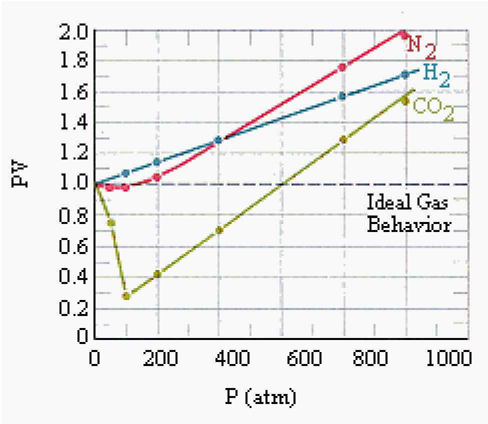
AP Chemistry - Gases and Their Properties



A plot of the product of the pressure times the volume for samples of H_2, N_2, CO_2 gases versus the pressure of these gases. (chem.purdue.edu)

You can see in the graph how these gases deviate from what would be predicted using the Ideal Gas Law.

Gases with weak intermolecular forces, such as hydrogen, generally have observable volumes that are greater than predicted by the ideal gas law (Figure above). Intermolecular forces, which reduce the volume of a gas, are small for hydrogen and have little effect on its volume or pressure (except at very low temperatures). The deviation occurs because hydrogen molecules occupy a fraction of the space within a container. Gases such as carbon dioxide often have smaller volumes than predicted by the ideal gas law at high pressures. Here, intermolecular forces of attraction have the effect of reducing the volume of a gas. However, even carbon dioxide eventually deviates toward higher than ideal volumes as the pressure increases and the molecules occupy an increasing fraction of space within a container.

The Dutch physicist Johannes van der Waals (1837-1923) studied the breakdown of the ideal gas law equation and developed an equation to correct for some of the errors arising from nonideality. This equation is known as the **van der Waals equation:**

$$(P + \boldsymbol{a}[n/V]^2)(V - \boldsymbol{b}n) = nRT$$

van der Waals Constants - a & b

[These constants are used as correction factors for non-ideal behavior of gases.]

$$(P + a[n/V]^2)(V - bn) = nRT$$

P: Observed pressure

a: *van der Waals Constant (atm L^2/mol^2) - (Pressure correction accounts for intermolecular forces) [Experimentally determined constants]*

b: *van der Waals Constant (L/mol) - Correction for molecular volume - molecules take up some of the space in the container. [Experimentally determined constants]*

n: Amount of gas (mol)

V: Container Volume (L)

R: Ideal gas Law Constant

T: Temperature (K)

van der Waals Constants

Gas	***a Values (atm L^2/mol^2)***	***b Values (L/mol)***
He	*0.034*	*0.0237*
Ar	*1.34*	*0.0322*
H_2	*0.244*	*0.0266*
N_2	*1.39*	*0.0391*
O_2	*1.36*	*0.0318*
CO_2	*3.59*	*0.0427*
Cl_2	*6.49*	*0.0562*
H_2O	*5.46*	*0.0305*