Gas Laws

AP Chemistry

Gas Basics

A Gas

- Uniformly fills any container.
- Mixes completely with any other gas.
- Exerts pressure on its surroundings.

Gas properties described by:

- **V** = volume of the gas (L)
- **T** = temperature (K)
  - ALL temperatures in the entire chapter MUST be in Kelvin!!! No Exceptions!
- **P** = pressure (atmospheres)

Change one variable affects the other two!!!!!

Pressure

Pressure is defined as the force the gas exerts on a given area of the container in which it is contained. The SI unit for pressure is the Pascal, Pa.

- **KEY UNITS AT SEA LEVEL**
  - 101.325 kPa (kilopascal)
  - 1 atm
  - 760 mm Hg
  - 14.7 psi

- If you've ever inflated a tire, you've probably made a pressure measurement in pounds (force) per square inch (area) psi

Volume

Volume is the three-dimensional space inside the container holding the gas. The SI unit for volume is the cubic meter, m^3. A more common and convenient unit is the liter, L.

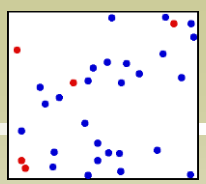
Think of a 2-liter bottle of soda to get an idea of how big a liter is.
(OK, how big two of them are…)

Temperature

Temperature is the measurement of heat…or how fast the particles are moving.

- **Always use absolute temperature (Kelvin) when working with gases.**
- $T_K = 273 + T_C$

Gases



- Gases **expand, diffuse, exert pressure**, and can be **compressed** because they are in a low-density state consisting of tiny, constantly moving particles
- Due to their constant, random motion, gas molecules **diffuse** into areas of lower concentration, and **effuse** through tiny openings
- Common **Examples** of **Diffusion**. You can smell perfume because it diffuses into the air and makes its way into your nose. A teabag placed in a cup of hot water will diffuse into the water.

STP: you need to memorize this

Standard Temperature & Pressure

Temp: 0°C or 273 K

Pressure 1 atm or 101.3 kPa

Combined Gas Law

- HERE'S AN EASY WAY TO MEMORIZE ALL OF THIS! Start with the combined gas law:
- $P_1V_1T_2 = P_2V_2T_1$
- Memorize just this use a simple pattern to figure the rest out:
- ♣ Place the scientist names in alphabetical order.
- ♣ Boyle's Law uses the first 2 variables, Charles' Law the second 2 variables & Gay-Lussac's Law the remaining combination of variables. Whichever variable doesn't appear in the formula is being held CONSTANT!

Kinetic Molecular Theory (KMT)

- The KMT states that particles of matter are always in constant, rapid motion.
  - Explains properties of gases, liquids, and solids in terms of energy using an ideal gas

- **The five assumptions of KMT**
  - gas particles are small and the space occupied is mostly empty space
  - elastic collisions occur between gas particles
    - No kinetic energy is lost during collisions
  - gas particles are in constant rapid motion
  - there are no forces of attraction or repulsion between gas particles
  - the kinetic energy of a gas particle depends on the temperature

Ideal Gas Law

$$PV = nRT$$

- R=0.08206 L·atm/mol·K (universal gas constant)
- n = number of moles of gas (moles)
- P = pressure (atm)
- V = volume (Liters)
- T = temperature (K)

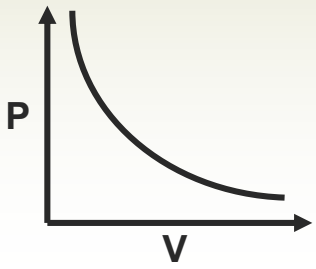
Ideal Gas Law – solve all using

$$PV = nRT$$

- Put variables on left
- Constants on Right
- Remove right, repeat left on Right
- Solve for unknown

Boyle's Law

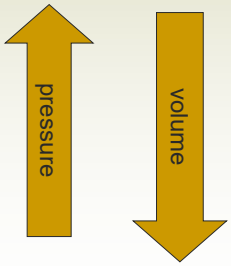
Boyle's Law: describes the relationship between **pressure** and **volume** of gases.



$$P_1V_1 = P_2V_2$$

Boyle's Law $P_1V_1T_2 = P_2V_2T_1$ T =Constant

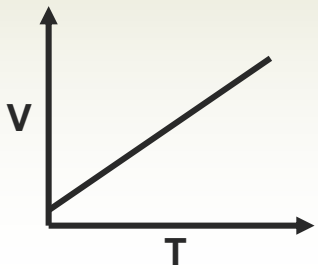
- Boyle determined that for the **same amount** of a gas at **constant temperature**, results in an **inverse relationship**:
  when one goes up, the other goes down.



Real life Example: Squeezing a Balloon

Charles' Law

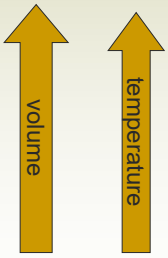
Charles' Law: describes the relationship between **volume** and **temperature** of gases.



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

Charles' Law $P_1V_1T_2 = P_2V_2T_1$ P =Constant

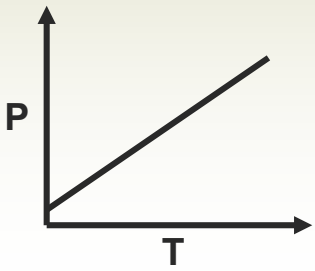
- This defines a direct relationship:
  With the same amount of gas he found that as the volume **increases** the temperature also **increases** or vice versa



Real life Example: Balloon in Flask, heating up water

Gay-Lussac's Law $P_1V_1T_2 = P_2V_2T_1$ V=Constant

The **pressure** and absolute **temperature (K)** of a gas are directly related at constant mass & volume.

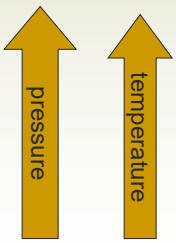


$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

What does it mean?

$P_1V_1T_2 = P_2V_2T_1$
V=Constant

- For a gas at constant mass and volume, the pressure and temperature are directly related.



One example is how tire pressure changes with temperature. Tire pressure increases as the weather gets warmer,

Combined Gas Law

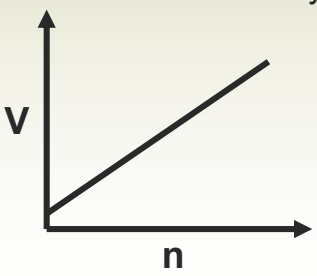
- It is a law that *combines* the previous laws into one.

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

$$P_1V_1T_2 = P_2V_2T_1$$

Avogadro's Principle

- Equal volumes of gases contain equal numbers of moles
  - at constant temp & pressure
  - true for any ideal gas



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

What does it mean?

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