24.6: The Translational Partition Function of An Ideal Gas

We can make use of Stirling's approximation to write the translational contribution to $\ln Z_{IG}$ per mole of ideal gas. This is

$$\ln\left[\frac{(z_t)^{\overline{N}}}{\overline{N}!}\right] = \overline{N}\ln z_t - \overline{N}\ln\overline{N} + \overline{N} = \overline{N} + \overline{N}\ln\frac{z_t}{\overline{N}}$$

(We omit the other factors in Stirling's approximation. Their contribution to the thermodynamic values we calculate is less than the uncertainty introduced by the measurement errors in the molecular parameters we use.) In Section 24.3 we find the molecular partition function for translation:

$$z_t = \left(\frac{2\pi mkT}{h^2}\right)^{3/2} V$$

For one mole of an ideal gas, $\overline{V} = \overline{N}kT/P$. The translational contribution to the partition function for one mole of an ideal gas becomes

$$\ln\left[\frac{(z_t)^{\overline{N}}}{\overline{N}!}\right] = \overline{N} + \overline{N}\ln\left[\left(\frac{2\pi mkT}{h^2}\right)^{3/2}\frac{\overline{V}}{\overline{N}}\right] = \overline{N} + \overline{N}\ln\left[\left(\frac{2\pi mkT}{h^2}\right)^{3/2}\frac{kT}{P}\right]$$