Unit 5
Solving Gas Law Word Problems
The Ideal Gas Law: describes the relationship between various quantities involving gases. For a given gas, let:

\[ P = \text{pressure in atmospheres (atm.)} \]
\[ V = \text{volume in liters (L)} \]
\[ n = \text{number of moles (mol)} \]
\[ T = \text{temperature in degrees Kelvin (K)} \]
\[ R = \text{Gas constant} = 0.08205 \text{ (L-atm)/(mol-K)} \]

\[ P \cdot V = n \cdot R \cdot T \]
NOTE: Keeping track of the units of given quantities is especially necessary in dealing with the Ideal Gas Law, since each of the four variables ($P$, $V$, $n$ and $T$) is expressed in a different unit of measurement, and the constant is expressed in a combination of the four units.
NOTE: The Ideal Gas Law can be expressed in various combinations of units other than those indicated here. For example, “SI” units are often used in gas problems. SI (“Système Internationale d’unités”) uses “Pascals” (“Pa”) instead of “atmospheres” (“atm”).

Different combinations of units used result in very different values for $R$, so you have to very careful about choosing the right units of measurement and choosing the $R$ appropriate for those units.
“Hi, I’m Blaise Pascal, after whom the ‘pascal,’ as a unit of pressure, is named. (And believe me, was I under a lot of pressure in my life!) Now, other people might get pretty uppity about being awarded such an honor. Hey, but me, I’m blasé.”
Additional gas laws:

**Boyle’s Law:**
For a given gas:

\[ P_1 V_1 = P_2 V_2 \]

**Charles’s Law:**
For a given gas:

\[ \frac{V_1}{T_1} = \frac{V_2}{T_2} \]

(where \( P, V, \) and \( T \) are pressure, volume, and temperature in appropriate units)

(Due to popular demand, Boyle and Charles are not pictured.)
Problem: A gas sample in a flexible container has the following properties: amount: one mole; pressure: 1.5 atmospheres; and temperature: 300 degrees Kelvin. What is its volume?

Solution:
1. Read the problem carefully.
2. We organize the data given:
   - The amount of gas is one mole
   - The pressure is 1.5 atmospheres
   - The temperature (300 degrees Kelvin).
3. The answer we are asked for is the volume. We designate volume, the unknown variable, as $V$ in keeping with the formulas.
4. The right formula here is the ideal gas law

\[ P \, V = n \, R \, T \]

(The units are the same as in the version of the law we learned, so we can use the value of \( R \) we were given.)

5. Substitute the given data into the formula:

\[ P \, V = n \, R \, T \]

\[(1.5 \, \text{atm})V = (1 \, \text{mol})(0.0805 \, [\text{L-atm/mol-K}])(300 \, \text{K})\]

6. Solve mathematically (including 7.: performing operations on the units as well as the numbers):

\[ V = (1 \, \text{mol})(0.0805 \, [\text{L-atm/mol-K}])(300 \, \text{K}) \]

\[(1.5 \, \text{atm})\]

\[ V = 24.15 \, \text{L-atm} \]

\[(1.5 \, \text{atm})\]
Unit Five: Problem – Solution 3

Finally, we get:

\[ V = 16.1 \text{ L} \]

The gas sample occupies 16.1 liters of volume.

7. We have been careful with the units of measurement as we have gone along, so we can confirm that the units are correct.

**Note:** If the pressure had been expressed in Pascals, we would have had to use a different expression of the constant, \( R \), using Pascals:

\[ R = 8.3145 \text{ L-kPa}/(\text{mol-K}) \]

*Never get blasé about checking for the correct units of measurement!*