Chapter 10
Gases

Characteristics of Gases

- Unlike liquids and solids, they
  - Expand to fill their containers.
  - Are highly compressible.
  - Have extremely low densities.

Pressure

- Pressure is the amount of force applied to an area.

Units of Pressure

- Pascals
  - 1 Pa = 1 N/m^2
- Bar
  - 1 bar = 10^5 Pa = 100 kPa

1 atm = 760 mm Hg = 760 torr = 1.01325x 10^5 Pa = 101.325 kPa

Units of Pressure

- mm Hg or torr

Manometer

Used to measure the difference in pressure between atmospheric pressure and that of a gas in a vessel.

Standard Pressure

- Normal atmospheric pressure at sea level.

Boyle's Law

The volume of a fixed quantity of gas at constant temperature is inversely proportional to the pressure.

As *P* and *V* are
inversely proportional

A plot of *V* versus *P* results in a curve.

Charles's Law

- The volume of a fixed amount of gas at constant pressure is directly proportional to its absolute temperature.
- $V \propto T$

Avogadro's Law

- The volume of a gas at constant temperature and pressure is directly proportional to the number of moles of the gas.

Ideal-Gas Equation

$V \propto 1/P$ (Boyle's law)

$V \propto T$ (Charles's law)

$V \propto n$ (Avogadro's law)

Ideal-Gas Equation

The constant of proportionality is known as R, the gas constant.

The relationship

Densities of Gases

If we divide both sides of the ideal-gas equation by V and by RT, we get

We know that

- ➢moles $\times$ molecular mass = mass
- Mass ÷ volume = density

- So,

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Molecular Mass

We can manipulate the density equation to enable us to find the molecular mass of a gas:

Dalton's Law of
Partial Pressures

- The total pressure of a mixture of gases equals the sum of the pressures that each would exert if it were present alone.
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Partial Pressures of Gases

Partial Pressures

- When one collects a gas over water, there is water vapor mixed in with the gas.
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Kinetic-Molecular Theory

This is a model that aids in our understanding of what happens to gas particles as environmental conditions change.

Main Tenets of Kinetic-Molecular Theory

Gases consist of large numbers of molecules that are in continuous, random motion.

- The combined volume of all the molecules of the gas is negligible relative to the total volume in which the gas is contained.

- Attractive and repulsive forces between gas molecules are negligible.

Energy can be transferred between molecules during collisions, but the *average* kinetic energy of the molecules does not change with time, as long as the temperature of the gas remains constant.

The average kinetic energy of the molecules is proportional to the absolute temperature.

Effusion

The escape of gas molecules through a tiny hole into an evacuated space.

Diffusion

The spread of one substance throughout a space or throughout a second substance.

Boltzmann Distributions

Effect of Molecular Mass on Rate of Effusion and Diffusion

Real Gases

In the real world, the behavior of gases only conforms to the ideal-gas equation at relatively high temperature and low pressure.

Deviations from Ideal Behavior

The assumptions made in the kinetic-molecular model break down at high pressure and/or low temperature.

Corrections for Nonideal Behavior

- The ideal-gas equation can be adjusted to take these deviations from ideal behavior into account.

The van der Waals Equation