LO: Students will be able to identify the relationships between volume, pressure, and temperature of gases.

DOL: Students will be able to properly determine the relationships between V, P, and T using gas laws at least 4/5 times.

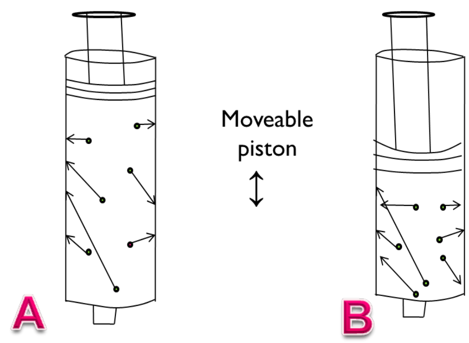
Boyle's Law

Boyle's Law – at **constant temperature**, the volume of the gas increases as the pressure decreases. The volume of the gas decreases and the pressure increases.

V↑ P↓

$P_1V_1 = P_2V_2$

If you squeeze a gas sample, you make its volume smaller.



Same temperature

Volume is 100 mL at 25°C

Volume is 50 mL at 25°C

In which system is the pressure higher? (Which has the greater number of collisions with the walls and each other?)

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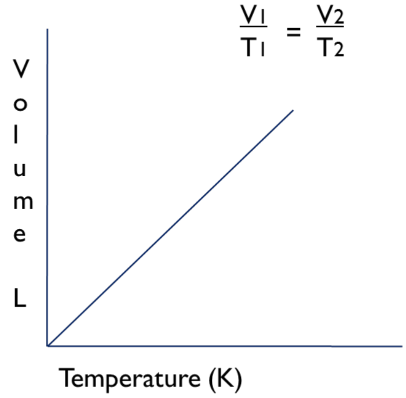
Charles' Law

Charles' Law – at a **constant pressure**, the volume of a gas increases as the temperature of the gas increases and the volume decreases when the temperature decreases.

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

- increase AKE
- increase the speed of the particles
- the walls of a flexible container expand – think of hot air balloons!



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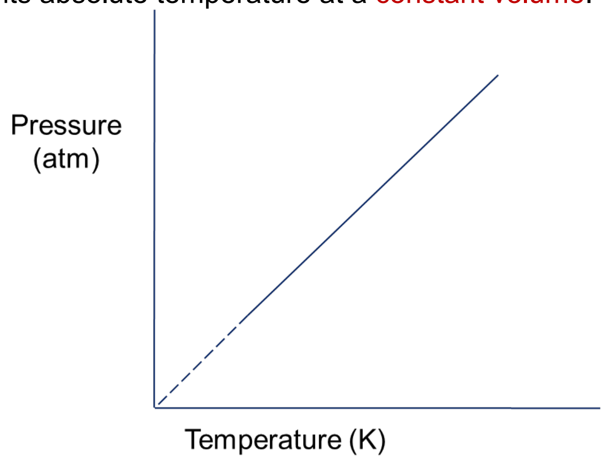
Gay-Lussac's Law

Gay-Lussac's Law – the pressure of a gas is directly proportional to its absolute temperature at a constant volume.

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



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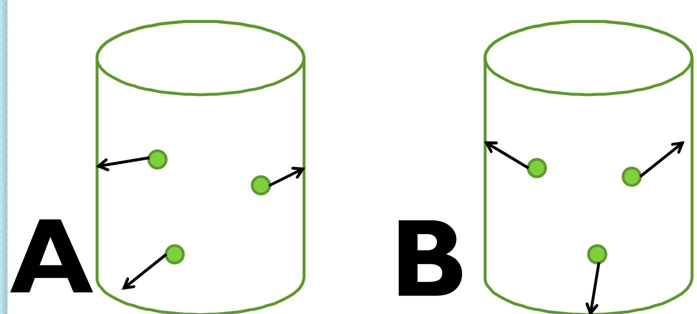

Steel cylinder (2L) contains 500 molecules of O_2 at 400 K

Steel cylinder (2L) contains 500 molecules of O_2 at 800 K

- In which system do the O2 molecules have the highest average kinetic energy?
- In which system will the particles collide with the container walls with the greatest force?
- In which system is the pressure higher?

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Combined Gas Law

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

Note that all temperatures must be in Kelvin!

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Units used to describe gas samples:

Volume	Temperature	Pressure
Liter (L)	Kelvin **ONLY**	Atmosphere (atm)
Milliliter (mL)		Kilopascale (kPa)
1000 mL = 1L		1 atm = 101.3 kPa
		1 atm = 760 mm Hg
		1 atm = 760 torr

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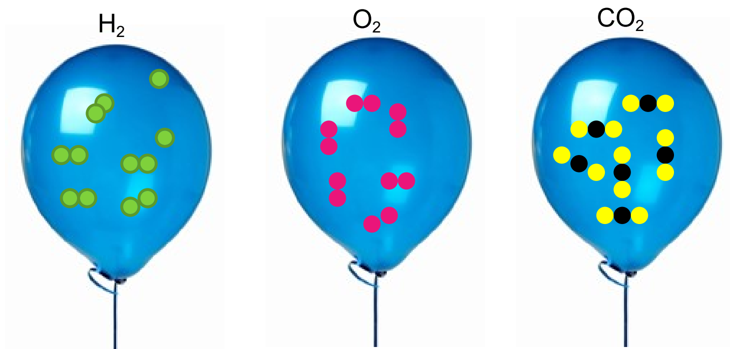
Avogadro's Law

Avogadro's Law – equal volumes of gases at the same temperature and pressure contain equal numbers of molecules.



1 mole of ANY gas takes up a volume of 22.4 L at STP.

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Two More Laws!!

Graham's Law – Particles of low molar mass travel faster than heavier particles.

Dalton's Law of Partial Pressure -

In a mixture of gases, each gas exerts a certain pressure as if it were alone. The pressure of each one of these gases is called the partial pressure. The total pressure of a mixture of gases is the sum of all of the partial pressures.

$$P_{total} = P_A + P_B + P_C$$

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And one more formula....

Ideal Gas Equation:

$$PV = nRT$$

n = mols

R = gas constant aka molar gas constant aka universal gas constant aka ideal gas constant

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Values of R [1]	Units (V P T $^{-1}$ n^{-1})
8.314 4598(48)	J K^{-1} mol^{-1}
8.314 4598(48) × 10^7	erg K^{-1} mol^{-1}
8.314 4598(48) × 10^{-3}	amu $(km/s)^2$ K^{-1}
8.314 4598(48)	L kPa K^{-1} mol^{-1}
8.314 4598(48) × 10^3	cm^3 kPa K^{-1} mol^{-1}
8.314 4598(48)	m^3 Pa K^{-1} mol^{-1}
8.314 4598(48)	cm^3 MPa K^{-1} mol^{-1}
8.314 4598(48) × 10^{-5}	m^3 bar K^{-1} mol^{-1}
8.314 4598(48) × 10^{-2}	L bar K^{-1} mol^{-1}
62.363 577(36)	L Torr K^{-1} mol^{-1}
1.987 2036(11)	cal_{th} K^{-1} mol^{-1}
0.082057338(47)	L atm K^{-1} mol^{-1}
82.057338(47)	cm^3 atm K^{-1} mol^{-1}

Commonly used are:

8.314 L kPa K^{-1} mol^{-1}

0.08206 L atm K^{-1} mol^{-1}

62.36 L mm Hg K^{-1} mol^{-1}

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