2.6: Deriving the Ideal Gas Law from Boyle's and Charles' Laws

We can solve Boyle's law and Charles' law for the volume. Equating the two, we have

$$\frac{n\alpha(T)}{P} = n\beta\left(P\right)T$$

The number of moles, n, cancels. Rearranging gives

$$\frac{\alpha(T)}{T} = P\beta(P)$$

In this equation, the left side is a function only of temperature, the right side only of pressure. Since pressure and temperature are independent of one another, this can be true only if each side is in fact constant. If we let this constant be R, we have

$$\alpha\left(T\right) = RT$$

and

$$\beta\left(P\right) = R/P$$

Since the values of $\alpha(T)$ and $\beta(P)$ are independent of the gas being studied, the value of R is also the same for any gas. R is called the ***gas constant***, the ***ideal gas constant***, or the ***universal gas constant***. Substituting the appropriate relationship into either Boyle's law or Charles' law gives the ***ideal gas equation***

$$PV = nRT$$

The product of pressure and volume has the units of work or energy, so the gas constant has units of energy per mole per degree. (Remember that we simplified the form of Charles's law by defining the Kelvin temperature scale; temperature in the ideal gas equation is in degrees Kelvin.)