

Ideal and Real Gases

Learning Objectives

- Identify assumptions present in ideal gas model and assess how these break down for real gases
- Connect the equation of state for a real gas to conceptual and graphical models

Ideal Gases

The equation of state for an ideal gas is given by:

$$PV = nRT$$

1. Using this equation, give the relationship between:
 - a. Temperature (T) and Volume (V)

 - b. Pressure (P) and Temperature

 - c. Pressure and Volume

2. In MATLAB, make a plot of Temperature vs. Volume. Use 1 mol of gas at 1 atm.
 - a. What happens to the volume as $T \rightarrow 0$?

 - b. Will this be true for a real gas? Why or why not?

 - c. How does this behavior change as the pressure increases? Decreases?

Real Gases

There are many equations of state that have been developed for real gases. One of the most common is the van der Waals equation of state shown below (a and b are always positive and constant dependent on the identity of the gas).

$$P = \frac{nRT}{V - nb} - \frac{an^2}{V^2}$$

- Looking at this equation, what happens when a and b are both equal to 0?
- If $a = 0$ and $b > 0$, how is the temperature affected relative to that of an ideal gas? Does this change if $a > 0$ and $b = 0$?
- In MATLAB, make a plot of Temperature vs. Volume. Use 1 mol of gas at 1 atm. Use a and b for N_2 , given in the table below.
 - What happens to the volume as $T \rightarrow 0$?
 - How does this compare with what must be true physically?
- The van der Waals constants for some real gases are included in the following table.

| Gas | a | b |
|-----------------|--------|--------|
| He | 0.0341 | 0.0237 |
| H ₂ | 0.2461 | 0.0267 |
| N ₂ | 1.39 | 0.0391 |
| O ₂ | 1.36 | 0.0318 |
| CO ₂ | 3.59 | 0.0427 |
| NH ₃ | 4.17 | 0.0371 |

- Which gas do you expect to behave the most like an ideal gas? Does this agree with your chemical intuition? Why or why not.
 - Which gas do you expect to behave the least like an ideal gas? Why?
 - Make a plot of Temperature vs. Volume for the gases in the table.
 - Predict the values of a and b (roughly) for H₂O? Justify your predictions.
- State the two primary failings of the ideal gas law. Explain how a and b are used in the van der Waals equation of state to correct for each of these issues.