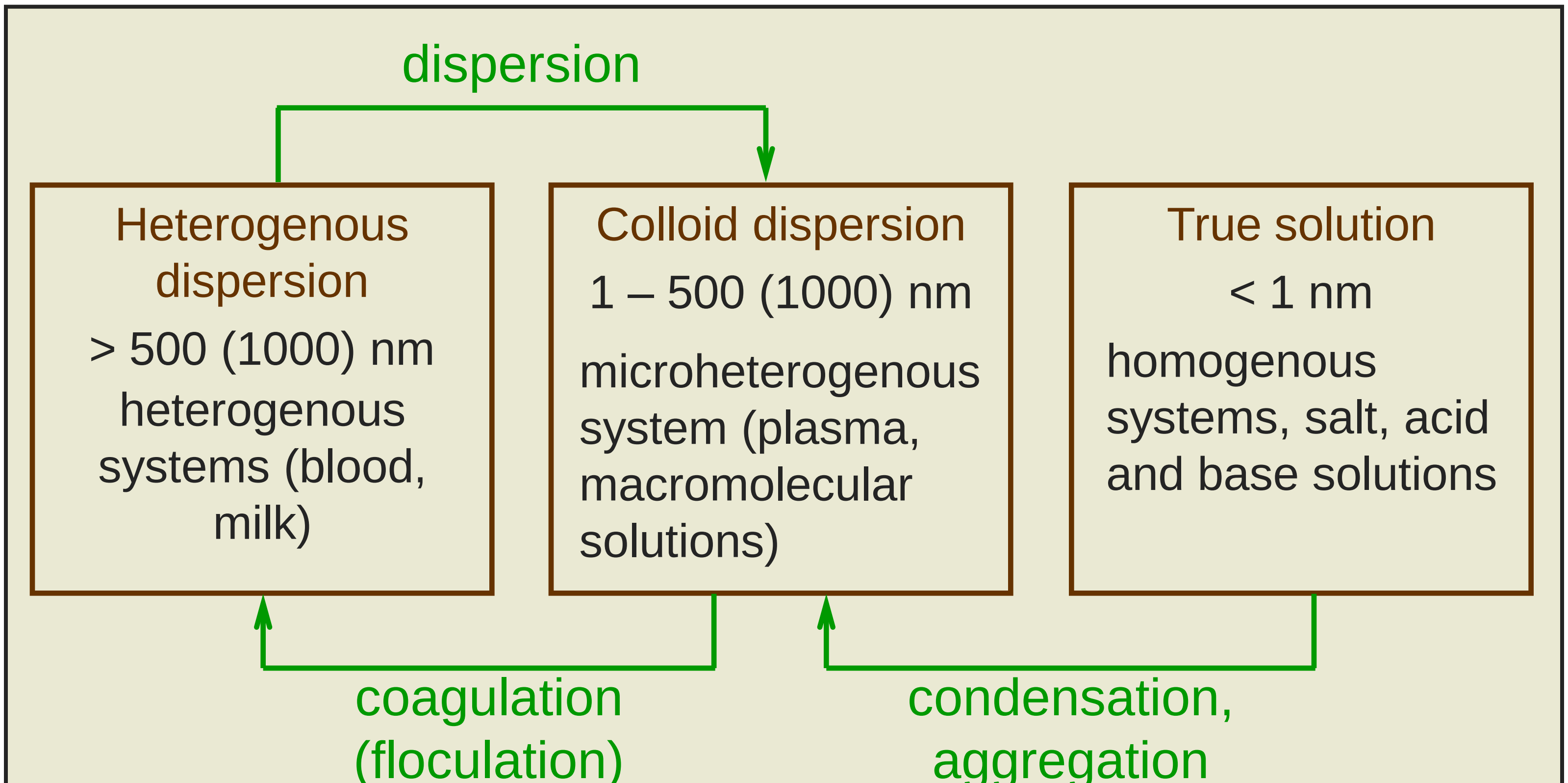
Disperse and Colloidal systems, Solutions and Gases

Types of disperse systems

- The term "Disperse System" refers to a system in which one substance (**the dispersed phase**) is distributed, in discrete units, throughout a second substance (**the continuous phase** or vehicle).
- Each phase can exist in solid, liquid, or gaseous state .

Types of disperse systems



Classification of desperse systems

Continuous medium — Medium/Phase	Dispersed phase: **Gas**	**Liquid**	**Solid**
Gas	None (All gases are mutually miscible)	Liquid aerosol (fog, hair sprays)	Solid aerosol (smoke cloud, air particles)
Liquid	Foam (whipped cream, shaving cream)	Emulsion (milk mayonnaise)	Sol (blood pigmented ink)
Solid	Solid foam (aerogel, pumice polystyrene foam)	Gel (agar, gelatine jelly, opal)	Solid sol (jewel, gemstone)

Properties of disperse systems

	Heterogenous dispersion	Colloid dispersion	True solution
Pass through membranes	–	Semipermeabil does not pass	+
Visibility of particles	Eye, optical microscope	Electron microscope	–
Sedimentation	+	Ultracentrifu-gation	–
Thermal motion	Small	Middle	High

Properties of disperse systems

	Heterogenous dispersion	Colloid dispersion	True solution
Colligative properties	–	Small	High
Difuse	–	Slow	Fast
Optical properties	Frequently opaque	Opalescent (Tyndall effect)	Transparent
Separability	Paper filters	Membrane filters	None

Heterogenous (rough) dispersion

- **Suspension** - heterogeneous fluid containing *solid particles* that are sufficiently large for sedimentation.
- Particle size is > 1 μm
- Dispersion is made by mechanical agitation (sand in the water).
- **Aerosol** - a suspension of *liquid droplets* or a suspension of fine *solid particles* in a gas.
  - Example : smoke, air pollution, smog etc.

Heterogenous (rough) dispersion

- **Emulsion** - a mixture of two or more immiscible liquids
- one liquid (the dispersed phase) is dispersed in the other (the continuous phase).
- Prepared by shaking – oil/water (milk), water/ oil (butter).

Colloids

- Particle size 1 – 1000 nm.
- Particles have very large surface area
- Homogenous colloidal system - lyophilic dispersion.
- Heterogenic colloidal system – lyophobic dispersion

Properties of colloid solutions

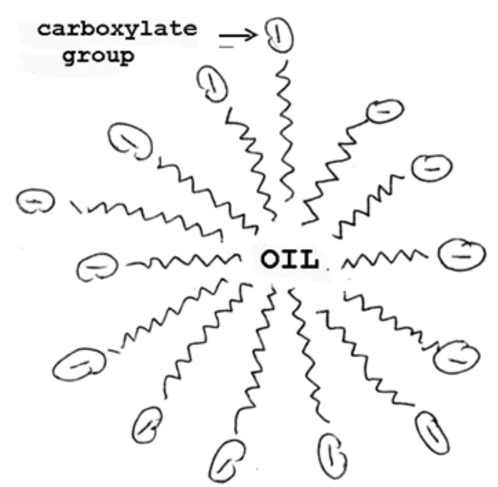
- Particles are visible only by ultramicroskop or electron microskop – Brown motion.
- They do not sedimentate, pass through common filters (but not through semipermeable membrane).
- Dispersion of passing light (Tyndall efect).
- Produce osmotic pressure.

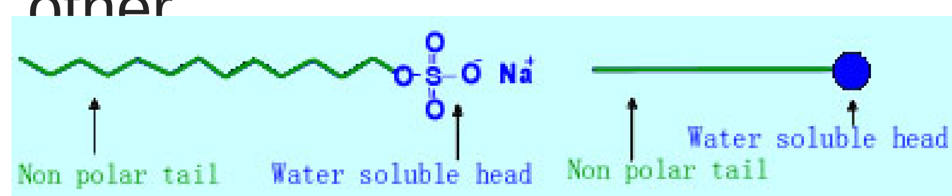
Properties of colloid solutions

- Colloids are everywhere
  - In the human body
  - Washing powder, soup, tooth paste, etc.
  - Many foods (yogurt, butter, milk)
  - Nanotechnologies are based on chemistry of colloids

Emulsions

- Stable coloidal system in which both phases are liquids (water and oil)
- Miscible liquid form a *solution*
- Lyophobic colloids form an *emulsion*
- *Emulsifying agent* – substance require to form a stable emulsion
- Emulsifyin agent is surface-active, i.e.it reduce the surface tension (soap, many other detergents.





Solutions

- Types of solutions:
  - Solvent is gas (mixture of different gases)
  - Solvent is liquid
    - Gas in liquid (water solution of HCl)
    - Liquid in liquid (H_2SO_4 in the water)
    - Solid in liquid (glucose, NaCl in the water)
  - Solvent is solid – alloys like bronze (Cu and Sn)

Properties of Solutions

- A **solution** is a homogenous (uniform) mixture of two or more substances.
- A solution is composed of one or more *solutes*, dissolved in a *solvent*.
- The **solute** is a compound of a solution that is present in lesser quantity than the solvent.
- The **solvent** is the solution component that is present in the largest quantity.
- An **aqueous** solution is one in which water is the solvent.

True Solutions

- A true solution is a homogenous mixture with uniform properties throughout.
- The solute cannot be isolated from the solution by filtration.
- The particle size of the solute and solvent are about the same and both pass directly through the filter paper.
- Solute particles will not “settle out” over time.

True Solutions

- All of the molecules of solute and solvent are intimately mixed.
- The particles are in continuous motion and therefore maintain a homogenous, random distribution of solute and solvent particles.
- Volumes of solute and solvent are not additive.
  - 1 L of alcohol mixed with 1 L of water does not result in exactly 2L of solution.
  - It depends upon how the molecules “fit together”.

Solubility

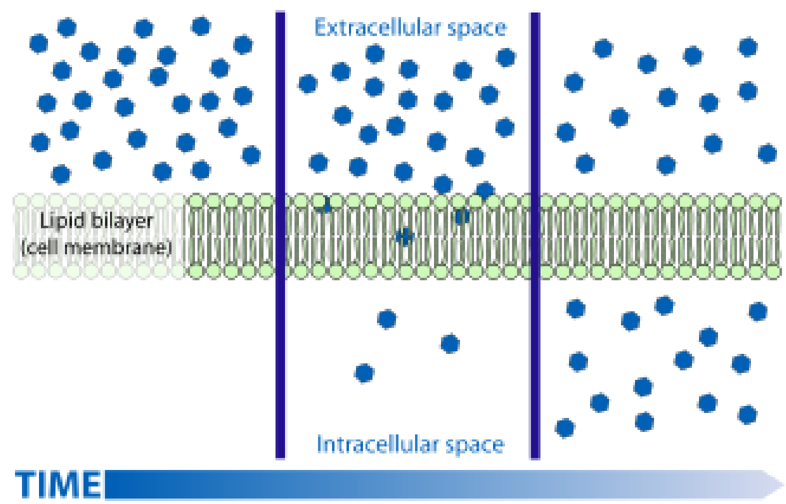
- The ability of one compound to dissolve in another compound
- *Miscible liquids* - liquid is able to completely dissolve in another liquid (ethanol, water).
- The solubility of a given solute in a given solvent typically depends on *temperature*
- Solubility of ionic compounds - there is a limit to how much salt can be dissolved in a given volume of water

Diffusion

- Diffusion is the spontaneous mixing of two substances with different concentrations over a semi-permeable membrane.
- The reason of diffusion is the thermal motion of molecules.
- The bulk of diffusion is characterized by diffusion coefficient (D)
- D = amount of diffusing substance per time unit through 1 cm^3, at a concentration gradient equal to 1 .
- Concentration gradient is

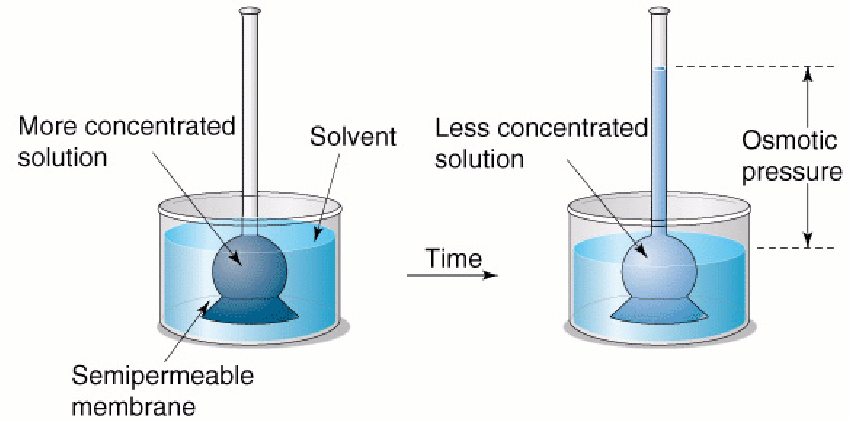
$$D = \Delta c/l$$

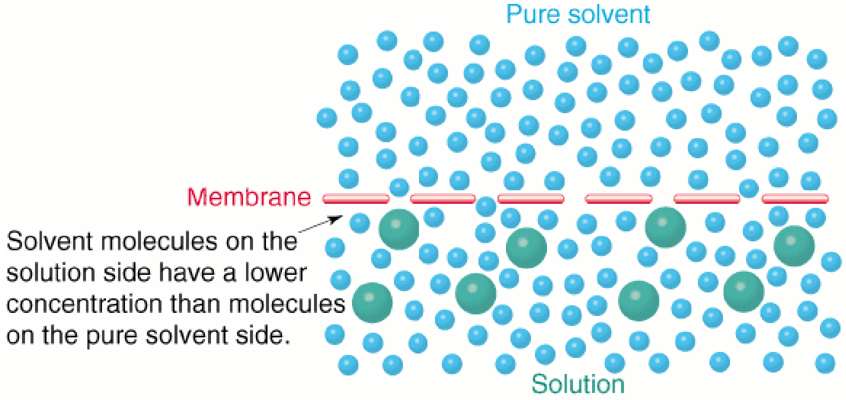
c – concentration, l - membrane thickness



Osmosis

- Two solutions of different concentrations are separated by semi-permeable membrane
- Equilibrium occurs
  - when the membrane is permeable - the substance is distributed equally
  - when the membrane is semi-permeable – the solvent moves
- **Osmotic pressure** - the pressure applied against the transfer of solvents through the membrane

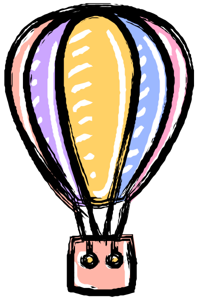




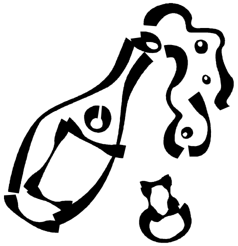
Gases and Gas Laws: Pressure, Volume, and Hot Air

Opening thoughts…

Have you ever:



Seen a hot air balloon?



Had a soda bottle spray all over you?

Baked (or eaten) a nice, fluffy cake?

These are all examples of **gases** at work!

Properties of Gases

You can predict the behavior of gases based on the following properties:

Pressure

Volume

Amount (moles)

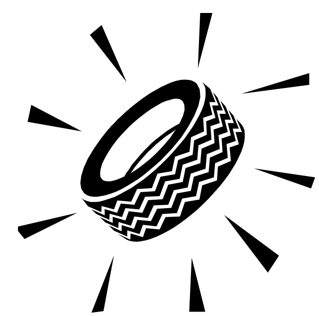
Temperature

Lets review each of these briefly…

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.

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



Pressure Units

- **<u>KEY UNITS AT SEA LEVEL</u>**

  101.325 kPa (kilopascal)

  1 atm

  760 mm Hg

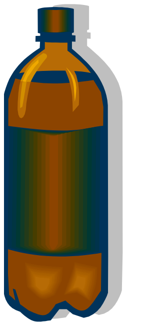
  760 torr

  14.7 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…)



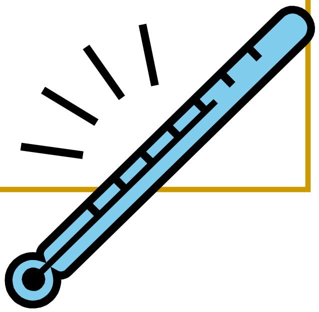
Amount (moles)

Amount of substance is tricky. As we've already learned, the SI unit for amount of substance is the mole, mol. Since we can't count molecules, we can convert measured mass (in kg) to the number of moles, n, using the molecular or formula weight of the gas.

By definition, one mole of a substance contains approximately 6.022×10^{23} particles of the substance. You can understand why we use mass and moles!

Temperature

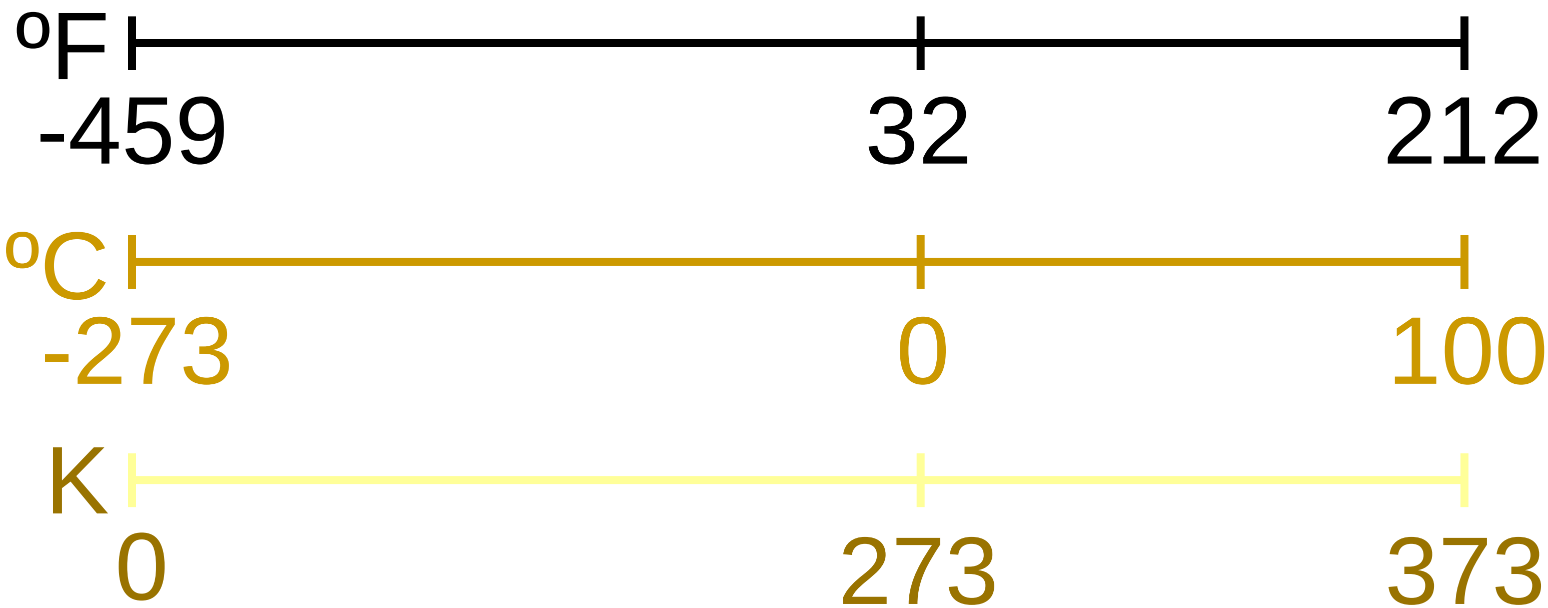
Temperature is the measurement of heat…or how fast the particles are moving. Gases, at room temperature, have a lower boiling point than things that are liquid or solid at the same temperature. **Remember**: Not all substance freeze, melt or evaporate at the same temperature.



Water will freeze at zero degrees Celsius. However alcohol will not freeze at this temperature.

Temperature (cont.)

- Always use absolute temperature (Kelvin) when working with gases.



STP: you need to memorize this

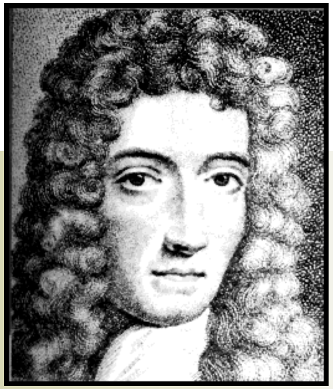
Standard Temperature & Pressure

0°C		273 K
1 atm	or	101.325 kPa

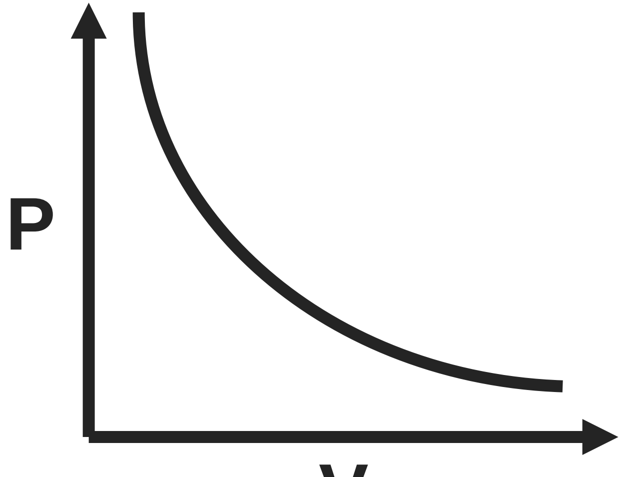
How do they all relate?

Some relationships of gases may be easy to predict. Some are more subtle. Now that we understand the factors that affect the behavior of gases, we will study how those factors interact.

Boyle’s Law



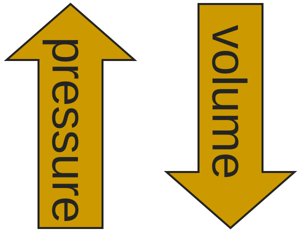
The Boyle’s Law describes the relationship between pressure and volume of gases.



$$P_1V_1 = P_2V_2$$

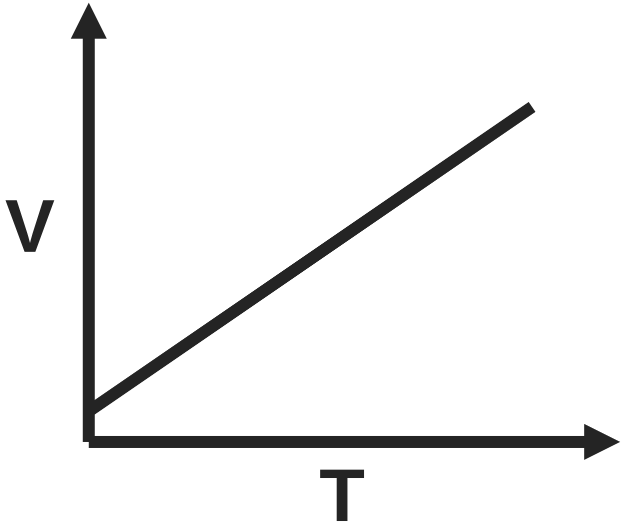
Boyle's Law

- This law is named for Charles Boyle, who studied the relationship between **pressure**, p, and **volume**, V, in the mid-1600s.
- Boyle determined that for the same **amount** of a gas at constant **temperature,** results in an **inverse relationship**: when one goes up, the other comes down.



Charles' Law

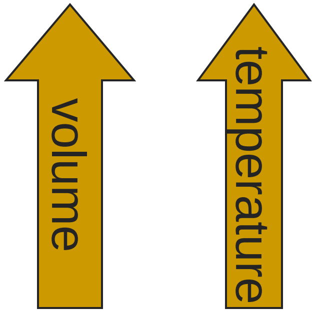
The Charles' Law describes the relationship between volume and temperature of gases.



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

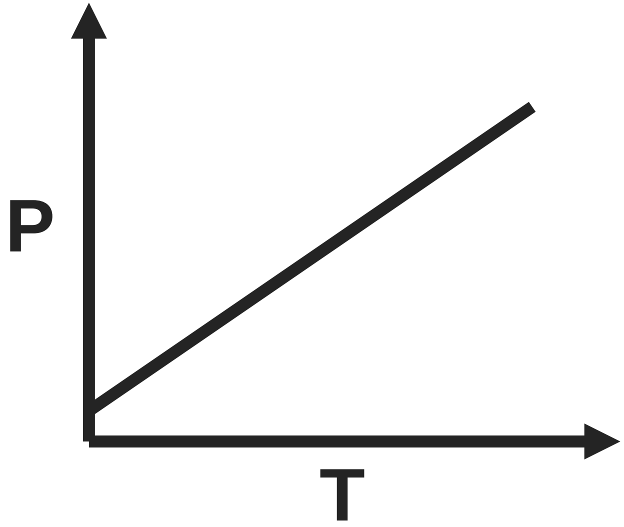
Charles' Law

- This law is named for Jacques Charles, who studied the relationship **volume**, V, and **temperature**, T, around the turn of the 19th century.
- This defines a direct relationship: With the same amount of gas he found that as the volume **increases** the temperature also **increases**. If the temperature **decreases** than the volume also **decreases**.



Gay-Lussac's Law

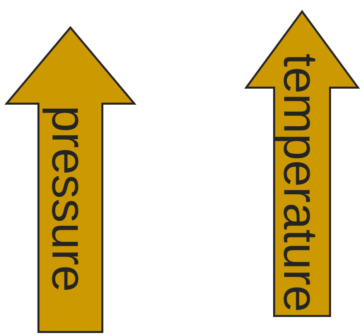
The pressure and absolute temperature (K) of a gas are directly related at constant mass & volume.



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

What does it mean?

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



Combined Gas Law

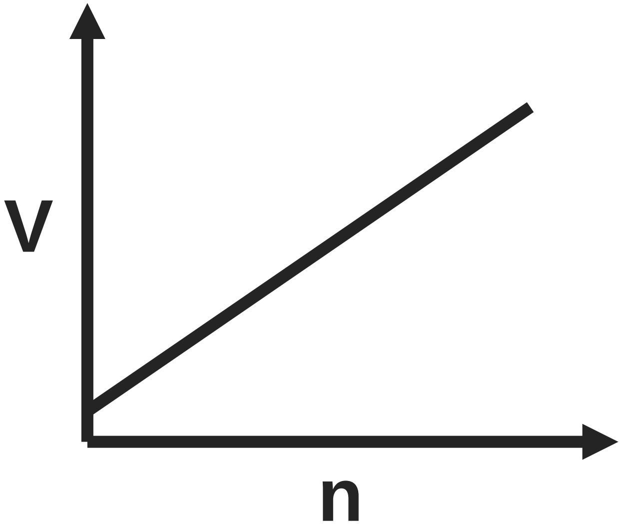
- It is a law that *combines* the previous laws into one.

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

$$P_1V_1T_2 = P_2V_2T_1$$

Avogadro's Principle

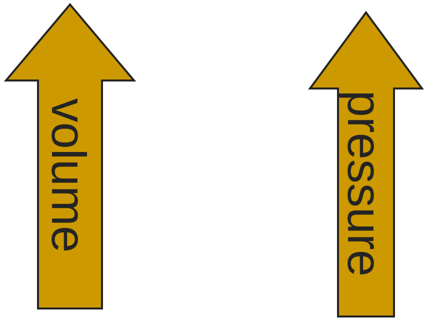
- Equal volumes of gases contain equal numbers of moles
  - at constant temp & pressure
  - true for any ideal gas



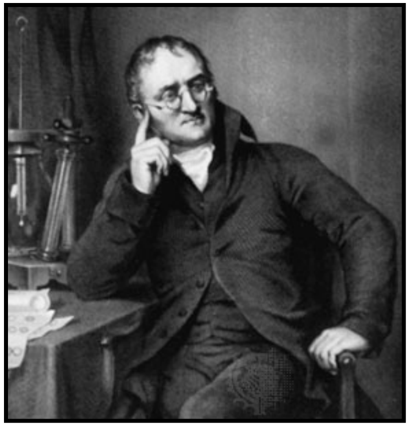
$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

What does it mean?

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



Dalton's Law of Partial Pressures



The total pressure of a mixture of gases equals the sum of the partial pressures of the individual gases.

$$P_{total} = P_1 + P_2 + \ldots$$

Ideal Gas Law

$$PV = nRT$$

- UNIVERSAL GAS CONSTANT
  - R=0.08206 L·atm/mol·K
  - R=8.315 dm^3·kPa/mol·K