A gas may be treated as an Ideal Gas when it is far away from vaporization (liquid→gas) or from sublimation (solid→gas). Specifically, this means at:
- low density
- low pressure
- high temperature

**Ideal Gas Law**

\[ PV = nRT \]

- \( P \) = absolute pressure (not gauge)
- \( V \) = volume
- \( T \) = absolute temperature (Kelvin)
- \( n \) = \# moles

\[
\eta = \frac{\# \text{ molecules}}{\text{Avagadro's}} = \frac{N}{N_A} = \frac{N}{6.02 \times 10^{23}}
\]

\[
\eta = \frac{\text{mass of substance}}{\text{molar mass}}
\]

\[
R = \text{Ideal Gas Constant} = 8.31 J \text{ mol}^{-1} \text{ K}^{-1}
\]

or

\[
R = 0.0821 \text{ L atm} \text{ mol}^{-1} \text{ K}^{-1}
\]

**Alternative Form:** \( PV = Nk_B T \)

\[
P = \frac{n}{N_A} RT
\]

\[
N = \left( \frac{RT}{k_B} \right)
\]

\[
k_B = \text{Boltzmann's Constant}
\]
How we came up with ideal gas law...

Boyle's Law: \( V \propto \frac{1}{P} \) at a constant temp

\[
\begin{align*}
V \propto \frac{1}{P} & \quad \text{or} \quad V \propto \frac{1}{\frac{1}{P}} \\
\Rightarrow P \cdot V &= \text{constant}
\end{align*}
\]

Charles's Law: \( V \propto T \) at constant pressure

\[
\begin{align*}
V \propto T \\
v = (\text{constant}) \cdot T
\end{align*}
\]

*Note that with Charles's Law we can trace the straight line down to a temperature where volume = 0. Since volume can't possibly be negative, this temperature must be the minimum possible. This is how we can experimentally determine \textbf{Absolute zero}.*

\[
\begin{align*}
\text{Absolute zero} &= -273.15 \degree C \\
T &= T(\text{celsius})
\end{align*}
\]

Gay-Lussac's Law: \( P \propto T \) at a constant volume

\[
\begin{align*}
P \propto T \\
P = (\text{constant}) \cdot T
\end{align*}
\]
Putting all three laws together

\[ v \cdot P = \text{constant}, \]
\[ v = \text{constant}_1 \cdot T \]
\[ P = \text{constant}_3 \cdot T \]

\[ \{ \text{These constants} \]
\[ \text{are all different} \]

We get \[ PV = \text{constant}_1 \cdot T \]

This constant is \( \eta R \)

\[ \text{STP (Standard Temperature and Pressure)} \]

\[ T = 273.15 \text{K (0}^\circ\text{C)} \]
\[ P = 1.00 \text{ atm} = 1.013 \times 10^5 \frac{\text{N}}{\text{m}^2} = 1.013 \text{ kPa} \]