7.1: Background Material

Text References

- kinetic theory of gases
- particle speed in a gas
- ideal and non-ideal (van der Waals) gases

van der Waals Gases

In one of the text references above, we encounter a state equation relating pressure, volume, temperature, and particle number (Equation 5.5.4) that is more general than the ideal gas law. It accounts for the size of the particles (they can't occupy the same space), and the attractive forces they feel toward each other (van der Waals forces).

In this lab, we will be examining the kinetic theory of gases with a simulator, and the simulator includes an option for allowing the particles to collide elastically with each other (they behave as "hard spheres"), but the particles are still not allowed to attract each other. Including this feature would complicate the picture beyond our current study of gases, because at low temperatures these attractive forces will cause our "gas" to start changing phase into liquid and solid.

We can therefore cut down the full van der Waals equation for the purposes of this lab. Another useful change is to change the variable for number of moles to number of particles, since the simulator will not have anything close to 10^{23} particles involved. The modified van der Waals equation that applies to our simulator is therefore:

$$P\left(V - N\beta\right) = Nk_BT \tag{7.1.1}$$

We have replaced the constant b with a new constant $\beta = \frac{b}{N_A}$. The simple physical interpretation of β is that it is the volume of a single particle. Multiplying it by the particle number gives the total volume of all the particles combined. Subtracting this from the total volume of the chamber gives the spatial volume available for the movement of the particles, which is what is needed in the state equation. If the gas is ideal, then the entire volume of the chamber is available, giving us $\beta = 0$ and the usual ideal gas law.