Gas Pressure

- Gas pressure is the total force due to particle collisions with the walls of the container at an instant in time divided by the area of the walls.
- The total force of collisions is determined by
  - The number of collisions
  - The average force per collision

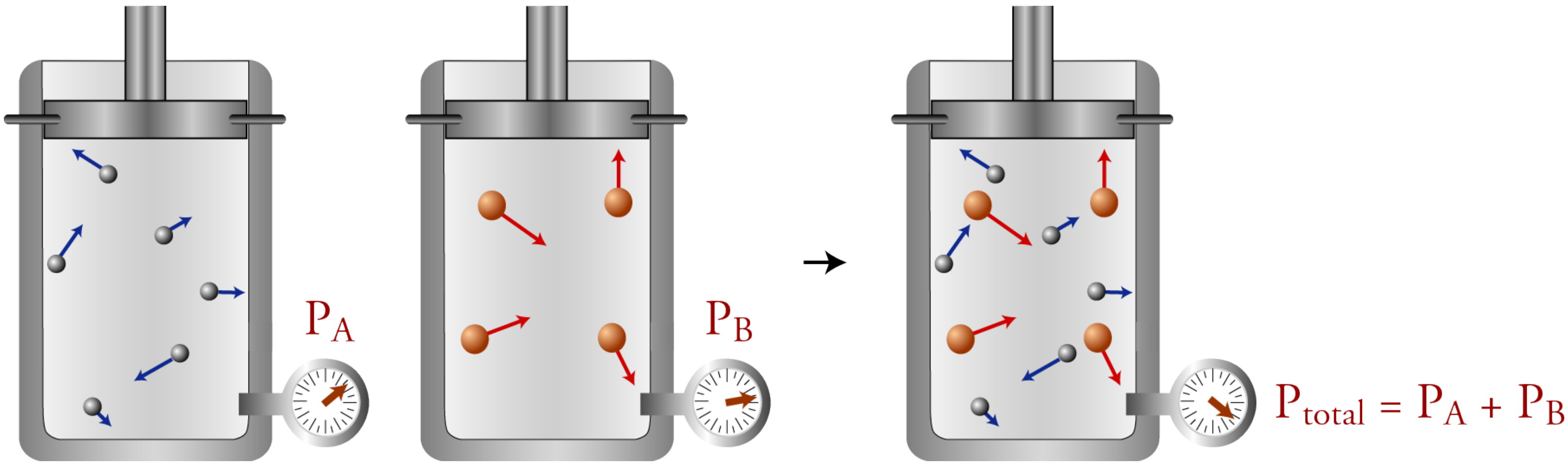
Force per Collision

- The force per collision is proportional to the momentum of the colliding particle.
- Momentum is mass times velocity.
- At a constant temperature, the mass and average velocity are constant, so the average momentum is constant, so the average force per collision is constant.

Ideal Gas Assumptions

- The particles are assumed to be point-masses, that is, particles that have a mass but occupy no volume.
- There are no attractive or repulsive forces at all between the particles.

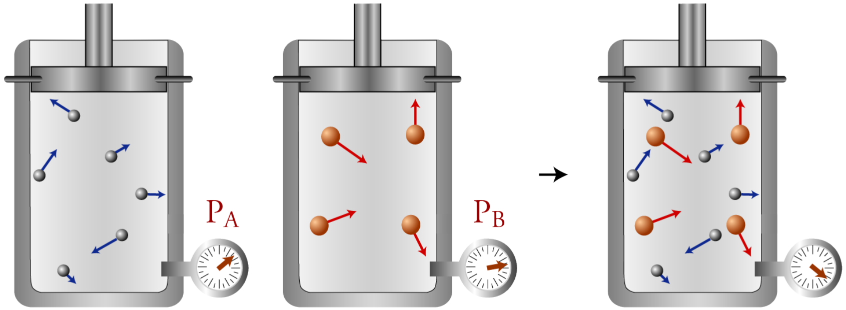
Mixture of Gases



- Partial pressure can be defined as the portion of the total pressure that one gas in a mixture of gases contributes.
- For ideal gases, this is the pressure that a gas would have if it were alone in the container.

Dalton's Law of Partial Pressures

Dalton's Law of Partial Pressures states that the total pressure of a mixture of gases is equal to the sum of the partial pressures of all the gases.



$$P_{\mathrm{total}} = P_{\mathrm{A}} + P_{\mathrm{B}}$$

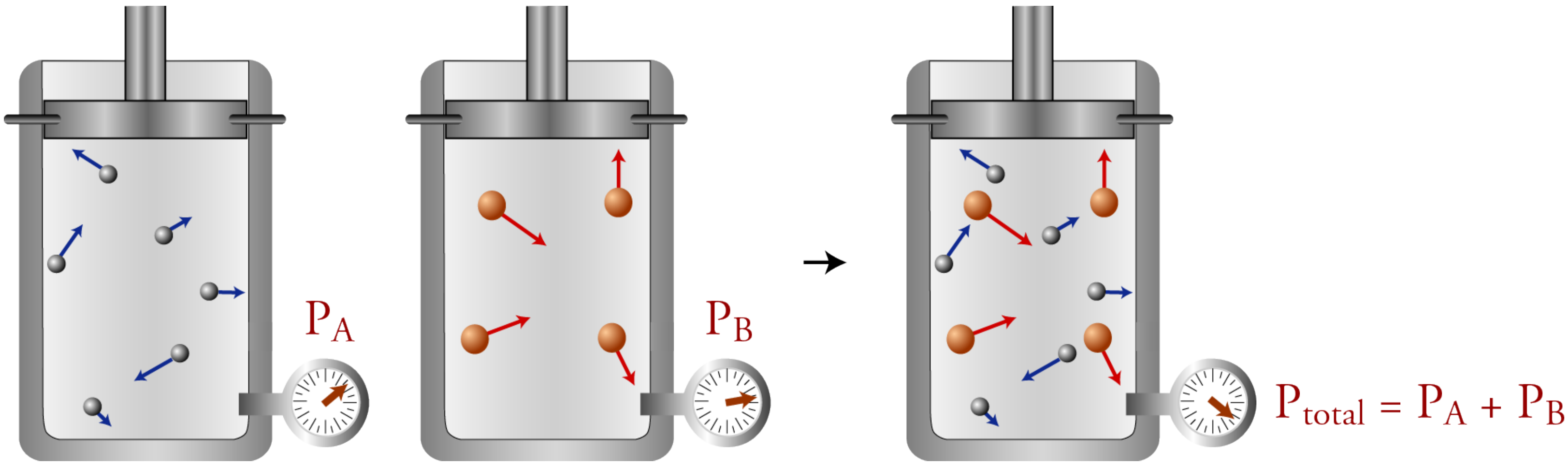
$$P_{\mathrm{A}} = \frac{n_{\mathrm{A}} R T_{\mathrm{A}}}{V_{\mathrm{A}}} \qquad P_{\mathrm{B}} = \frac{n_{\mathrm{B}} R T_{\mathrm{B}}}{V_{\mathrm{B}}}$$

$$P_{\mathrm{total}} = \frac{n_{\mathrm{A}} R T_{\mathrm{A}}}{V_{\mathrm{A}}} + \frac{n_{\mathrm{B}} R T_{\mathrm{B}}}{V_{\mathrm{B}}}$$

$$V_{\mathrm{A}} + V_{\mathrm{B}} = V \qquad T_{\mathrm{A}} + T_{\mathrm{B}} = T$$

$$P_{\mathrm{total}} = \frac{n_{\mathrm{A}} R T}{V} + \frac{n_{\mathrm{B}} R T}{V} = (n_{\mathrm{A}} + n_{\mathrm{B}}) \frac{R T}{V}$$

Dalton's Law of Partial Pressures



$$P_{total} = \Sigma P_{partial} \quad \text{or} \quad P_{total} = (\Sigma n_{\text{each gas}})\frac{RT}{V}$$

Dalton’s Law of Partial Pressures Problems

- **Tip-off –** The problem involves a mixture of gases and no chemical reaction. You are asked to calculate a value for one of the variables in the equations below, and you are given (directly or indirectly) values for the other variables.

Dalton's Law of Partial Pressures Problem Steps 1 & 2

- **Step 1:** Assign variables to the values that are given and the value that is unknown.
- **Step 2:** From the following equations, choose the one that best fits the variables assigned in Step 1.

$$P_{\text{total}} = \Sigma P_{\text{partial}} \quad \text{or} \quad P_{\text{total}} = (\Sigma n_{\text{each gas}})\frac{RT}{V}$$

Dalton's Law of Partial Pressures Problem Steps 3-6

- **Step 3:** Rearrange the equation to solve for your unknown.
- **Step 4:** Plug in the values for the given properties.
- **Step 5:** Make sure that the equation yields the correct units. Make any necessary unit conversions.
- **Step 6:** Calculate your answer and report it with the correct units and significant figures.

Example 1

A typical "neon light" contains neon gas mixed with argon gas. If the total pressure of the mixture of gases is 1.30 kPa and the partial pressure of neon gas is 0.27 kPa, what is the partial pressure of the argon gas?

P_T = 1.30 kPa $\qquad$ P_{Ne} = 0.27 kPa $\qquad$ P_{Ar} = ?

$$P_T = P_{Ne} + P_{Ar}$$

$$P_{Ar} = P_T - P_{Ne} = 1.30\text{ kPa} - 0.27\text{ kPa} = 1.03\text{ kPa}$$

Example 2

If 6.3 mg of Ar and 1.2 mg Ne are added to a 375-mL tube at 291 K, what is the total pressure of the gases in kilopascals?

V = 375 mL T = 291 K P = ?

$$n_{\text{Ar}} = ?\ \text{mol Ar} = 6.3\ \text{mg Ar}\left(\frac{1\ \text{g}}{10^3\ \text{mg}}\right)\left(\frac{1\ \text{mol Ar}}{39.948\ \text{g Ar}}\right) = 0.00016\ \text{mol Ar}$$

$$n_{\text{Ne}} = ?\ \text{mol Ne} = 1.2\ \text{mg Ne}\left(\frac{1\ \text{g}}{10^3\ \text{mg}}\right)\left(\frac{1\ \text{mol Ne}}{20.1797\ \text{g Ne}}\right) = 0.000059\ \text{mol Ne}$$

$$P_{\text{total}} = (\Sigma n_{\text{each gas}})\frac{RT}{V} \qquad P_{\text{total}} = (n_{\text{Ar}} + n_{\text{N}_2})\frac{RT}{V}$$

$$P_{\text{total}} = (0.00016\ \text{mol Ar} + 0.000059\ \text{mol Ne})\left(\frac{\left(\frac{8.3145\ \text{L}\cdot\text{kPa}}{\text{K}\cdot\text{mol}}\right)(291\ \text{K})}{375\ \text{mL}}\right)\left(\frac{10^3\ \text{mL}}{1\ \text{L}}\right)$$

$$= \mathbf{1.4\ kPa}$$

Tip-offs for Gas Problems

- **Ideal Gas Equation:** 1 gas, no chemical reaction, and no changing properties.
- **Combined Gas Law Equation:** 1 gas, no chemical reaction, changing properties.
- **Gas Stoichiometry:** converting from one substance to another, both in a chemical reaction, and one or both are gases.
- **Dalton's Law of Partial Pressures:** 2 or more gases, no changing properties, no chemical reaction.