Gas Laws

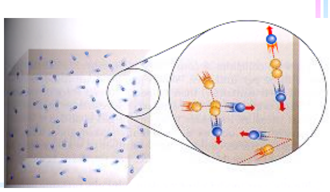
- Gas Properties
- Gases and the Kinetic Molecular Theory
- Pressure
- Gas Laws

Gas Properties

1) Gases have mass - the density of the gas is very low in comparison to solids and liquids, which make it seem lighter.
2) Gases are compressible - Squeezing a gas is much easier than squeezing some solids and liquids.
3) Gases fill containers completely - air is distributed completely throughout a balloon.

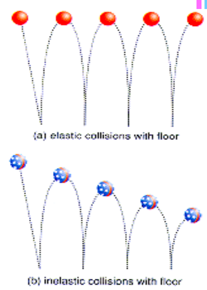
Gas Properties

4) Gases diffuse - gases can move through each other very easily.
5) Gases exert pressure - balloons are given their shape due to the pressure of the gas in the balloon.



Gases and KMT

- A gas consists of very small particles, each with a mass.
- The distance between particles of a gas is relatively large.
- Gas particles are in random, constant motion.
- Collisions between gases and their container are perfectly elastic.
- Gas particles exert no net force on one another.

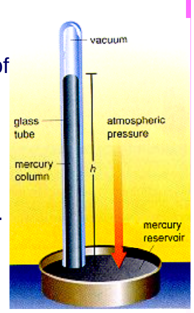


Measurement of Gases

- Amount (n) - standard unit - mole
- Volume (V) - st. unit - liter
- Temperature (T) - st. unit - Kelvin
- Pressure (P) - st. unit - atmosphere

What is Pressure?

- Pressure is the result of the gases colliding with the walls of the container it is in. Every time a particle hits the wall of the container, it exerts a force or push.
- Pressure is a measure of this force over the whole container.
- Atmospheric pressure is the weight of the air above an object



Units of Pressure

At Sea Level:

- 1 atmosphere
- 760 mm Hg
- 760 torr
- 101,325 Pa or 101.325 kPa
- 14.70 psi (pounds/square inch)

Temperature

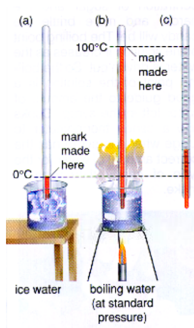
Measure of the movement of the molecules in a substance. In science, either the Celsius or the Kelvin temperature scale is used.

$^{o}C = 5/9(^{o}F - 32)$

$^{o}F = 9/5(^{o}C) + 32$

$K = {}^{o}C + 273$

$^{o}C = K - 273$



Absolute Temperature

An absolute scale means that it has limits on one or both ends of the scale.

The Kelvin temperature scale cannot go below 0 K because this point corresponds to the point where the motion of the particles (their kinetic energy) ceases.

This point is called absolute zero.

Boyle's Law

The pressure and volume of a sample of gas at constant temperature are inversely proportional to each other.

- i.e., one goes up, the other goes down.

Equation: $P_1V_1 = P_2V_2$

Charles' Law

At constant pressure, the volume of a fixed amount of gas is directly proportional to its absolute temperature.

- i.e., one goes up, the other goes up.

Equation: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Gay-Lussac's Law

At constant volume, the pressure of a fixed amount of gas is directly proportional to its absolute temperature.

- i.e., one goes up, the other goes up.

Equation: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

Combined Gas Law

However, if none of the values can be kept constant, we can combine the 3 gas laws into one equation:

Equation: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Avogadro's Principle

Equal volumes of gases under the same conditions have equal number of molecules.

Equation: $\frac{V_1}{n_1} = \frac{V_2}{n_2}$

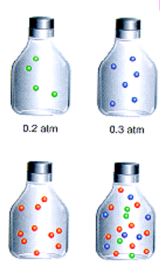
Recall that at STP, the molar volume (volume of one mole of a gas) is 22.4 L

Dalton's Law of Partial Pressures

The total pressure in a gas mixture is the sum of the partial pressures of the individual components.

Partial pressures are the pressures due to each gas in the mixture.

Equation: $P_{total} = P_1 + P_2 + P_3 + \ldots$



Ideal Gas Law

It is possible to combine all the gas laws that we have learned thus far into one gas law.

The ideal gas law describes the physical behavior in terms of the gases' pressure, volume, moles and temperature.

The ideal gas law works for any gas provided it obeys the KMT postulates. Deviations from ideal gas occur at very low temperatures and at very high pressures.

Ideal Gas Law & Constant

When putting the gas laws together, we discover the mathematical equation:

$$PV = nRT$$

where R stands for the universal gas constant.

Values for R:

0.0821 atm•L/mol•K

or 8.314 kPa•L/mol•K

or 8.314 Pa•m^3/mol•K

or 62.36 mmHg•L/mol•K

Gas Density

The ideal gas law equation can be rearranged to determine the density of a gas:

$$D = \frac{PM}{RT}$$

The density will be calculated in g/L.

This equation can be rearranged to calculate the molar mass of a gas:

$$M = \frac{DRT}{P}$$

Stoichiometry & Ideal Gases

- In cases of a chemical reaction in which a gas is either reacted or produced, you may need to use the ideal gas law to determine the moles of gas to complete a stoichiometry problem. And as we have recently learned, 1 mole = 22.4 L ONLY at STP.
- Example: A sample of hydrogen gas is confined to a 500 mL flask at 15 ^{O}C and 850 torr. The gas is released to react with excess oxygen in the air to produce water vapor. How many grams of water will be produced?