**Lesson #10.5 - Gases**

The 5 assumptions of the Kinetic Molecular Theory (KMT) of Gases.

* The volume occupied by the individual particles of a gas is negligible compared to the volume of the gas itself.
* The particles of an ideal gas exert no attractive forces on each other or on their surroundings.
* Gas particles are in a constant state of random motion and move in straight lines until they collide with another body.
* The collisions exhibited by gas particles are completely elastic; when two molecules collide, total kinetic energy is conserved.
* The average kinetic energy of gas molecules is directly proportional to absolute temperature only; this implies that all molecular motion ceases if the temperature is reduced to absolute zero.

Though no gas can meet all 5 of these criteria, we usually define a gas as “**Ideal”** if it would. Gases that do not meet all these criteria are called **“Real Gases.”**

Though no gas is truly ideal, some gases are closer to being ideal then others. The most ideal gases are those with smaller particle volumes (the lightest ones) and very little intermolecular forces of attraction (IMF). We will learn about these forces in the next unit.

Hydrogen and Helium are considered the most Ideal.

Gases like water vapor and SO2 are considered less ideal (more real) because of the strong IMFs. Large gases like CCl4 vapor are also non-ideal.

However, if gases are studied under the right conditions, even the least ideal gases will behave ideally. These conditions are:

**High Temperature and Low Pressure.**

**Description of Measurements for Gases**

**Temperature Units Conversion**

oC (degrees Celsius) oC + 273 = K

K (Kelvin) K - 273 = oC

**Volume Units** **Conversion**

L (liters) 1 L = 1000 mL ( so x1000 to convert to mL)

mL (milliliters) 1000 mL = 1 L ( so /1000 to convert to L)

cm3 (cubic centimeters) 1 mL = 1 cm3

**Pressure Units** **Conversion**

mm Hg (millimeters of mercury) 760 mm Hg = 1 atm ( so /760 to convert to atm)

atm (atmospheres) 1 atm = 760 mm Hg ( so x760 to convert to mm Hg)

torr (same as mm Hg) 760 torr = 760 mm Hg

Pa (pascals) 1.013 x105 Pa = 1 atm

kPa (kilopascals) 101.3 kPa = 1 atm

**Amount Units** **Conversion**

mol (moles) 1 mole = 6.022 x 1023 particles

**Gas Laws**

**Boyle’s Law (Pressure–Volume Law)**

For a fixed amount of gas at constant temperature, volume varies inversely with pressure.

*V* ∝ 1/*P*. A useful form of the equation is ***P*1**.***V*1 =*P*2**.***V*2.**

**Charles’ Law (Temperature–Volume Law)**

For a fixed amount of gas at constant pressure, volume varies directly with the Kelvin temperature. *V* ∝ *T*, or ***V*1 / *T*1 = *V*2 / *T*2.**

**Gay-Lussac’s Law (Temperature–Pressure Law)**

For a fixed amount of gas at constant volume, pressure varies directly with Kelvin temperature. *P* ∝ *T*, or ***P*1 / *T*1 = *P*2 / *T*2.**

**Avogadro’s Principle**

Equal volumes of gases contain equal numbers of moles when compared at the same temperature and pressure. *n* ∝ *V*, or ***n*1 / *V*1 = *n*2 / *V*2.**

At Standard Temperature and Pressure (**STP)**, 273.15 K and 1.00 atm, 1 mol of an ideal gas occupies a volume of 22.4 L.

**Combined Gas Law**

This combines the factors of Pressure, Volume and Temperature into one equation. ***P*1**.***V*1/*T*1 = *P*2**.***V*2/*T*2**.

**Ideal Gas Law**

***PV* = *nRT***. When *P* is in atm and *V* is in L,the value of *R* is 0.08206 L.atm/mol.K

The ideal-gas equation can be manipulated to solve a variety of different types of problems. In order to determine the density of a gas, we rearrange the equation to



Density of a gas is generally expressed in g/L. Multiplication of the left and right sides of the equation by the molar mass () of the gas gives



*= DRT/P*



**Dalton’s Law of Partial Pressures**

The total pressure of a mixture of gases is the sum of the partial pressures of the individual gases. ***P*total = *PA* + *PB* + *PC* + . . .**

Dalton’s Law is must useful when considering the collection of **gas over water**. This is because water vapor gets trapped with the gas that is collected. For this reason, you must subtract the water vapor pressure from the total (barometric) pressure of the container where the gases are collected. This will determine the exact pressure of the gas you are trying to collect.

**https://www.youtube.com/watch?v=jg4c0rVSckg**

**Graham’s Law of Effusion**

The rate of effusion of a gas varies inversely with the square root of its density (or the square root of its molecular mass) at constant pressure and temperature.

In short, ***the lighter the gas, the faster it moves.***



**PRACTICE PROBLEMS**

**1.** A balloon filled with helium at 96.3 kPa occupies 1.20 Liters. How much space

would the same amount of helium take up at 98.9 kPa at constant temperature?

**2.**  1 mole of oxygen at 25 oC takes up 300. mL of space. At constant pressure,

what would the volume be for the same amount of gas at 45 oC?

**3.** A metallic cylinder currently hold 506.5 kPa of pressurized argon at 20. oC.

What would the new pressure be for this cylinder at 45 oC?

**4.** 607.8 kPa of N2 gas at 25 oC are contained in a 2.00 liter cylinder. If the gas is

released into a room with a volume of 120. liters of empty space on a

cold February day when the temperature has dropped to –10. oC,

what would the new pressure of that nitrogen be?

**5.** 16 liters of air at STP is pressurized into a 3.00 liter tank at 25 oC .

What pressure (**in kPa)** would this cylinder be at?

1. The density of a gas is 2.0 grams/liter at STP. What is its molar mass?

(Remember your units!)

**7.** Given the reaction: **2** C2H6 + **7** O2 🡪 **4** CO2 + **6** H2O**,** at STP, what is

the total volume of CO2 formed when 6.0 liters of C2H6 are completely consumed? (Remember your units!)

1. At STP, the volume occupied by 32 grams of a gas is 11.2 liters. What is the
   1. molar mass of this gas? (Remember your units!)

1. How many liters of (dry) helium gas would there be in a filled container at

STP, if the container held exactly 2 moles of helium gas? (Remember your units!)

1. What would be the volume of 3.01 x 1023 atoms of neon at STP?

(Remember your units!)

1. What is the density of the F2 gas at STP? (Remember your units!)

**12.** How many moles of Argon gas would occupy 67.2 liters at STP?

(Remember your units!)

1. The gram molecular mass (molar mass) of a gas is 56 grams/mole. What

is its density at STP? (Remember your units!)

**14.** A 15 gram sample of a gas has a volume of 30. liters at STP. What is the density of this gas at STP? (Remember your units!)

1. At STP, 32 grams of O2 would occupy the same volume as how many

grams of helium? (Remember your units !)