N26 – Gases

Ideal Gases and Laws

N26 – Gases

Ideal Gases and Laws

Target: **I can manipulate Gas Law equations and units to perform more complex Gas Law calculations**

Ideal Gas Law

$$PV = nRT$$

$$PV = \frac{m}{M}RT$$

- **P =** pressure in atm
- **V =** volume in liters
- **n =** moles

  = m/M; *m = mass, M = molar mass*
- **R =** proportionality constant

  = 0.08206 L·atm/ mol·K

  = 8.314 L·Kpa/ mol·K

  = 62.4 L·mmHg/ mol·K
- **T =** temperature in Kelvins

R holds closely at P < 1 atm

Molar Mass Kitty!

$$M = \frac{mRT}{PV}$$

substitute

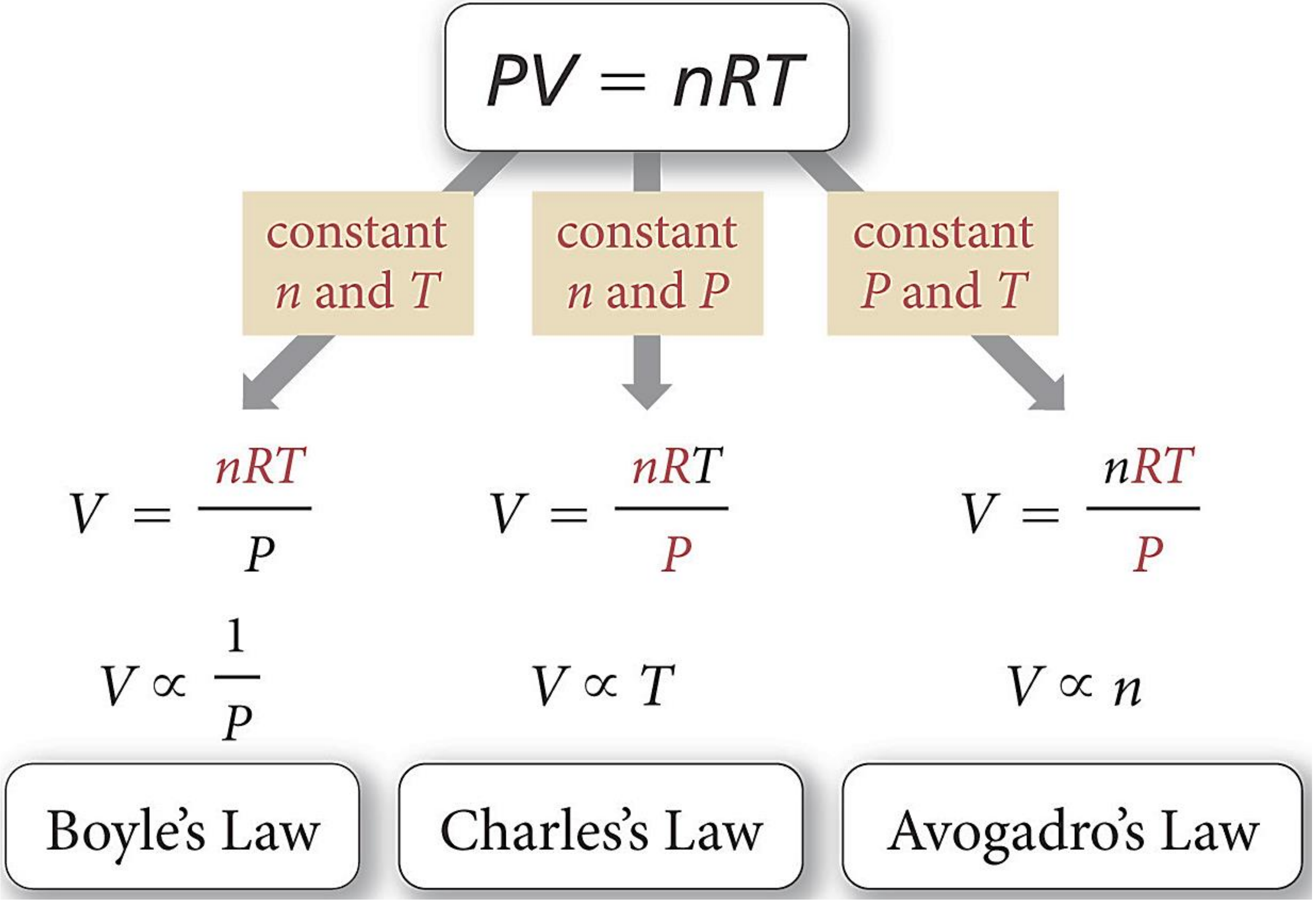
$$D = \frac{m}{V}$$

$$M = \frac{DRT}{P}$$

Molar Mass Kitty always puts DIRT over its PEE

Getting Other Gas Laws from Ideal Gas Law

If some variables are held constant then PV=nRT reduces into the other laws.

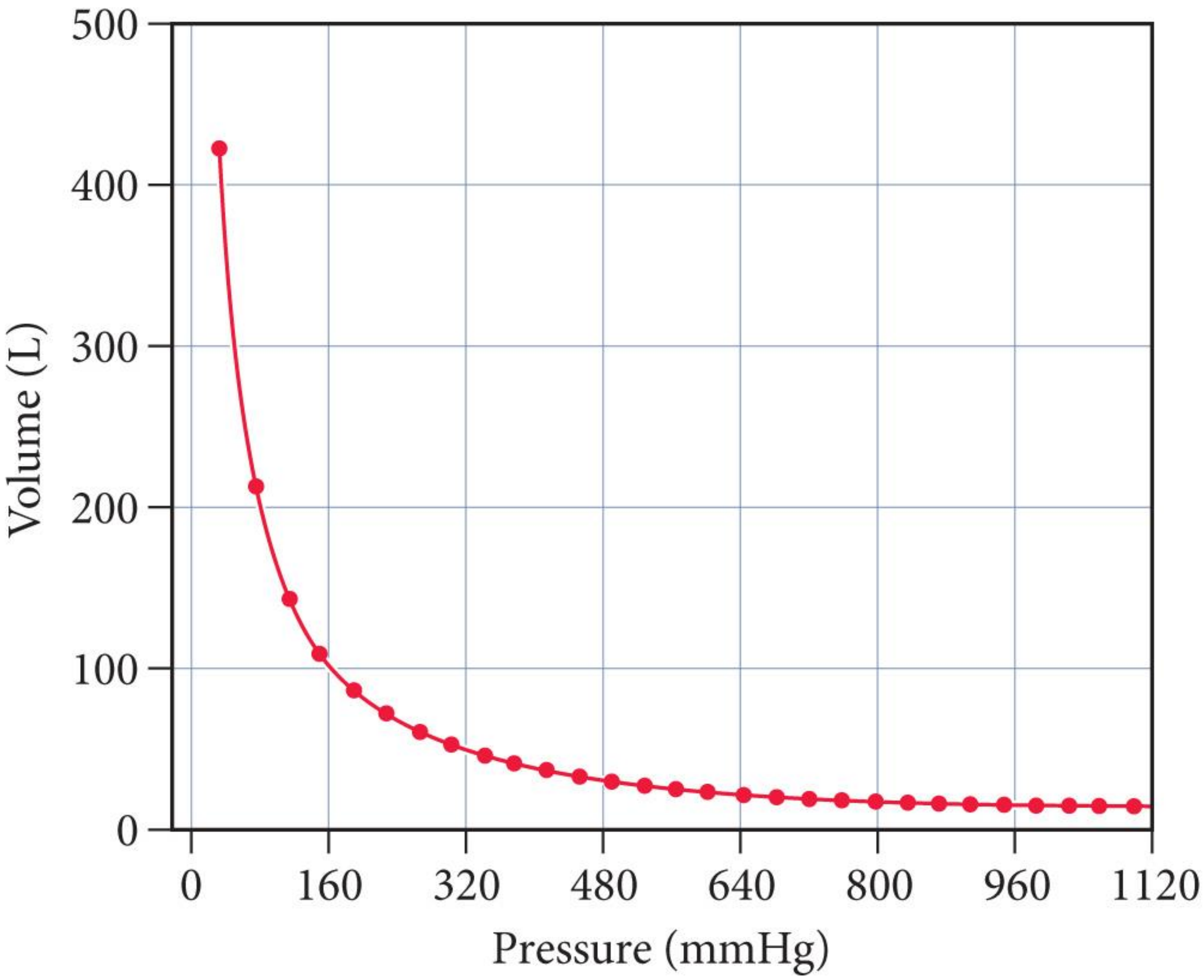


Boyle's Law

$P_1V_1 = P_2V_2$

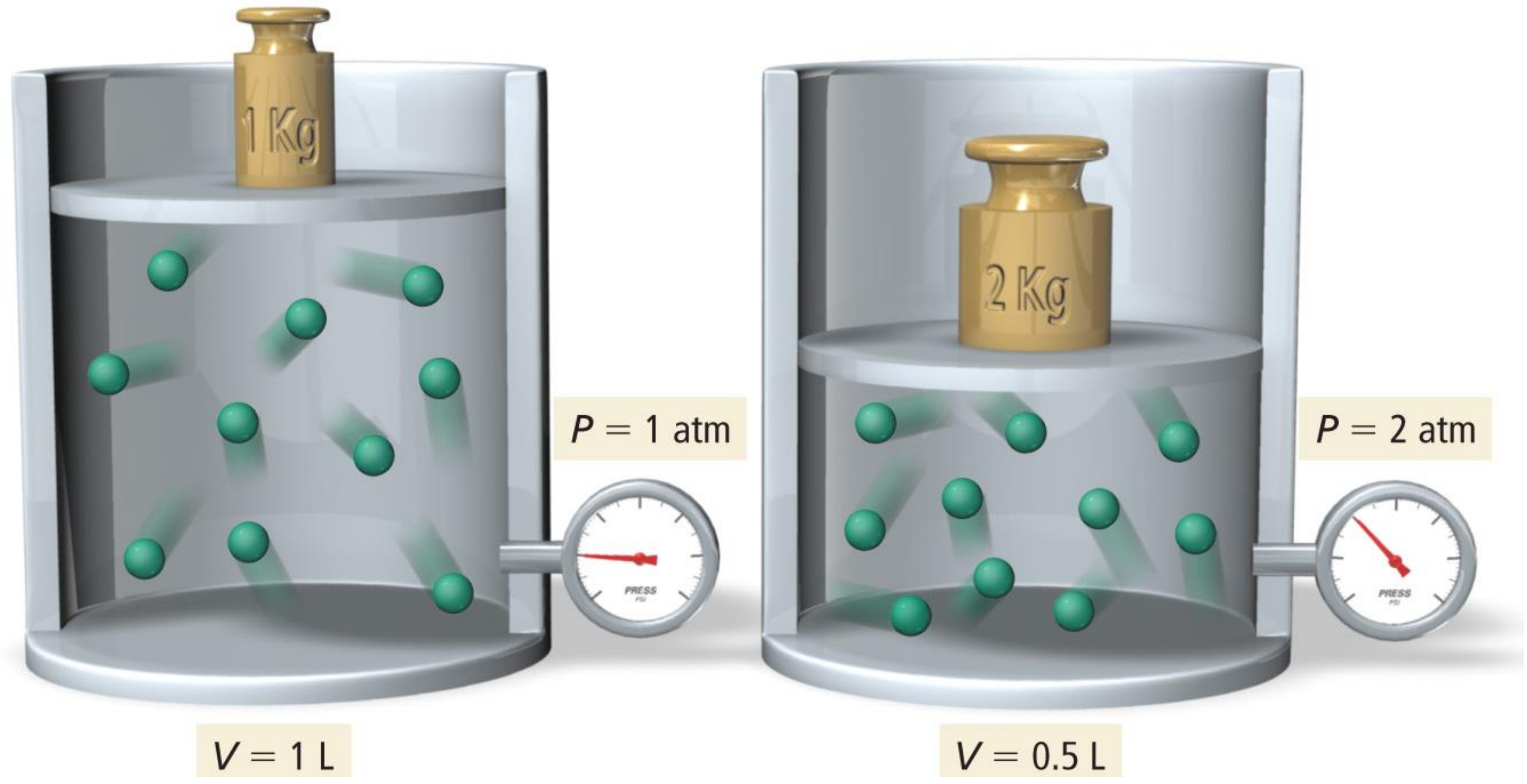
As pressure increases, volume decreases.

Indirect relationship.



Molecular Interpretation of Boyle's Law

As the volume of a gas sample is decreased, gas molecules collide with surrounding surfaces more frequently, resulting in greater pressure.

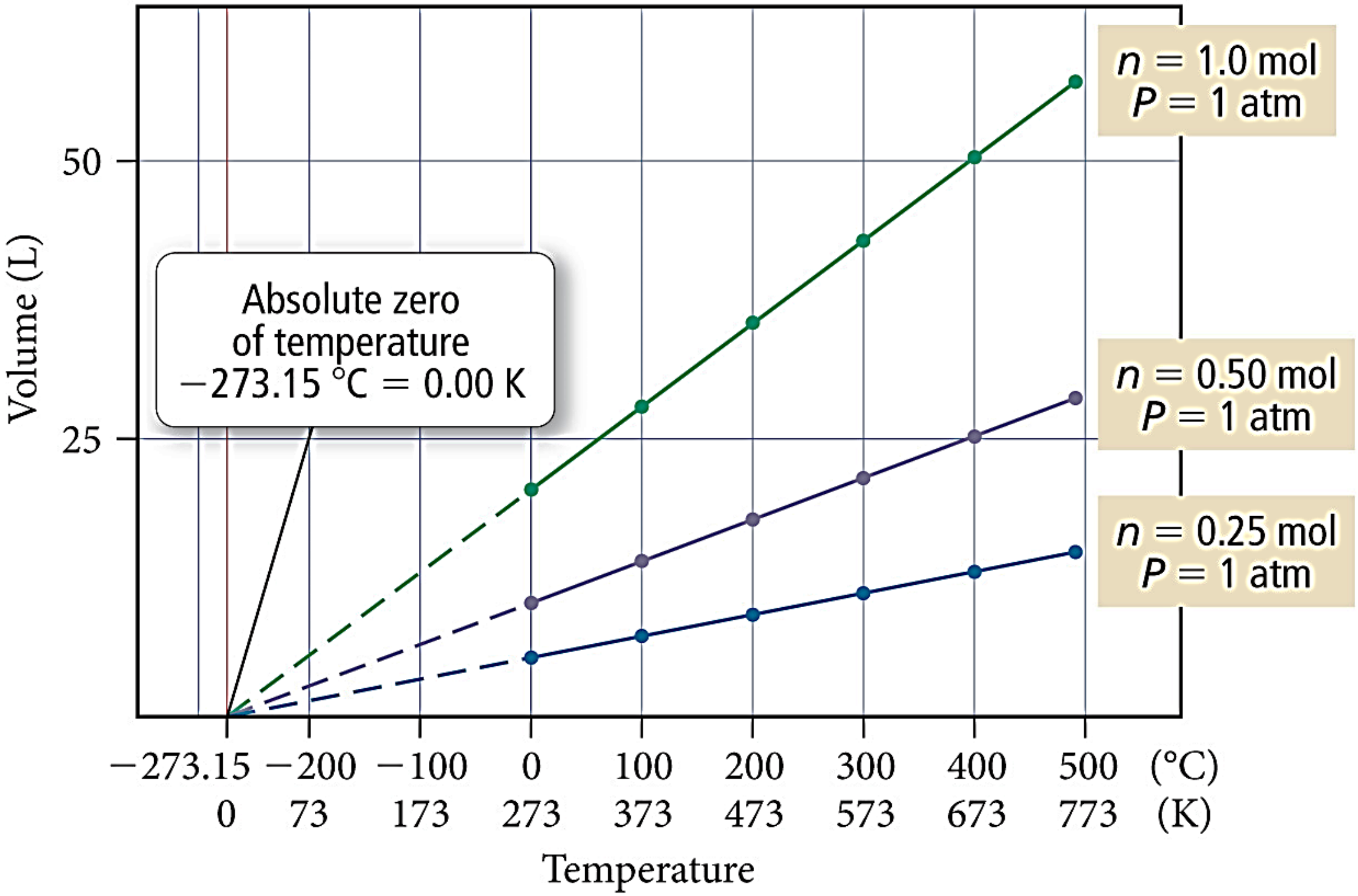


Charles's Law

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

As temperature increases, volume increases.

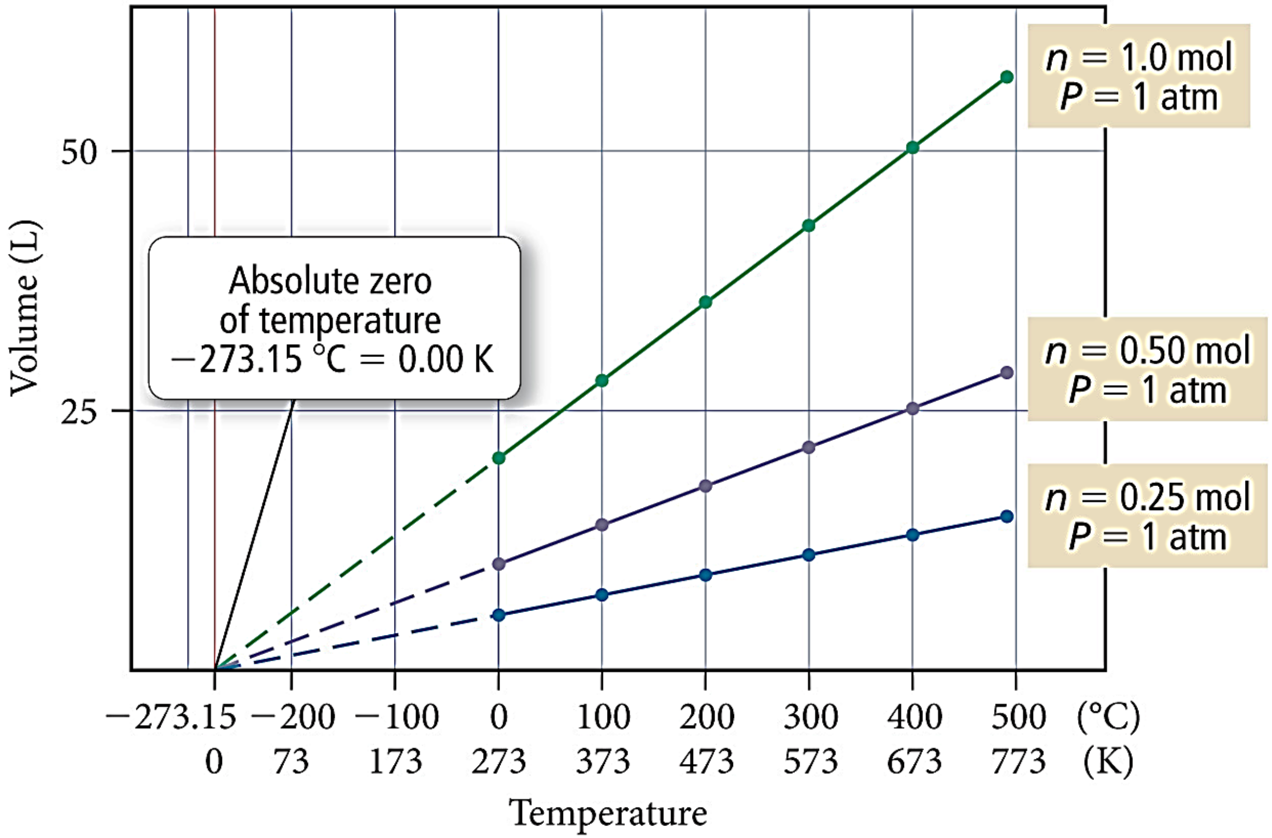
Direct relationship.



Charles's Law

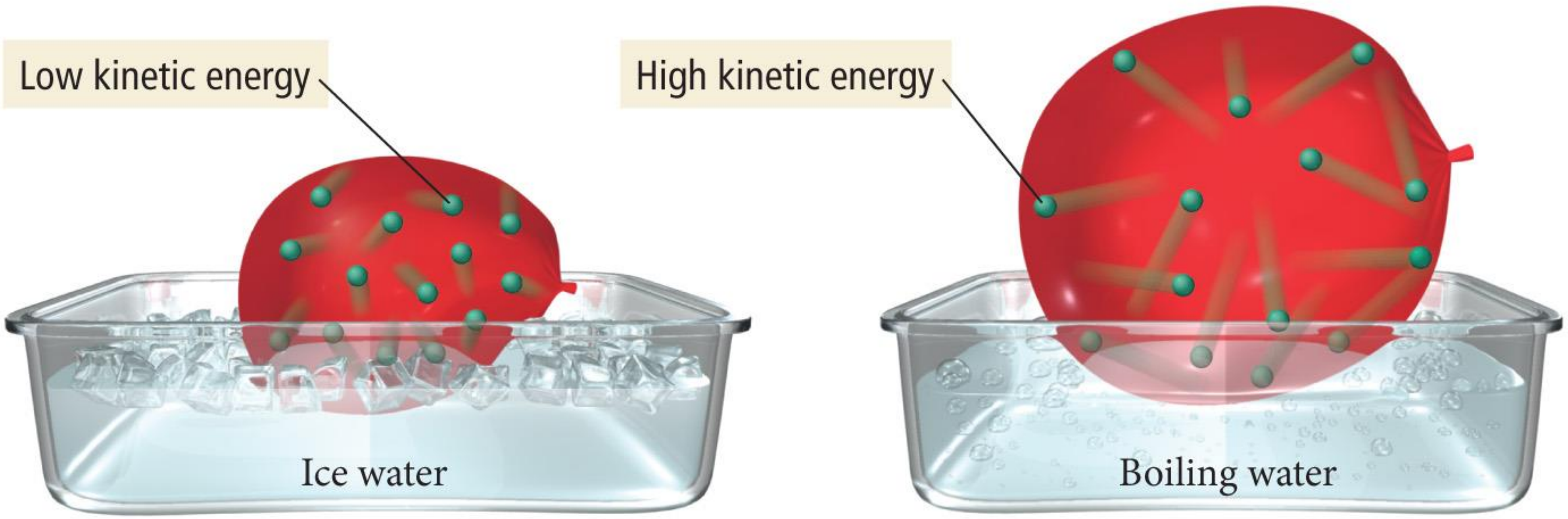
$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

If the lines are extrapolated back to a volume of "0," they all show the same temperature, −273.15 °C = 0 K, called **absolute zero**



The extrapolated lines cannot be measured experimentally because all gases condense into liquids before –273.15 °C is reached.

Molecular Interpretation of Charles's Law



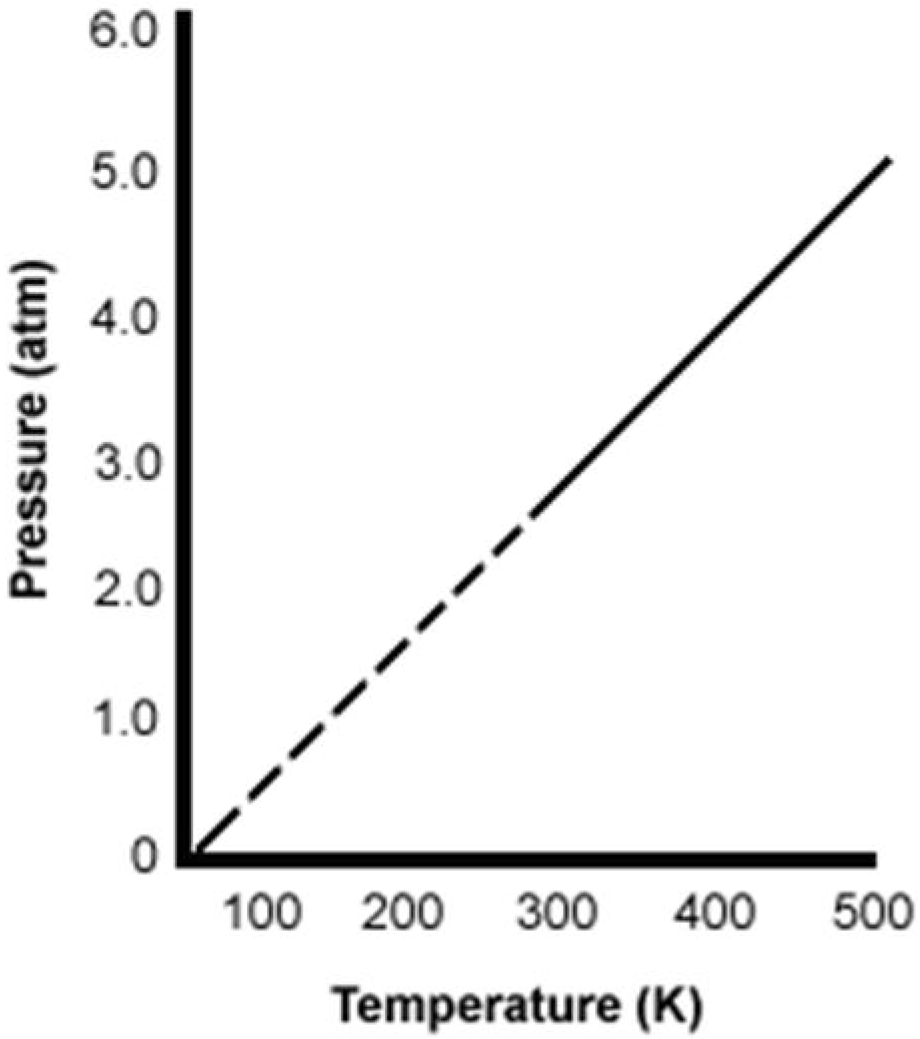
If we move a balloon from an ice water bath to a boiling water bath, its volume expands as the gas particles within the balloon move faster (due to the increased temperature) and collectively occupy more space.

Gay Lusaac's Law

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

As temperature increases, pressure increases.

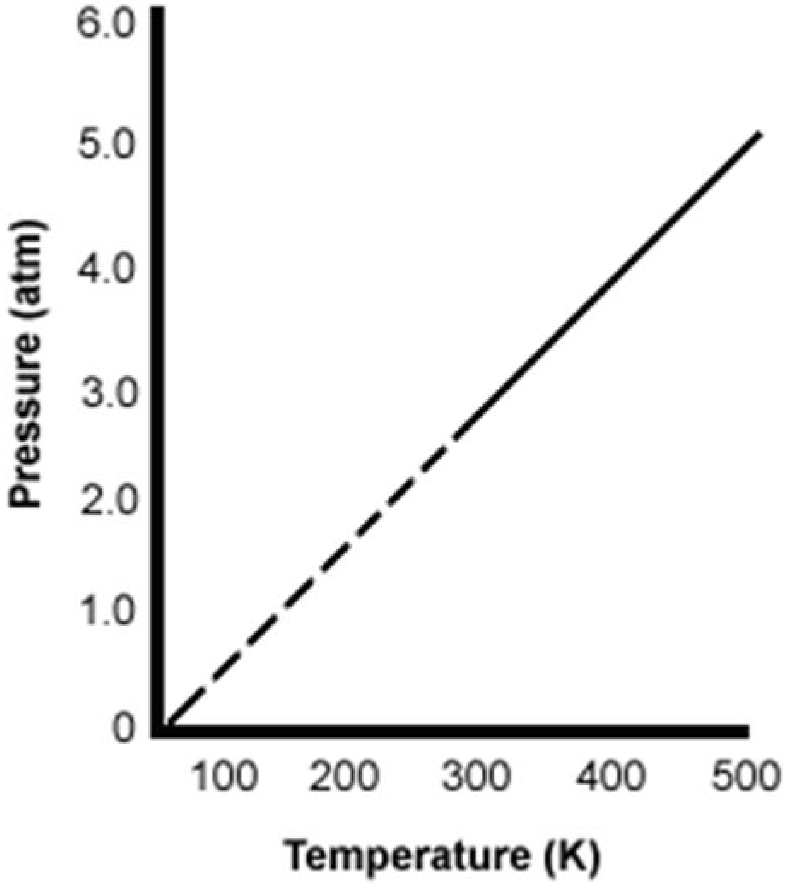
Direct relationship.



Gay Lusaac's Law

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

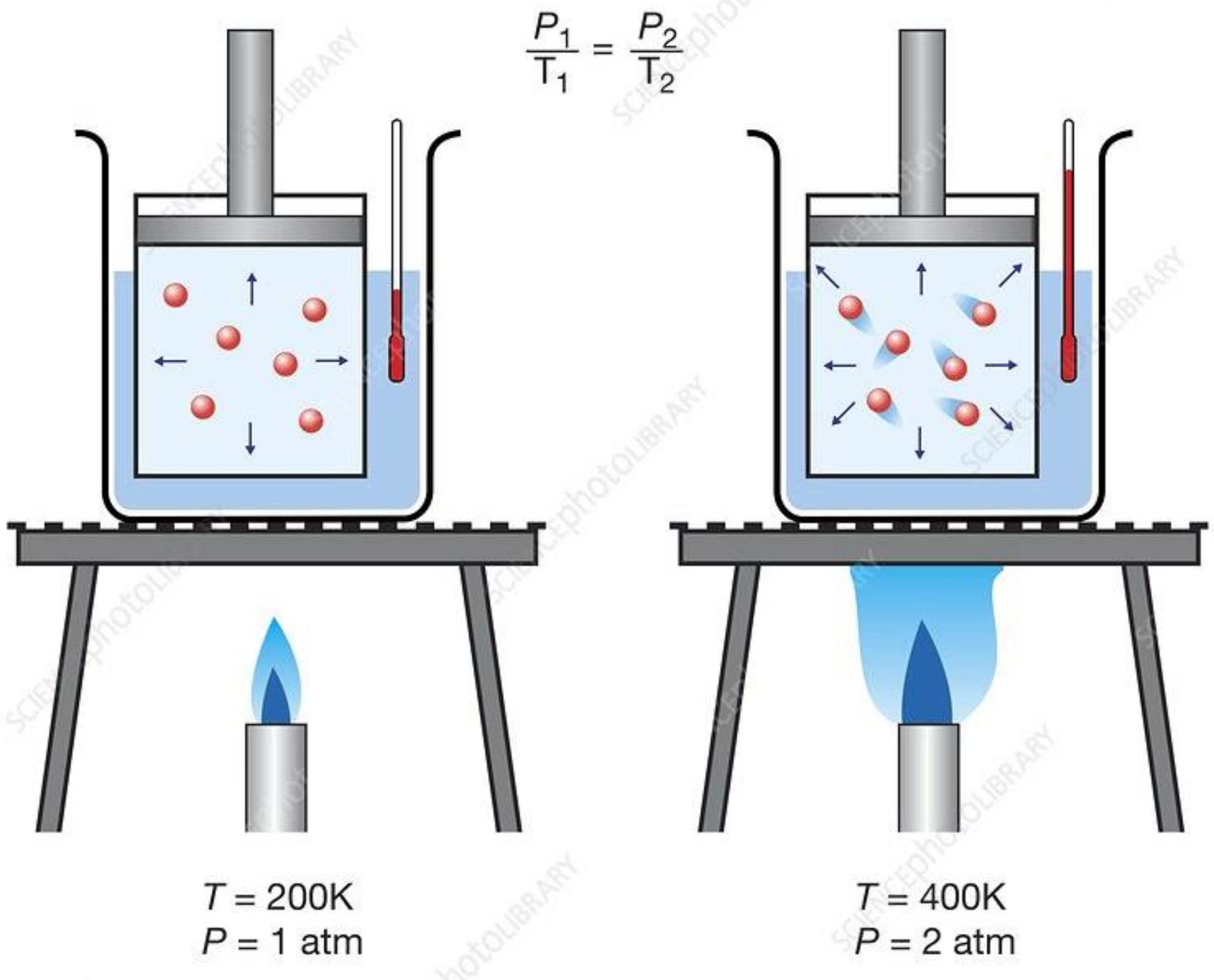
If the lines are extrapolated back to a pressure of "0," they all show the same temperature, −273.15 °C = 0 K, called **absolute zero**



The extrapolated lines cannot be measured experimentally because all gases condense into liquids before –273.15 °C is reached.

Molecular Interpretation of Gay Lusaac's Law

Increasing temperature on a constant volume container, results in the particles moving with higher KE (due to the increased temperature/speed) and therefore hit the sides of the container more often with more force, resulting in higher pressure.

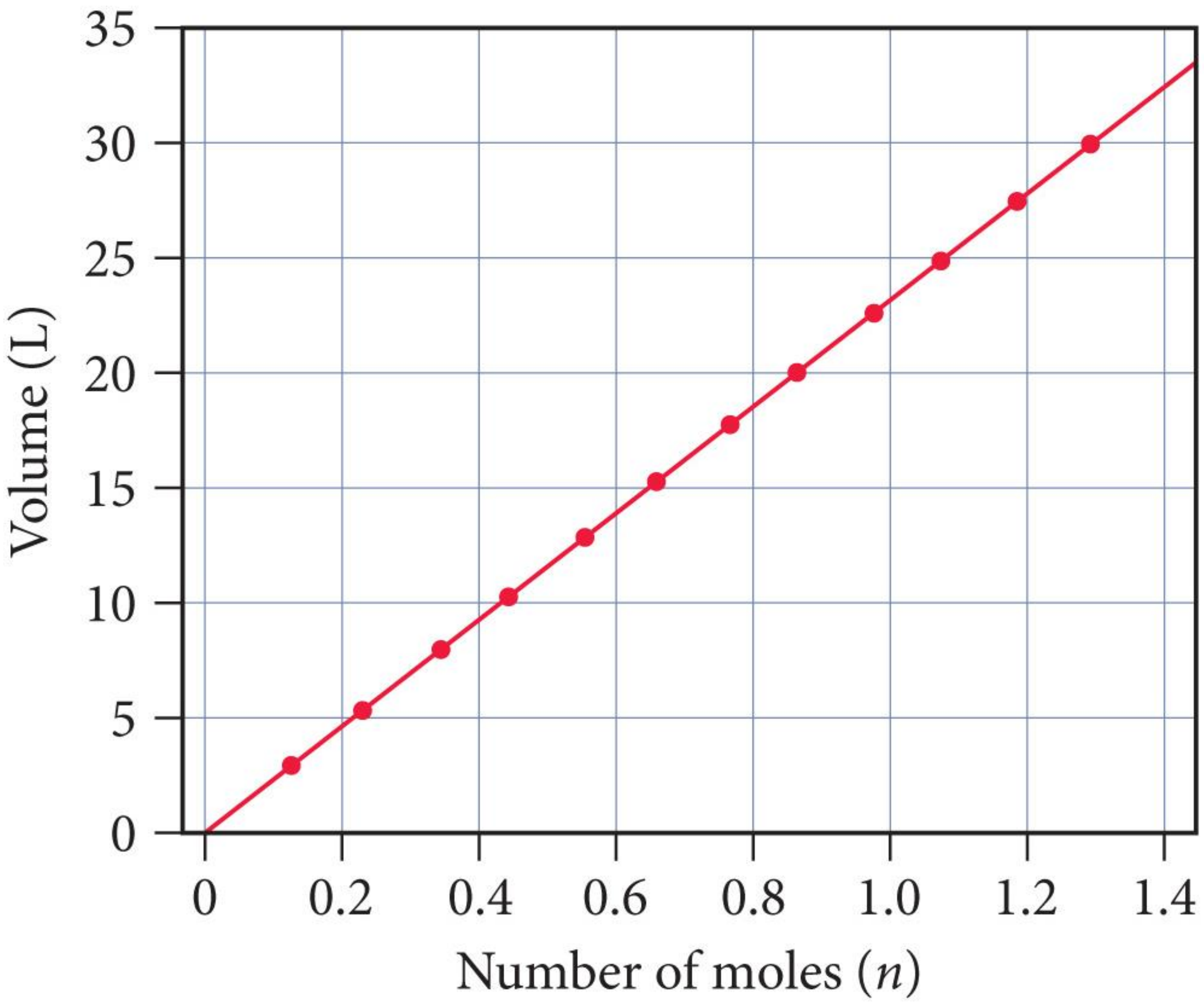


Avogadro’s Law

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

As number of moles of gas increases, volume increases.

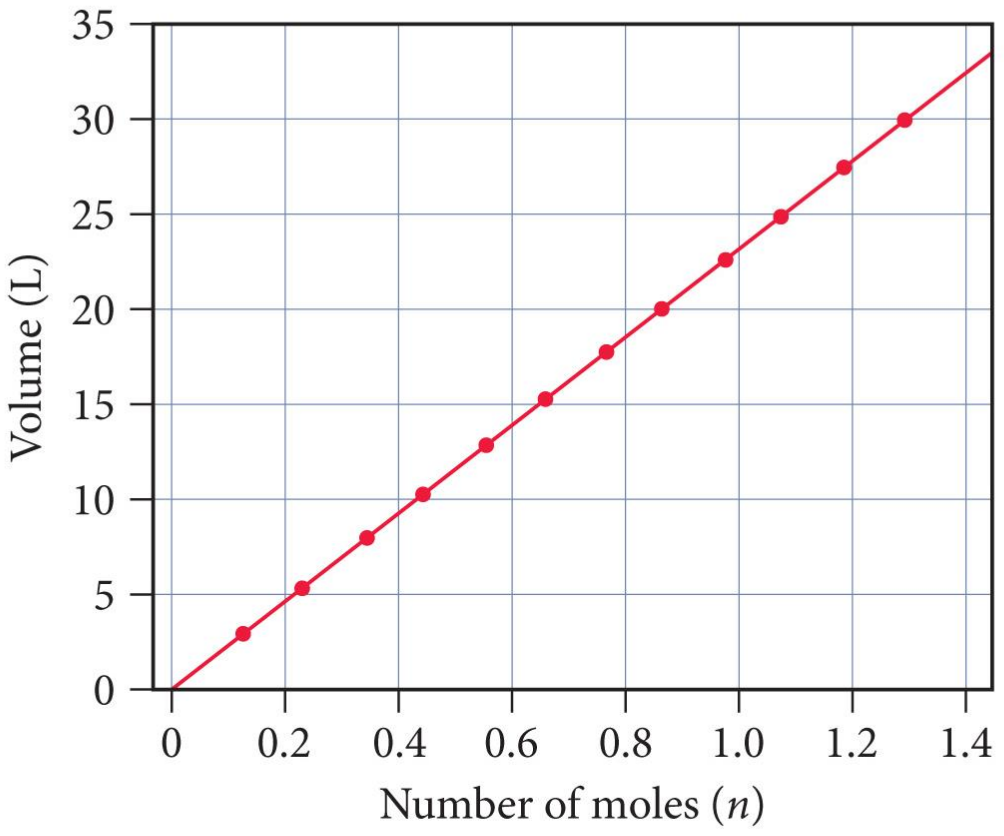
Direct relationship.



Avogadro's Law

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

When the amount of gas in a sample increases at constant temperature and pressure, its volume increases in direct proportion because the greater number of gas particles fill more space.



The volume of a gas sample increases linearly with the number of moles of gas in the sample.

Dalton's Law of Partial Pressures

$$P_{total} = P1 + P2 + P3 \ldots$$

P_{total} is the total pressure and P_1, P_2, P_3 or P_a, P_b, P_c, . . . are the partial pressures of the components.

$$= n_a \frac{RT}{V} + n_b \frac{RT}{V} + n_c \frac{RT}{V} + \ldots$$

$$= (n_a + n_b + n_c + \ldots) \frac{RT}{V}$$

$$= (n_{total}) \frac{RT}{V}$$

Mole Fraction

$$Xa = \frac{n_a}{n_{total}}$$

The ratio of the partial pressure a single gas contributes and total pressure is equal to the mole fraction.

The number of moles of a component in a mixture divided by the total number of moles in the mixture, is the mole fraction.

Mole Fraction

$$\frac{P_a}{P_{total}} = \frac{n_a(\cancel{RT/V})}{n_{total}(\cancel{RT/V})} = \frac{n_a}{n_{total}}$$

$$\chi_a = \frac{n_a}{n_{total}}$$

$$\frac{P_a}{P_{total}} = \frac{n_a}{n_{total}}$$

$$P_a = \frac{n_a}{n_{total}} P_{total} = \chi_a P_{total}$$

$$P_a = \chi_a P_{total}$$

Mole Fraction

The partial pressure of a component in a gaseous mixture is its mole fraction multiplied by the total pressure.

- **For gases, the mole fraction of a component is equivalent to its percent by volume divided by 100%.**
  - ✓ **Nitrogen has a 78% composition of air; find its partial pressure.**

$$P_{N_2} = 0.78 \times 1.00 \text{ atm}$$
$$= 0.78 \text{ atm}$$

$$P_{\text{total}} = P_{N_2} + P_{O_2} + P_{\text{Ar}}$$
$$P_{\text{total}} = 0.78 \text{ atm} + 0.21 \text{ atm} + 0.01 \text{ atm}$$
$$= 1.00 \text{ atm}$$

YouTube Link to Presentation:

https://youtu.be/OcGpbumMNug