Kinetic Molecular Theory

Auburn Mountainview

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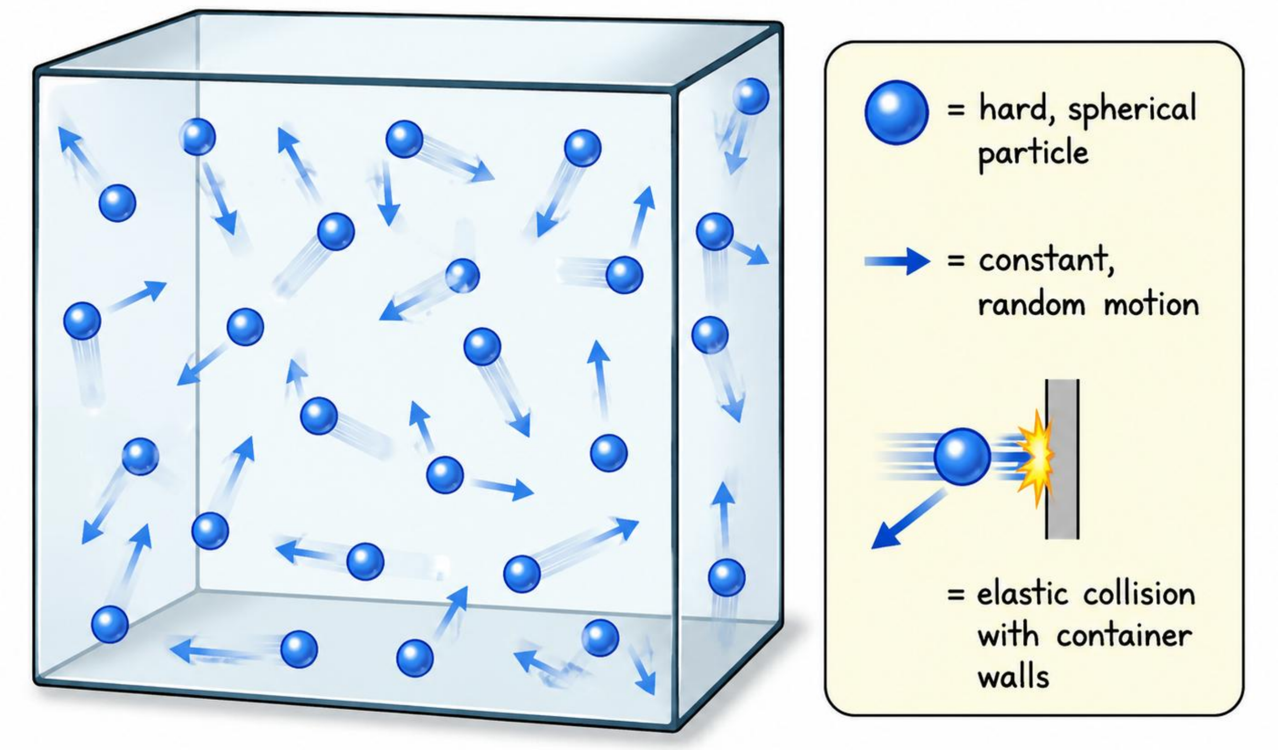
By end of this unit I can…

- **A.1 Create and/or evaluate models that illustrate how a gas exerts pressure.**
- **A.2 Explain the relationship between pressure in a gas and collisions.**
- **B.1 Explain the relationships between the macroscopic properties of a sample of a gas using the kinetic molecular theory.**
- **B.2 Create and/or evaluate models that illustrate how a sample of gas responds to changes in macroscopic properties.**
- **C.1 Determine mathematically and/or graphically the quantitative relationship between macroscopic properties of gases.**
- **C.2 Perform calculations relating to the macroscopic properties of gases.**

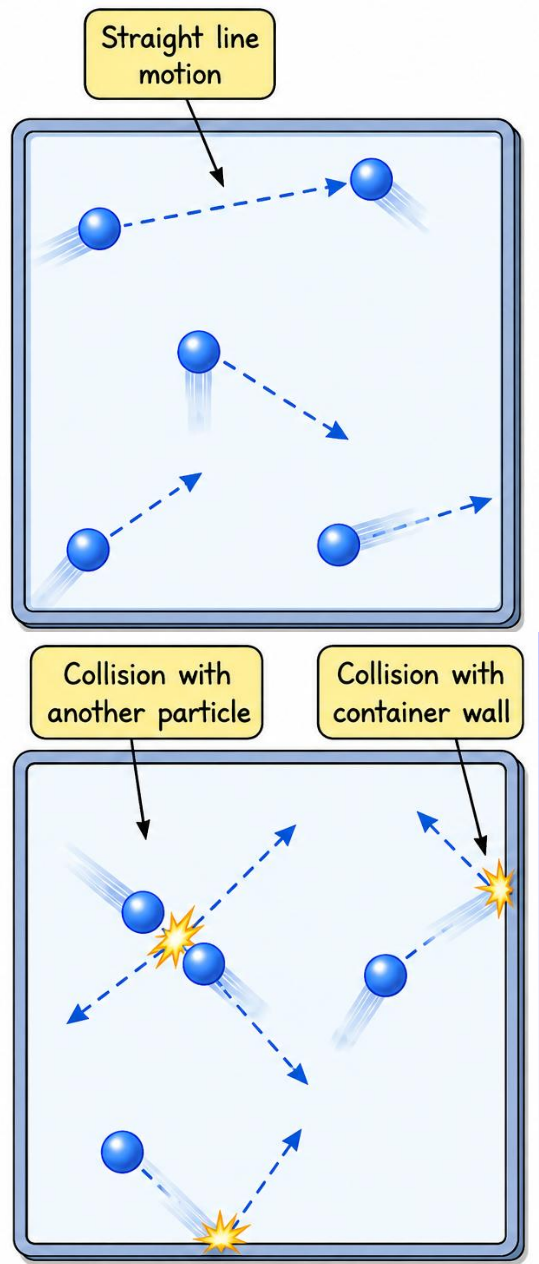
Kinetic Molecular Theory

1. Gases are composed of a large number of particles that behave like hard, spherical objects in a state of constant, random motion.



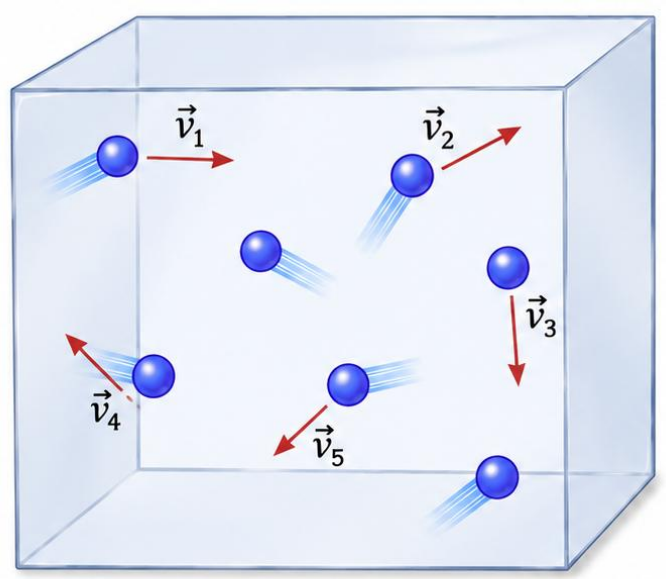
Kinetic Molecular Theory

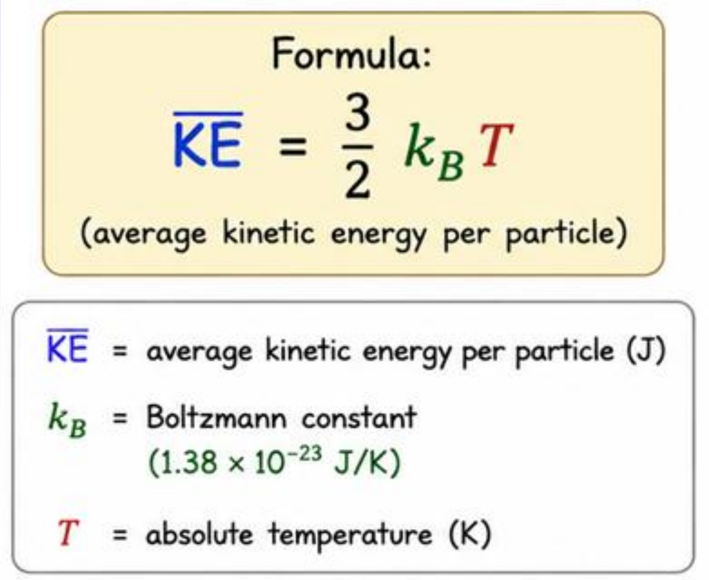
2. These particles move in a straight line until they collide with another particle or the walls of the container.
3. These particles are much smaller than the distance between particles. Most of the volume of a gas is therefore empty space.



Kinetic Molecular Theory

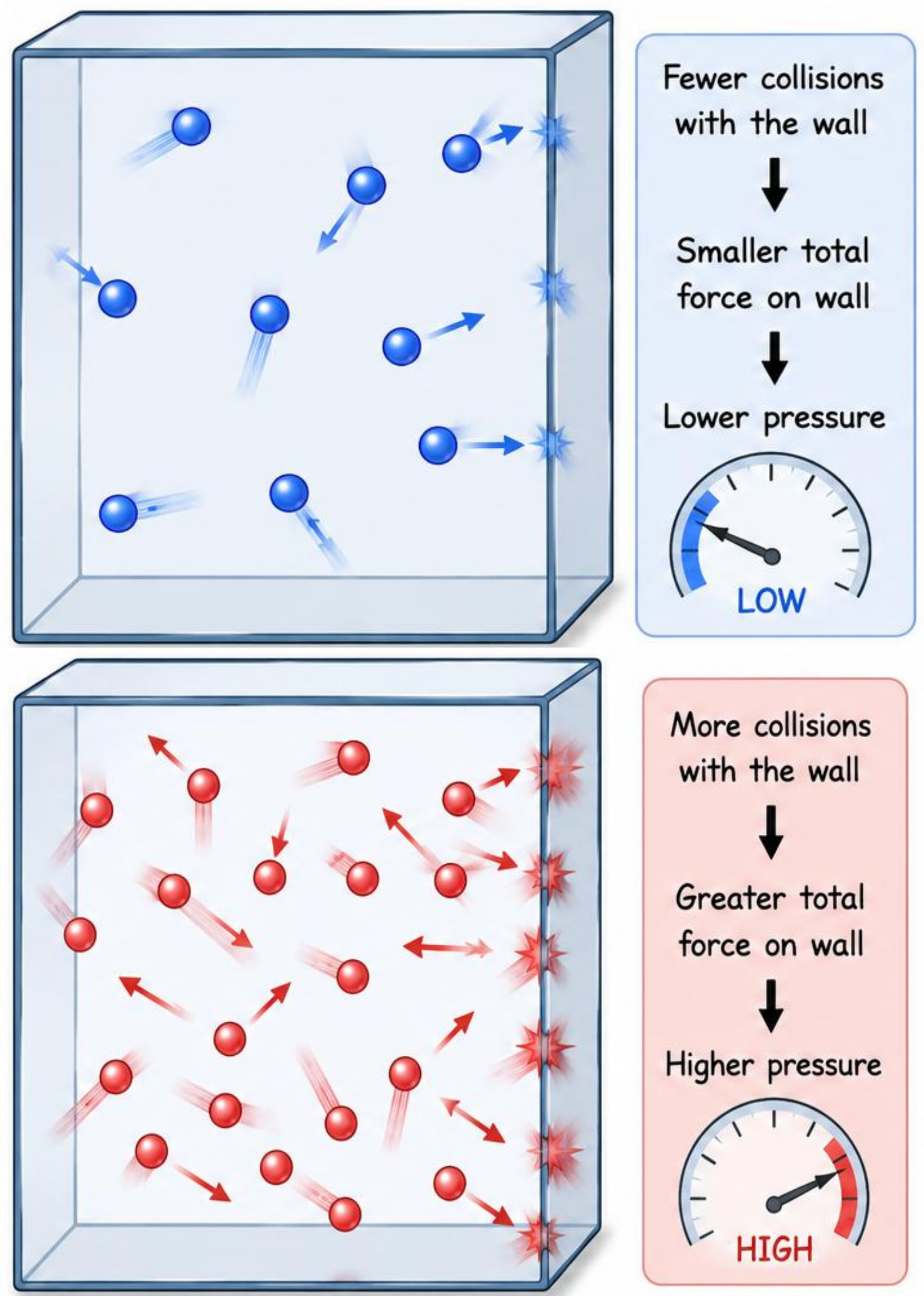
4. There is no force of attraction between gas particles or between the particles and the walls of the container.
5. The average kinetic energy of a collection of gas particles depends on the temperature of the gas and nothing else.





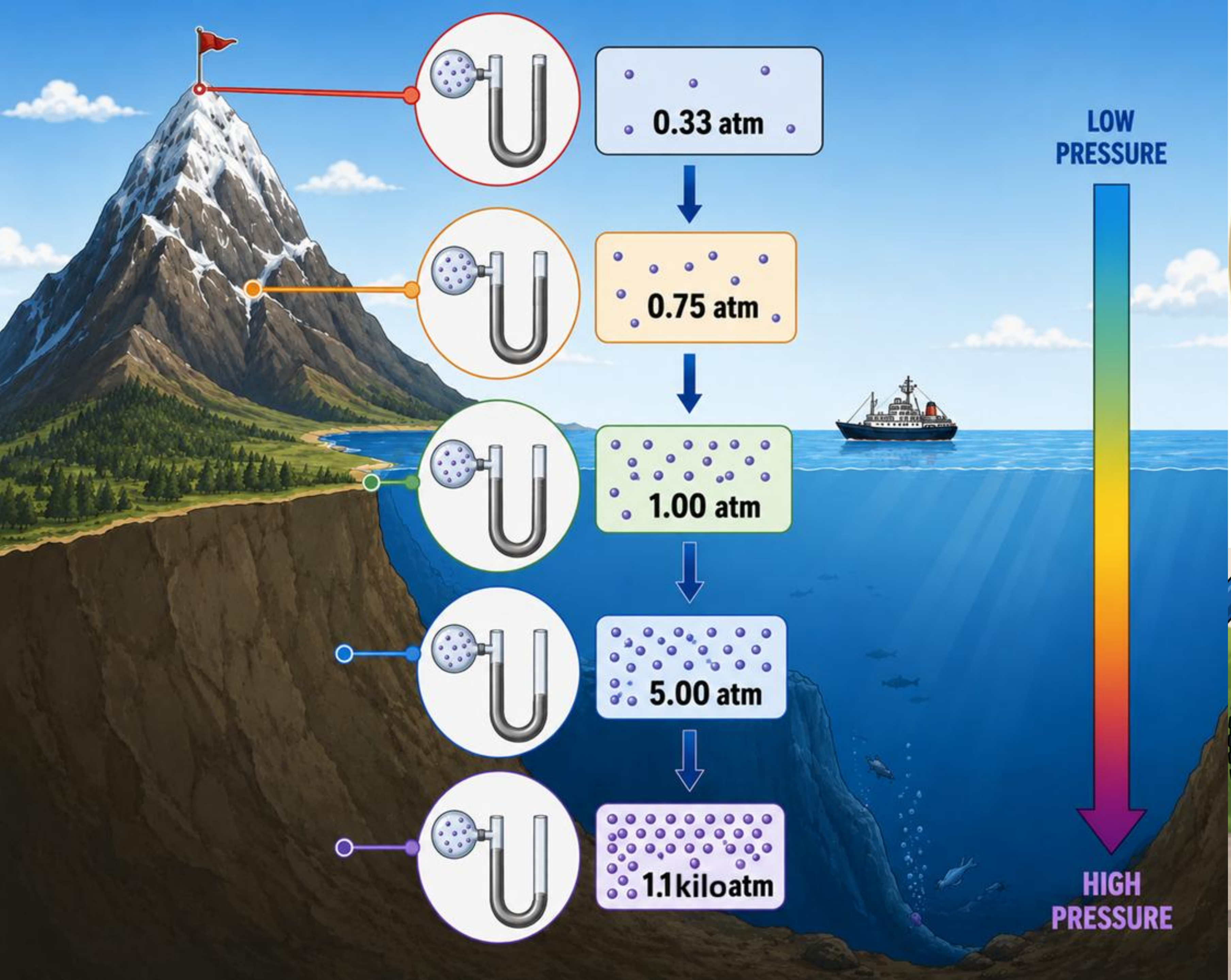
Pressure

- Collisions with a wall impart a force.
  - Faster particles hit harder.
  - Faster particles hit more often.
  - More particles hit more often.
  - Smaller container increate hits.
- Quantified: P=F/A
  - N/m^2 or Pascal (Pa)

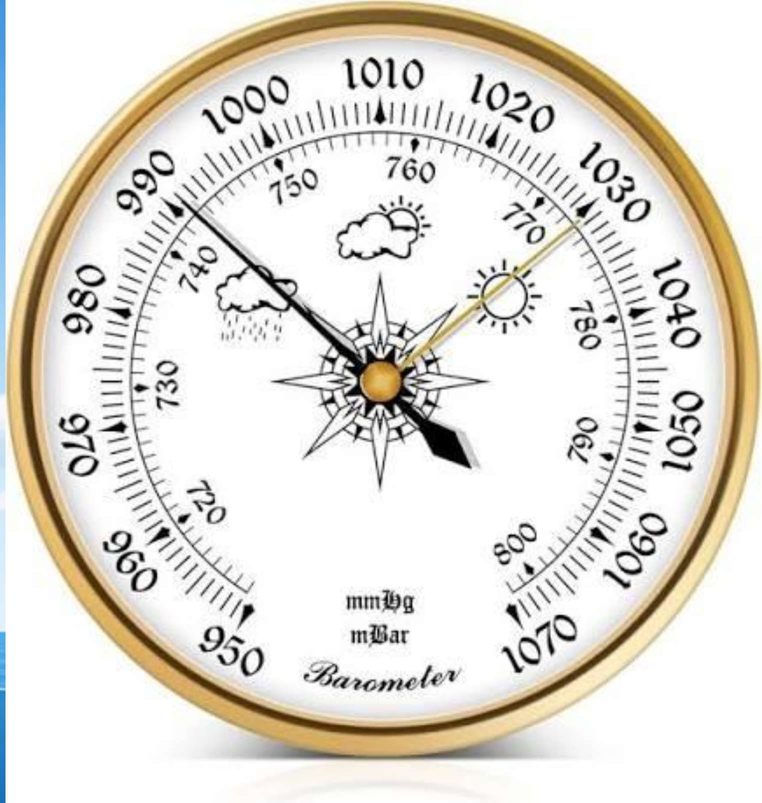


Pressure Conversions

- Atmosphere (atm): Average pressure at sea level (.33-1,100)
  - Physics, Chemistry, Divers
- Pascals (Pa): Default SI unit.
  - Physics, HVAC: 1-atm = 101.3-kPa (kilo Pascal's)
- mm of Hg: Difference in Mercury's height in a tube.
  - Medicine: 1-atm = 760 mm Hg
- psi: Imperial unit lbs/in^2
  - Tires, Hydraulics: 1-atm = 14.7 lb/in^2 (psi)
- bar: Greek for weight
  - Meteorologists, Nautical: 1-atm = 1.013-bar



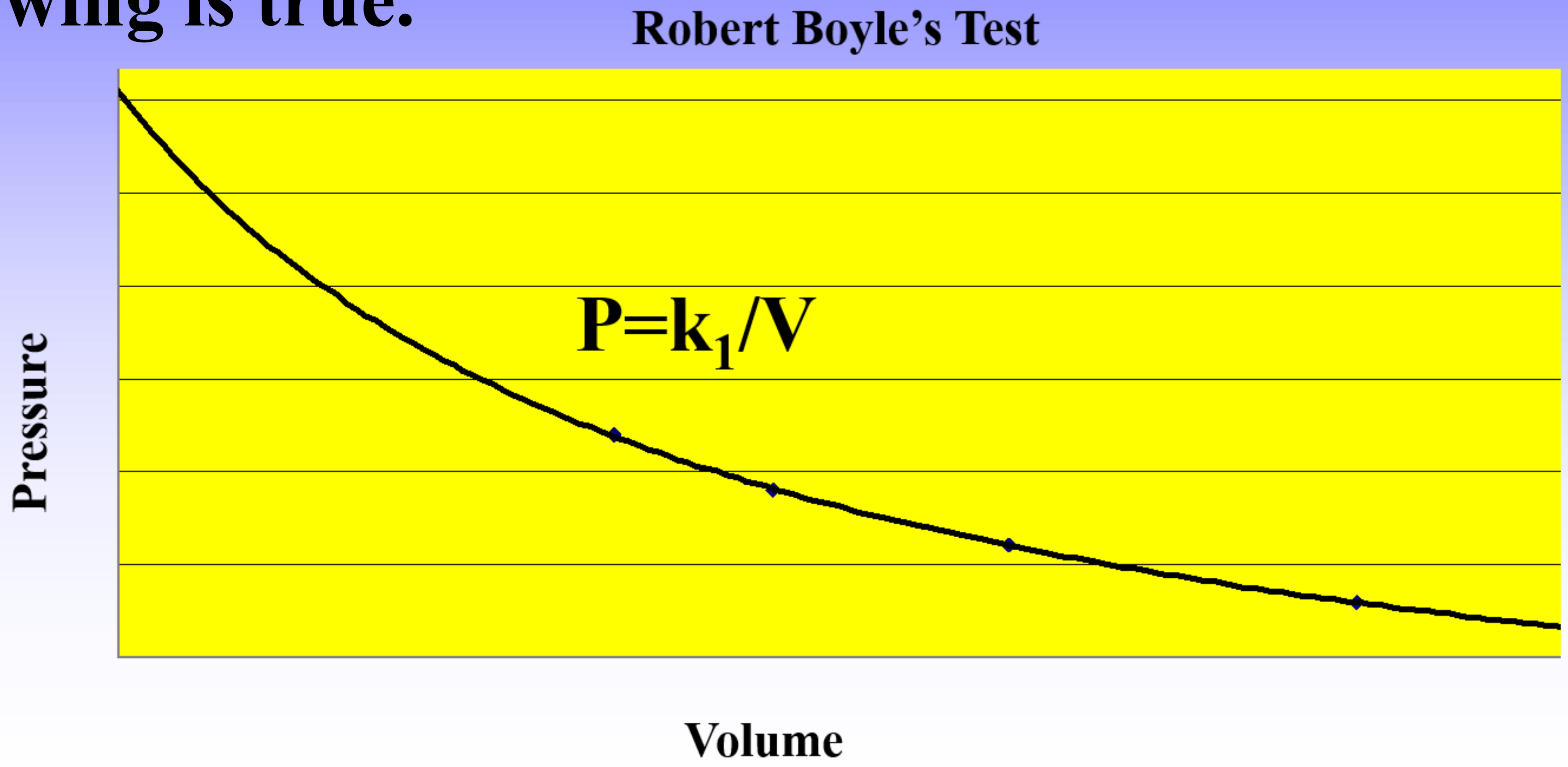
0.33 atm
0.75 atm
1.00 atm
5.00 atm
1.1kiloatm
LOW
PRESSURE
HIGH
PRESSURE



950
960
970
980
990
1000
1010
1020
1030
1040
1050
1060
1070
720
730
740
750
760
770
780
790
800
mmHg
mBar
Barometer

Gas Laws: Boyle

- While looking at gasses Boyle found that for any gas the following is true.



Gas Laws: Boyle

- Doing this experiment multiple times, he found that $P=k/V$ or $PV=k$.
  - This assumes a constant Temperature.
- For any sample of gas the following is true:

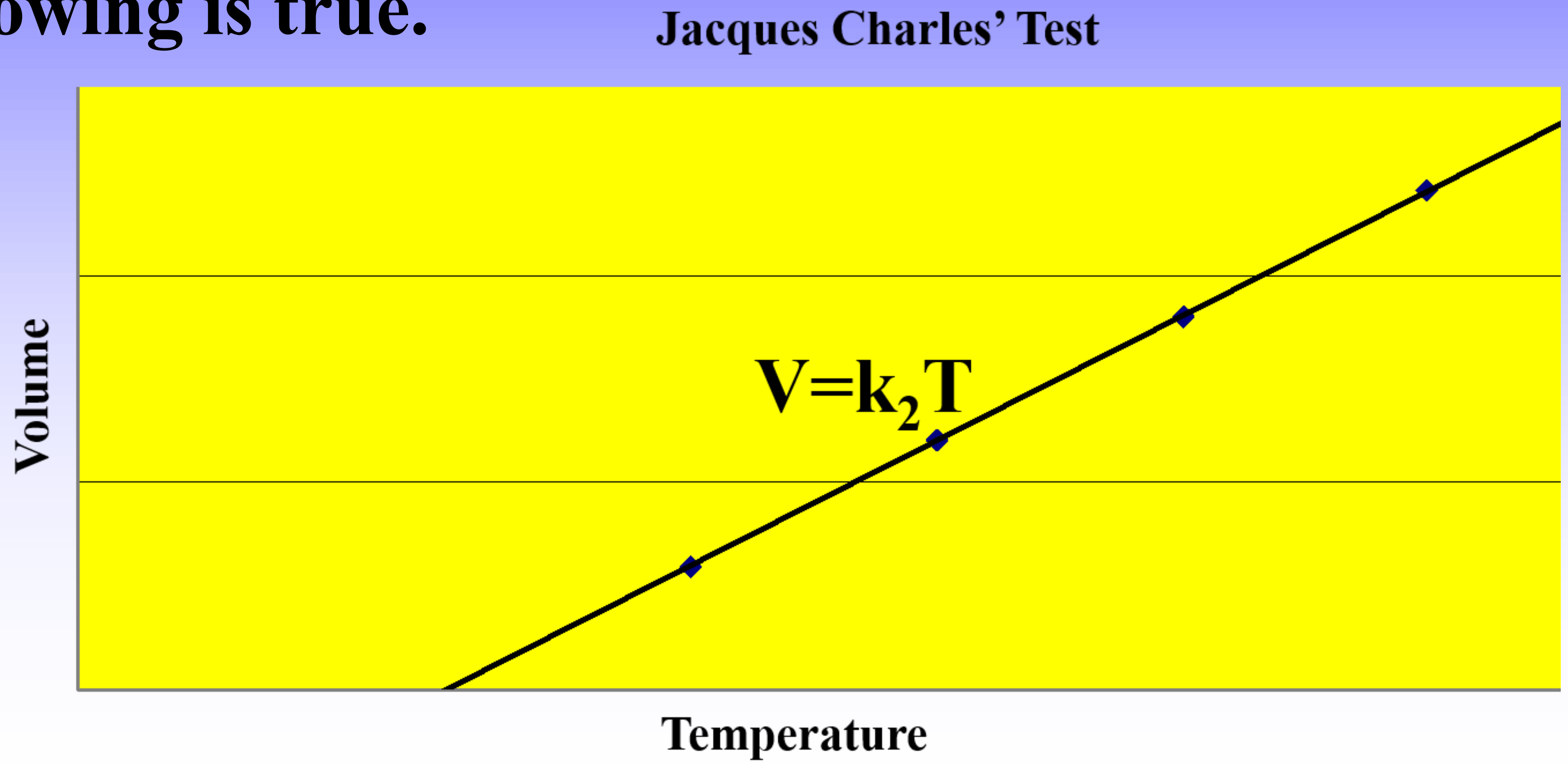
$$P_1V_1=k_1 \quad \text{and} \quad P_2V_2=k_1$$

so…

$$P_1V_1=P_2V_2$$

Gas Laws: Charles

- While looking at gasses it was found that for any gas the following is true.



Gas Laws: Charles

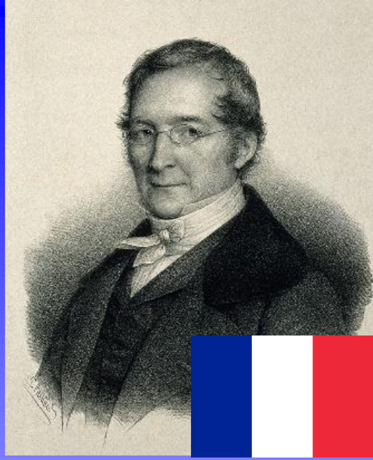
- **Doing this experiment multiple times, he found that $V=k_2T$.**
  - **This assumes a constant Pressure.**
- **For any sample of gas the following is true:**

$$V_1=k_2T_1 \quad \text{and} \quad V_2=k_2T_2$$

so…

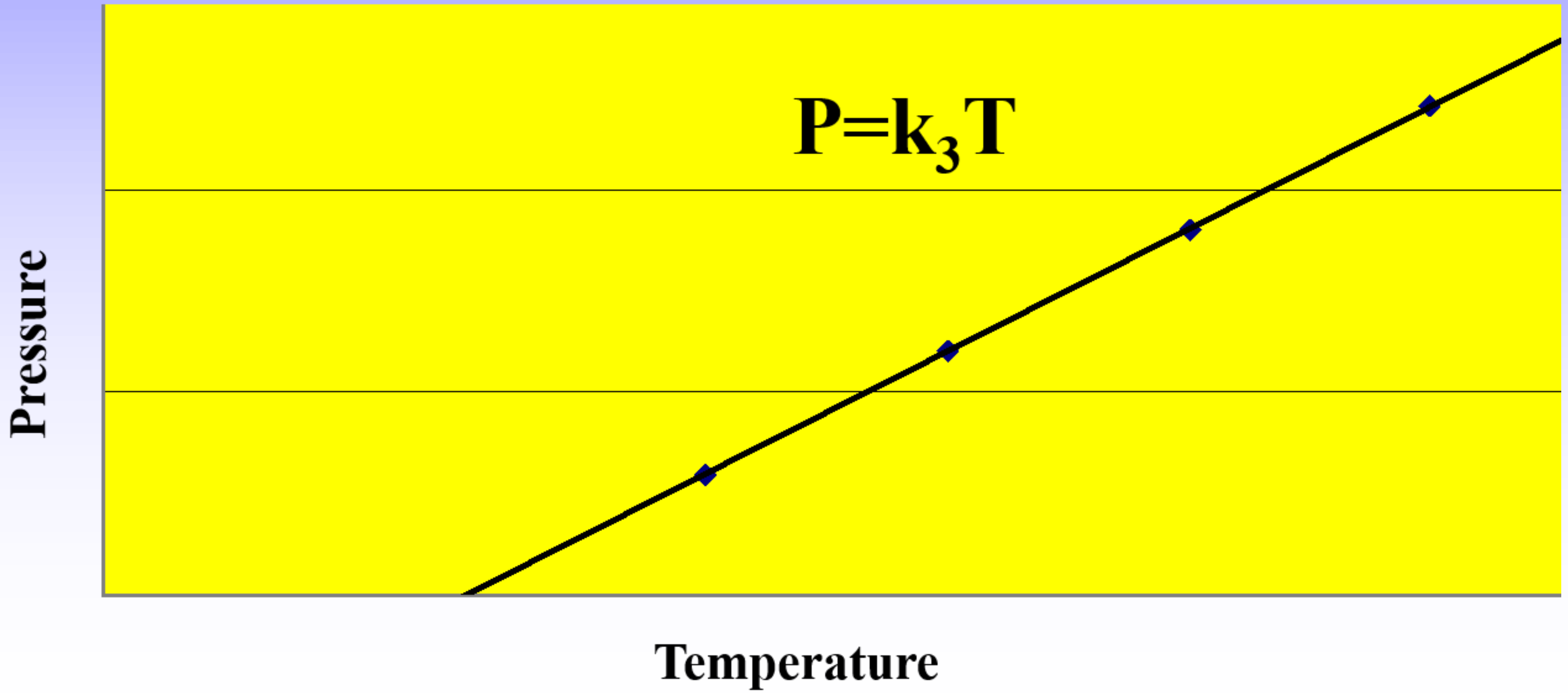
$$V_1/T_1=V_2/T_2$$

Gas Laws: Gay-Lussac

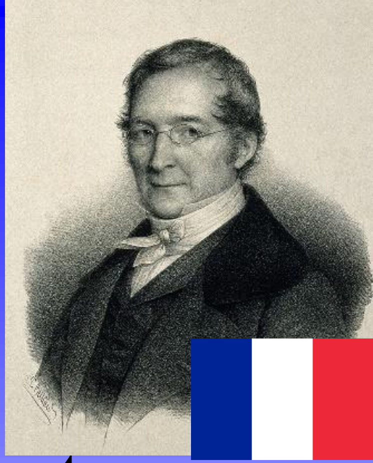


- While looking at gasses it was found that for any gas the following is true.

Joseph Louis Gay-Lussac's Test



Gas Laws: Gay-Lussac



- Doing this experiment multiple times, he found that $P=k_3T$.
  - This assumes a constant Volume.
- For any sample of gas the following is true:

$$P_1=k_3T_1 \quad \text{and} \quad P_2=k_3T_2$$

so…

$$P_1/T_1=P_2/T_2$$

Gas Law's: Combined

All these investigations combine:

Gay-Lussac Boyles

Boltzmann's Constant

$$\frac{PV}{NT} = k_B$$

$1.38x10^{-23}\ \frac{J}{K}$

Number of Particles

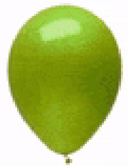
Charles

If the same gas is looked at later and there is a change:

Before = After

$$\frac{PV}{T} = \frac{PV}{T}$$

Gas Law Example: Combined



- At 310-K a balloon at 1.75-atm has a volume of 2.0-L. The temp drops to 250-K and then has a volume of 2.3-L. What is the new Pressure?

$$\frac{PV}{T} = \frac{PV}{T}$$

$$\frac{1.75 - atm \cdot 2 - \cancel{L}}{310 - \cancel{K}} = \frac{P \cdot 2.3 - \cancel{L}}{250 - \cancel{K}}$$

$$.01129 - atm = .0092 \cdot P$$

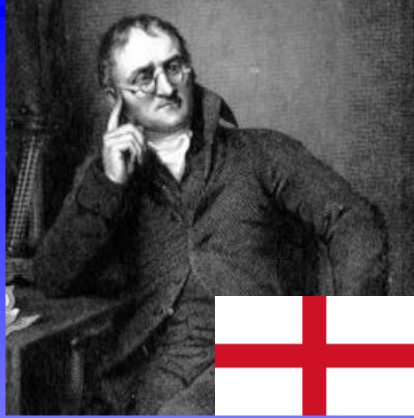
$$1.227 - atm = P$$

Before
P= 1.75-atm
V= 2.0-L
T= 310-K

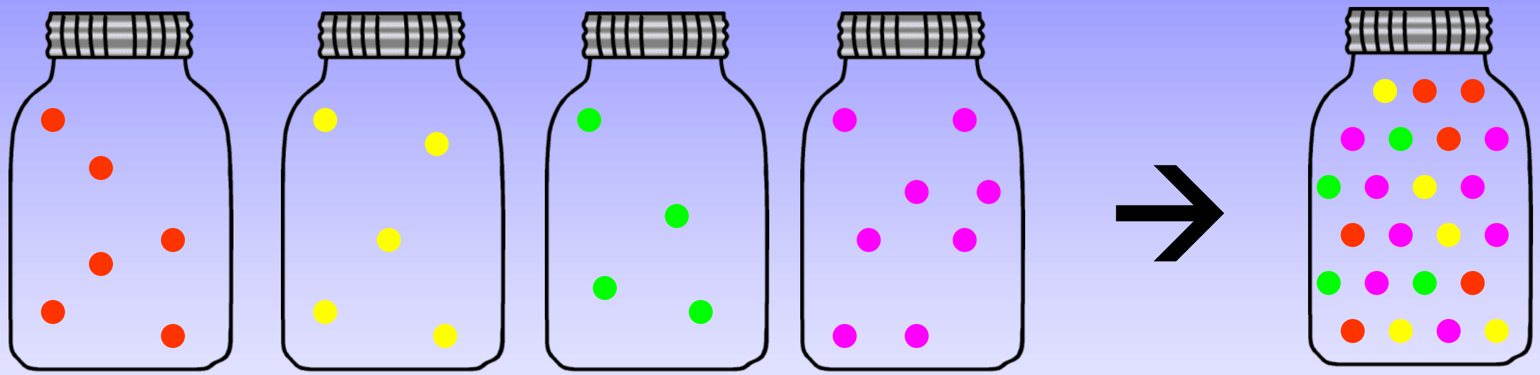
After
P=
V= 2.3-L
T= 250-K

$\boxed{\text{1.2-atm}}$

Gas Law: Dalton



- **John Dalton spent his time looking at Pressure. Dalton stated gasses with different Pressures…**



P_1 P_2 P_3 P_4 $P_\Sigma = P_1 + P_2 + P_3 + P_4$

- **Put together in the same size container, the total Pressure is the sum the parts.**