Ideal Gas Mixture

Amagat’s Law

The volume of an ideal gas mixture \( (V) \) is equal to the sum of the component volumes \( (V_j) \)'s of each individual component in the gas mixture at the same temperature \( (T) \) and total pressure \( (P) \) of the mixture. For example,

\[
P V_A = n_A R T \quad P V_B = n_B R T \quad PV = n R T
\]

\[
\frac{V_A}{n_A} = \frac{V_B}{n_B} = \frac{V}{n} \quad \text{thus} \quad \frac{n_A}{n} = \frac{V_A}{V} = y_A \quad \text{and} \quad \frac{n_B}{n} = \frac{V_B}{V} = y_B
\]

Dalton’s Law

The total pressure \( (P) \) of an ideal gas mixture is equal to the sum of the partial pressures \( (p_j) \)'s of each individual component in the gas mixture at the same temperature \( (T) \) and total volume \( (V) \) of the mixture. For example,

\[
p_A V = n_A R T \quad p_B V = n_B R T \quad PV = n R T
\]

\[
\frac{p_A}{n_A} = \frac{p_B}{n_B} = \frac{p}{n} \quad \text{thus} \quad \frac{n_A}{n} = \frac{p_A}{p} = y_A \quad \text{and} \quad \frac{n_B}{n} = \frac{p_B}{p} = y_B
\]

Ideal Gas Mixture

\[
x_j = \frac{n_j}{n} = \frac{V_j}{V} = \frac{p_j}{p} = y_j \quad \text{for each component } j
\]

Thus, mole fraction \( (x_j) \) and volume fraction \( (y_j) \) for an ideal gas mixture are equivalent.

To illustrate the above concepts, the next page presents the “EZ Setup” model for an ideal gas mixture of 21 mol\% O\(_2\) and 79 mol\% N\(_2\) at 25°C and 1 atm.

Note that a gas mixture will behave like an ideal gas when \( P \leq \) about 3 atm.
Ideal Gas Mixture

click here to download this model and solve it using the "EZ Setup"/Solver Add-Ins.

"EZ Setup" Mathematical Model

// Amagat's Law and Dalton's Law for Ideal Gas Mixture
// 21 mol% O2 and 79 mol% N2 at 25°C and 1 atm

// Given Information:
R  =  0.08205746  // L atm/mol K
T  =  25 + 273.15  // K
P  =  1  // atm
n  =  1  // moles of mixture

n_O2  =  0.21 * n  // moles of oxygen
n_N2  =  0.79 * n  // moles of nitrogen

// Amagat's Law:
/* mixture */        P * V  =  n * R * T
/* oxygen */         P * V_O2  =  n_O2 * R * T
/* nitrogen */       P * V_N2  =  n_N2 * R * T
/* total volume */   V_total =  V_O2  +  V_N2
/* volume fraction O2 */  y_O2  =  V_O2 / V_total
/* volume fraction N2 */  y_N2  =  V_N2 / V_total

// Dalton's Law:
/* partial pressure O2 */  p_O2 * V  =  n_O2 * R * T
/* partial pressure N2 */  p_N2 * V  =  n_N2 * R * T
/* total pressure */      P_total  =  p_O2  +  p_N2
/* mole fraction O2 */    x_O2  =  p_O2 / P_total
/* mole fraction N2 */    x_N2  =  p_N2 / P_total

Calculated Results

<table>
<thead>
<tr>
<th>V</th>
<th>24.4654  liters</th>
<th>p_N2</th>
<th>0.79  atm</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_N2</td>
<td>19.3277  liters</td>
<td>p_O2</td>
<td>0.21  atm</td>
</tr>
<tr>
<td>V_O2</td>
<td>5.13774  liters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V_total</td>
<td>24.4654  liters</td>
<td>P_total</td>
<td>1  atm</td>
</tr>
<tr>
<td>y_N2</td>
<td>0.79  vol frac</td>
<td>x_N2</td>
<td>0.79  mol frac</td>
</tr>
<tr>
<td>y_O2</td>
<td>0.21  vol frac</td>
<td>x_O2</td>
<td>0.21  mol frac</td>
</tr>
</tbody>
</table>