A} V_a \ dn_A + \int_0^{n_B} V_b \ dn_B \]

This result is important as it demonstrates an important quality of partial molar quantities. Specifically, if \( \xi_i \) represents the partial molar property \( X \) for component i of a mixture, the total property \( X \) for the mixture is given by

\[ X = \sum_i \xi_i n_i \]

It should be noted that while the volume of a substance is never negative, the partial molar volume can be. An example of this appears in the dissolution of a strong electrolyte in water. Because the water molecules in the solvation sphere of the ions are physically closer together than they are in bulk pure water, there is a volume decrease when the electrolyte dissolves. This is easily observable at high concentrations where a larger fraction of the water in the sample is tied up in solvation of the ions.

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