FOURTH QUARTER

Gas Law

BOYLE'S LAW

MODULE 1

THE INVISIBLE STATE OF MATTER

INVISIBLE BUT EVERYWHERE

- Unlike solids and liquids, **gases** cannot be seen and touched but they surround us.

Why Do Gases Spread Out? The Science of Particle Collisions

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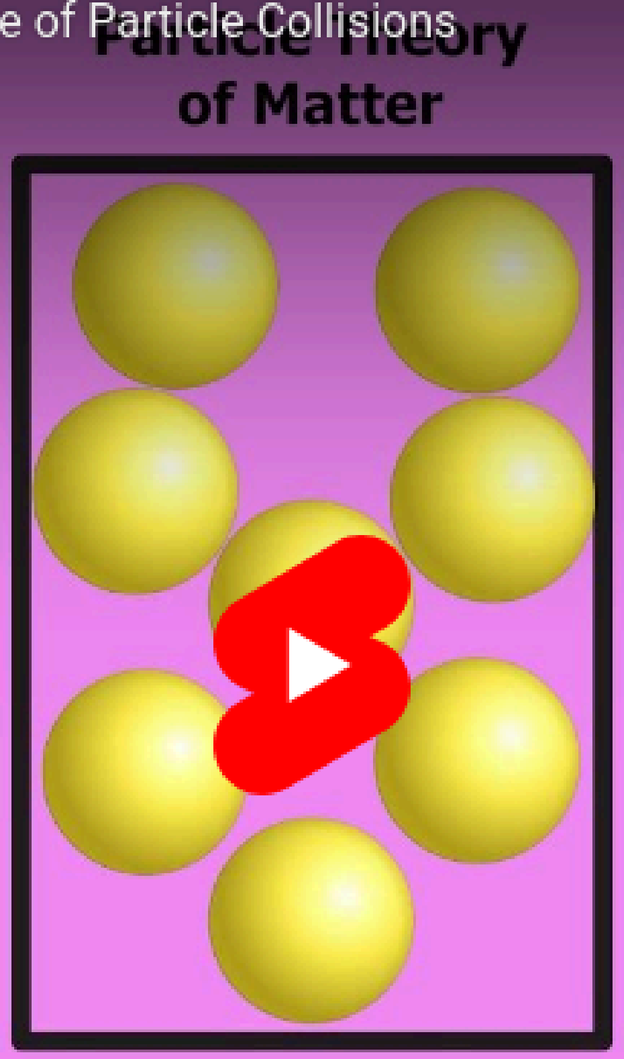


ROBERT BOYLE

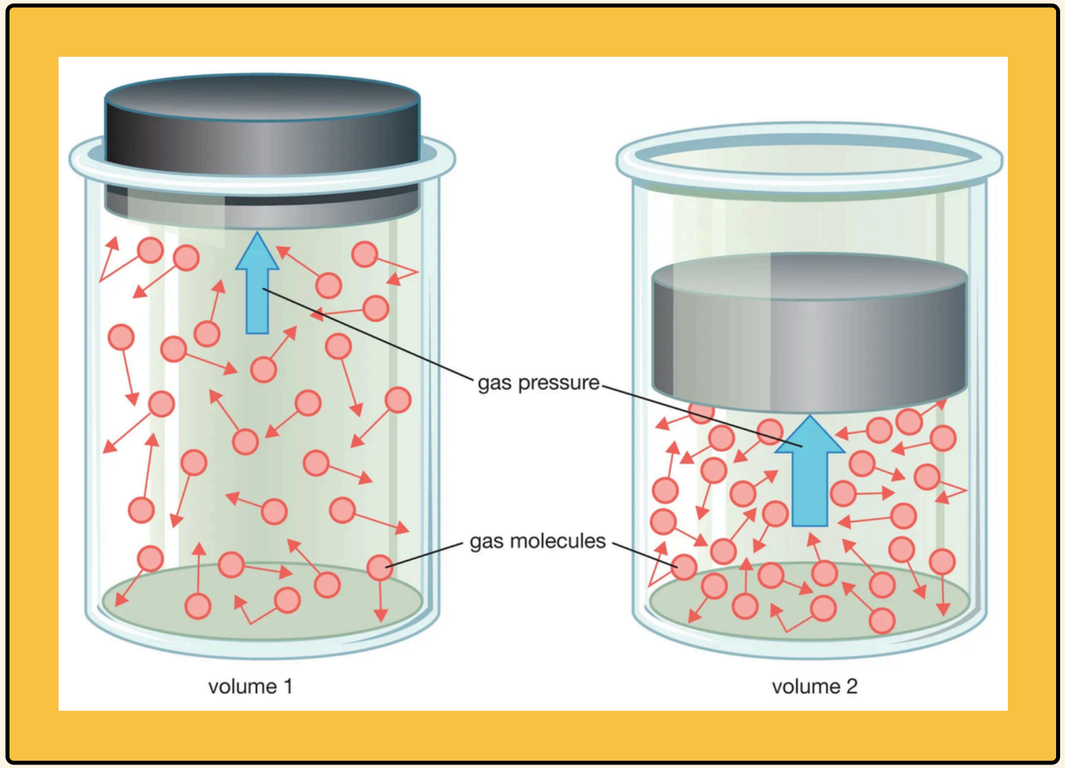
JACQUES CHARLES

Made significant discoveries about gases.

THE SCIENCE OF “NOTHING”

- A **gas has no definite shape** because the forces between its molecules are so small that they can move freely and randomly.

- It can also **compress or expand** depending on its environment.



Physical Properties of Gases

PRESSURE

AMOUNT OF GAS

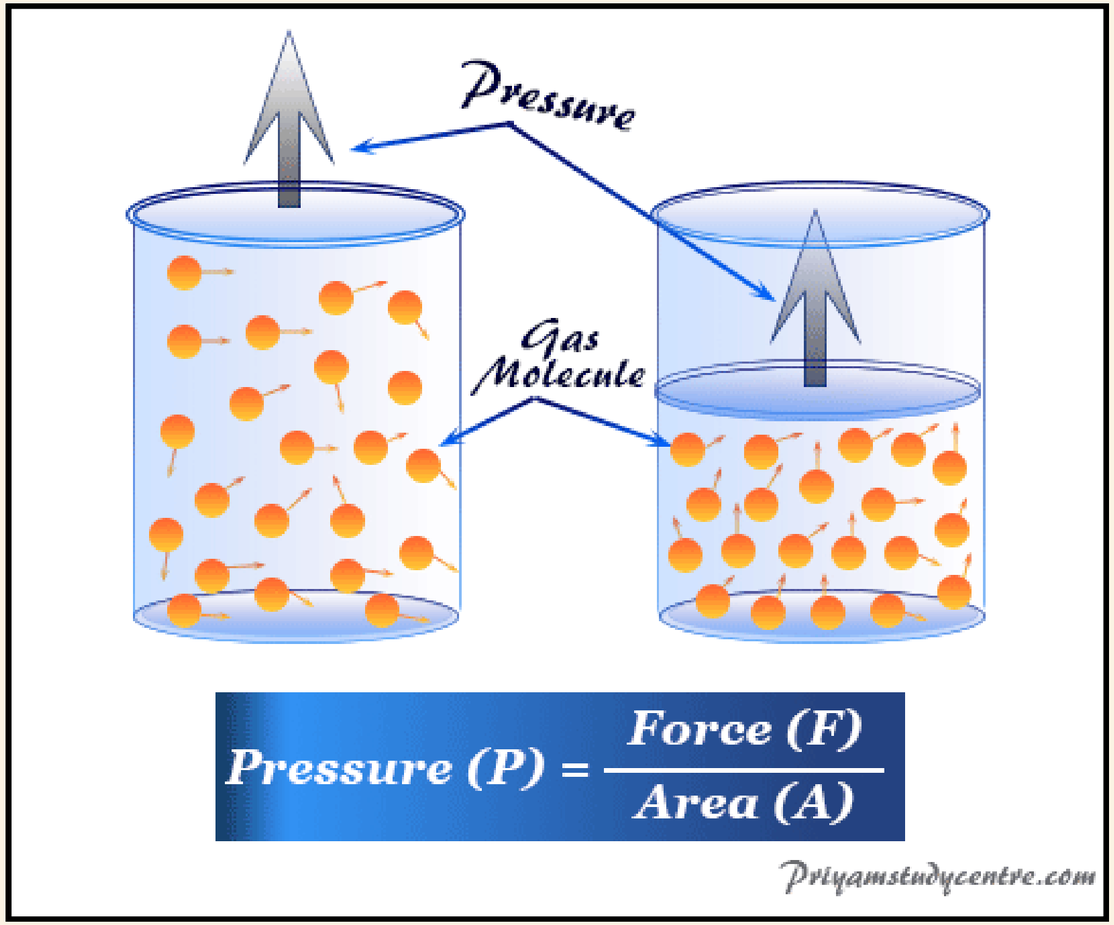
VOLUME

TEMPERATURE

Physical Properties of Gases

PRESSURE

- The **force applied per unit area.**
- The SI unit is the **Pascal (Pa)** 1 Pa = 1 N/m^2
- **Molecular Collisions occur** when gas particles strike the walls of a container.

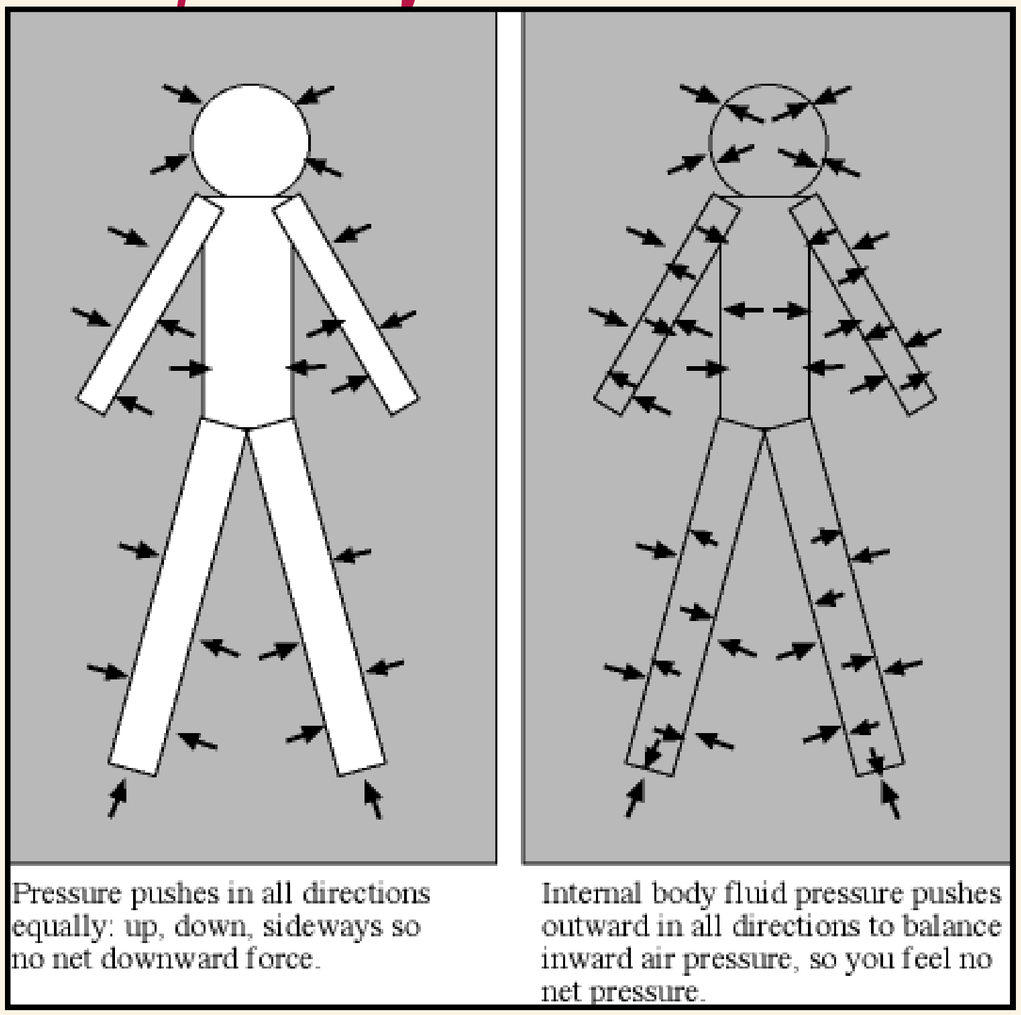


Physical Properties of Gases

PRESSURE

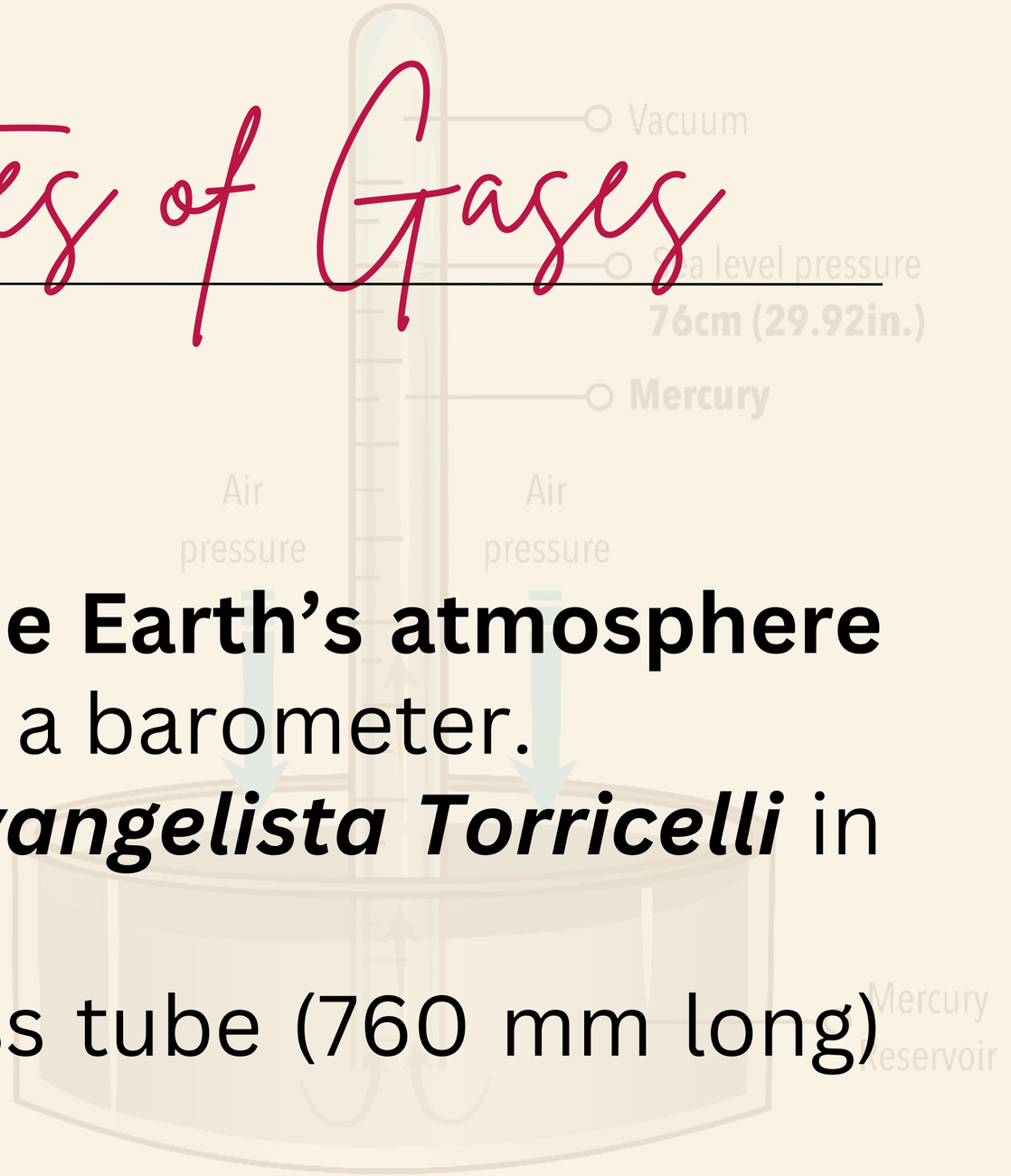
Fun Fact

- Gases exert pressure on our skin right now! We don't feel it because our bodies have adapted to it.



Physical Properties of Gases

ATMOSPHERIC PRESSURE

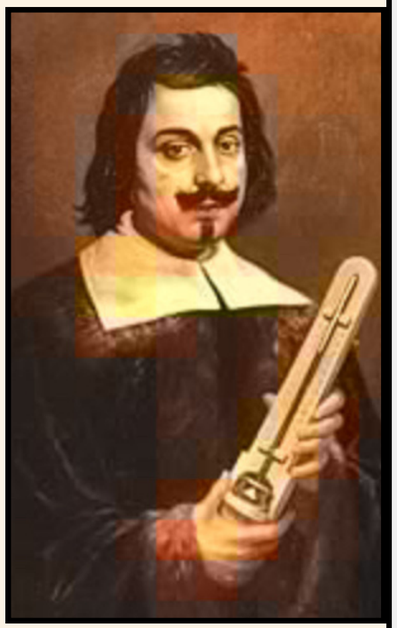


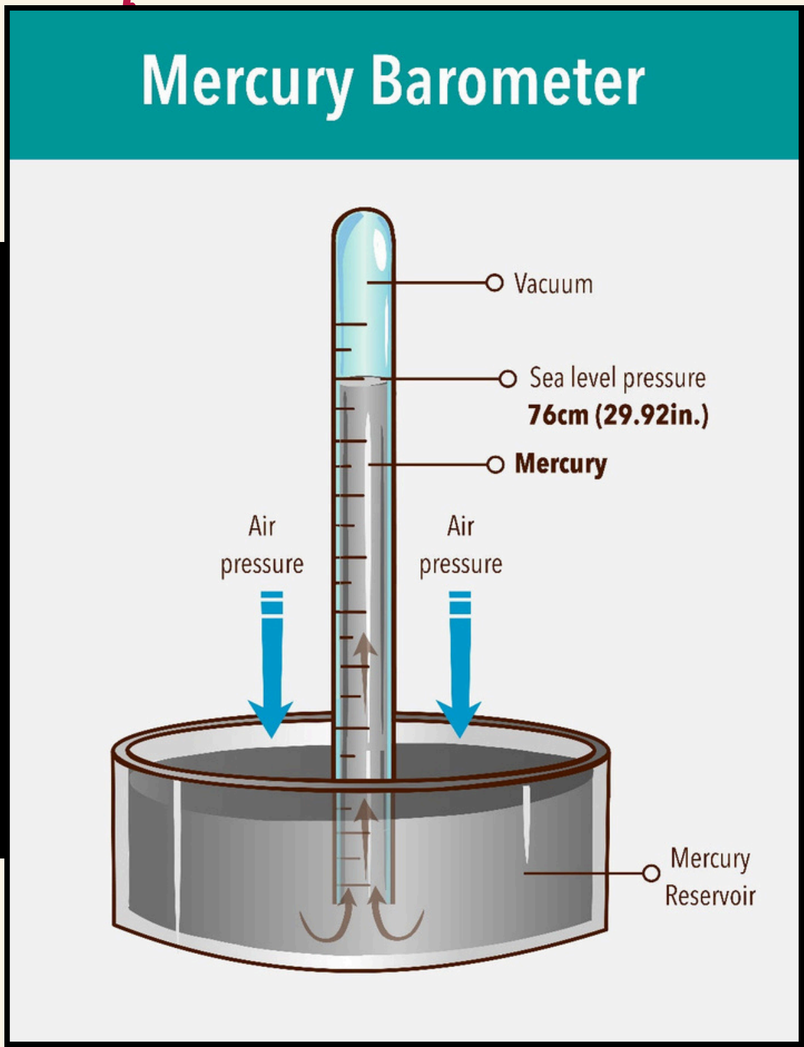
- The **pressure exerted by the Earth's atmosphere and can be measured** using a barometer.
- **Barometer**- invented by ***Evangelista Torricelli*** in the 17th century.
- How it works: It uses a glass tube (760 mm long) filled with mercury.

Physical Properties of Gases

ATMOSPHERIC PRESSURE

- If atmospheric pressure is higher than the weight of the mercury, the level rises.

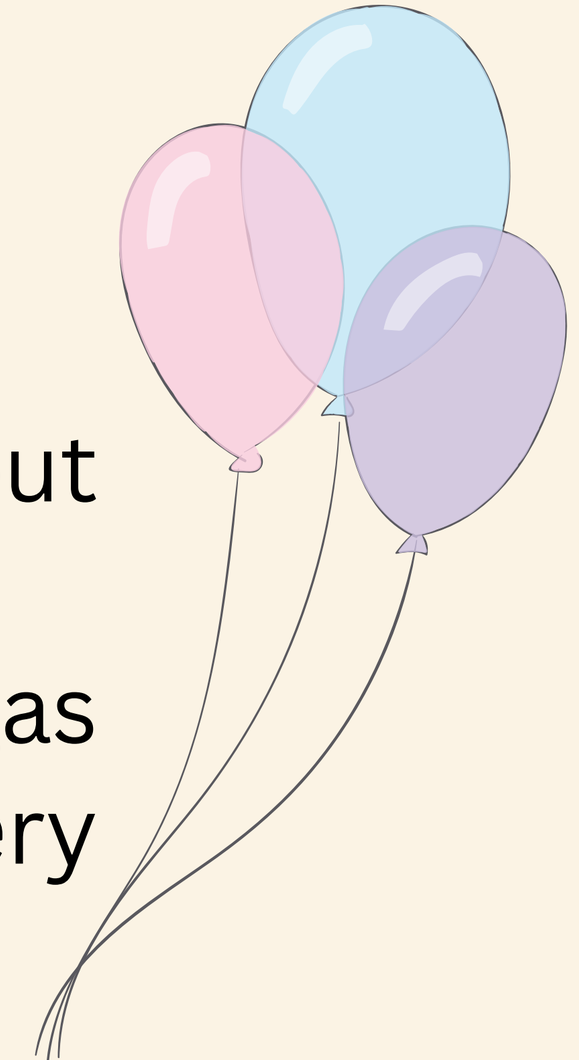




Physical Properties of Gases

VOLUME

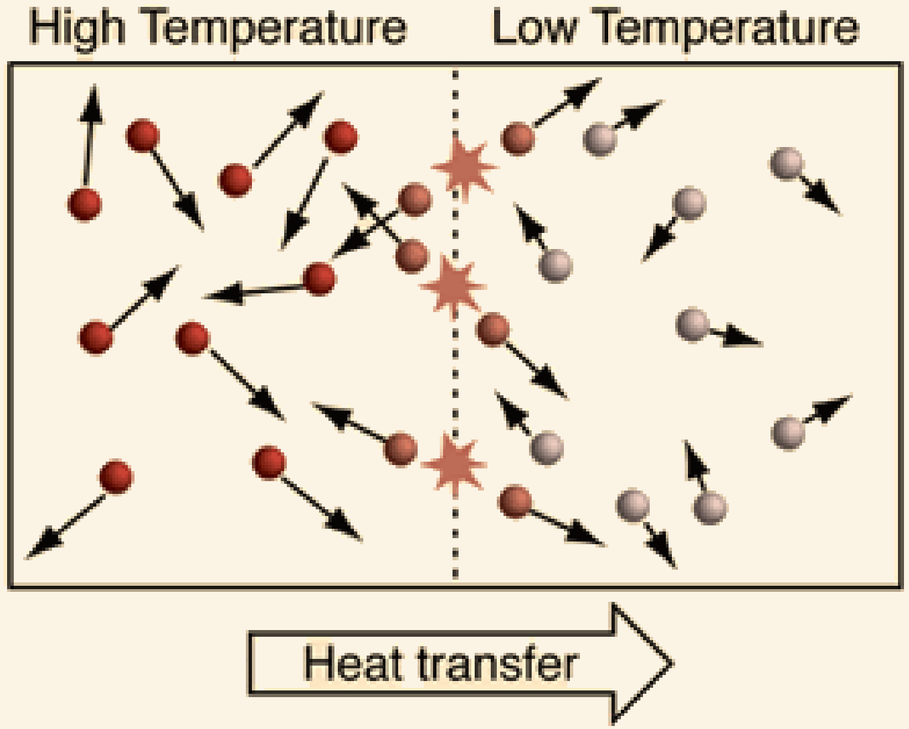
- The **space occupied by matter.**
- They **do not have definite shape** but occupy the space of the container.
- If you blow air into a balloon, the gas molecules spread evenly to fill every corner of that balloon.



Physical Properties of Gases

TEMPERATURE

- The hotness or coldness of an object, which actually measures the **average kinetic energy** of the particles.
- It can be measured using a **thermometer**



Physical Properties of Gases

TEMPERATURE

- As **temperature increases**, the **kinetic energy** (speed) of the gas molecules gets **higher.**

- **Absolute Zero (Kelvin Temperature Scale)-** the lowest possible temperature is -273.15**°C** (known as **0 K**).

Physical Properties of Gases

TEMPERATURE

Essential Formula for Gas Laws

- To convert Celsius to Kelvin:

$$K = \mathrm{C} + 273.15$$

- 30 degrees Celsius to Kelvin
- 300 K to degrees Celsius

Physical Properties of Gases

AMOUNT OF GAS

- The number of moles of gas particles.
- **Mole (n)** is the standard unit used to measure the amount of gas particles.
- More particles in a fixed volume increase wall collisions, raising pressure.
- More particles at constant pressure require more space, increasing volume.

Table 1. Commonly used units and their equivalents for volume, pressure and temperature

Variable	SI Unit	Metric Unit	English Unit	Units and their equivalents
Volume	cubic meter ($m3$) cubic decimeter ($dm3$) cubic centimeter ($cm3$)	liter(L) milliliter(mL	quart(qt) gallon(gal)	1 mL = 1 $cm3$ 1 L = 1 $dm3$ 1 $cm3$=1000 L
Pressure	Pascal (Pa)	atmosphere(atm) millimeters of mercury(mm Hg) centimeters of mercury (cm Hg)	torr lb/$in2$ (psi)	1 atm = 760 mm Hg = 76 cm Hg = 760 torr = 101,325 Pa = 14.6956 psi
Temperature	Kelvin(K)	Celsius(°C)	Fahrenheit(°F)	0 °C = 273.15 K 0 °C = 32 °F

The Story of Gas Laws

- These laws explain the mathematical relationships between **Pressure, Volume, Temperature, and Amount of gas.**

- These laws were named after the scientists who discovered how gases affect our everyday lives—from breathing to car tires and spray cans.

FOURTH QUARTER

Gas Law

BOYLE'S LAW

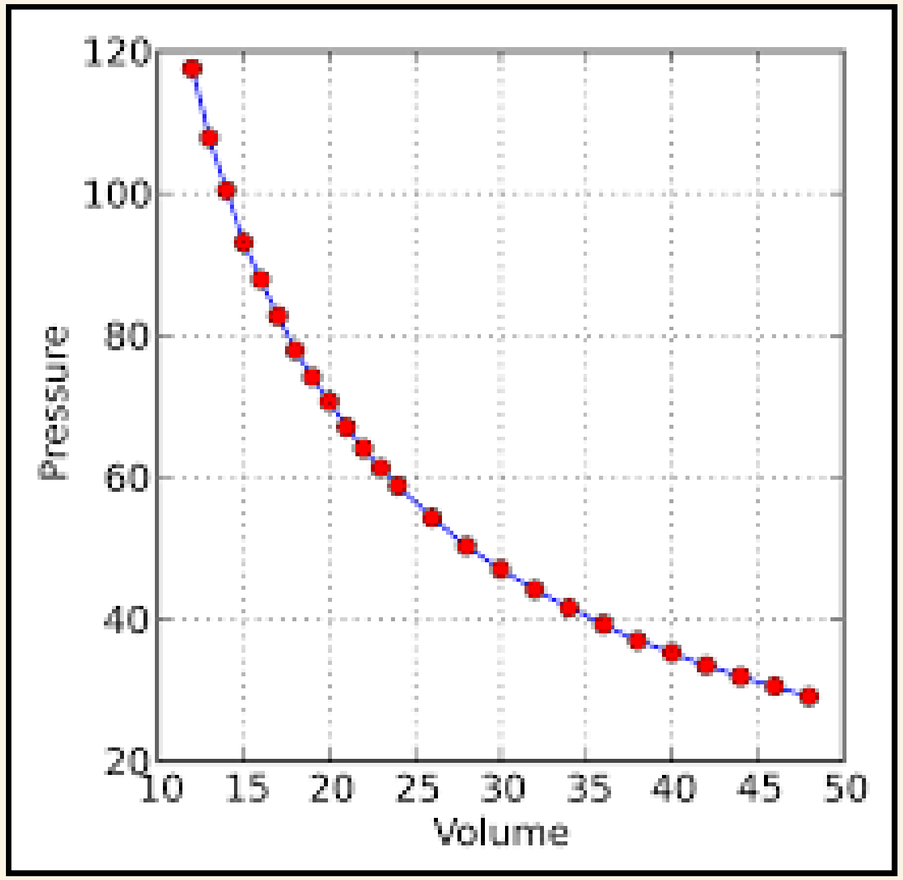
MODULE 1

BOYLE'S LAW: THE VOLUME-PRESSURE RELATIONSHIP

- A **British chemist** who studied the relationship of volume and pressure at constant temperature.
1.
- It states that at **constant temperature and fixed amount of gas, pressu**re is inversely proportional to volume.
- It means that when the **pressure is high, the volume of the gas decreases.**

Robert Boyle (1627-1691)

BOYLE'S LAW: THE VOLUME-PRESSURE RELATIONSHIP



- It states that at **constant temperature and fixed amount of gas, pressu**re is inversely proportional to volume.

- It means that when the **pressure is high, the volume of the gas decreases.**

Equation: *at constant T* $P_1V_1=P_2V_2$

Example 1:
At room temperature, a gas occupies 2.8 L at a pressure of 2.5 atm. What will be its final volume if the pressure is decreased to 1.3 atm? ***Equation:*** *at constant T* $P_1V_1=P_2V_2$

Given:

V_1= 2.8L V_2=? P_1 = 2.5 atm P_2 = 1.3 atm

Asked: V2 = ? Formula: P1V1 = P2V2

Solution:

$$V_2 = \frac{P_1V_1}{P_2}$$

$$V_2 = \frac{(2.5\ \text{atm})(2.8\ \text{L})}{1.3\ \text{atm}}$$

$$V_2 = \frac{7.0\ \text{L}}{1.3}$$

$$V_2 = 5.38\ \text{L}$$

Answer:
The final volume of the gas is **5.38L.**
Notice that the decrease in pressure causes an increase in volume.

Example 2:
A sample of oxygen gas exerts a pressure of 1.2 atm in a 5.0 L container. If the gas is compressed into a smaller 2.0 L container at the same temperature, what will be the new pressure?

Given:

$P_1 = 1.2\ \text{atm}\ \ P_2 = ?\ \ V_1 = 5.0\ \text{L}\ \ V_2 = 2.0\ \text{L}$

Asked: $P_2 = ?$ Formula: $P_1V_1 = P_2V_2$

Solution:

$$P_2 = \frac{P_1V_1}{V_2}$$

$$P_2 = \frac{(1.2\ \text{atm})(5.0\ \text{L})}{2.0\ \text{L}}$$

$$P_2 = \frac{6.0\ \text{atm}}{2.0}$$

$$P_2 = 3.0\ \text{atm}$$

Answer: The new pressure would be **3.0 atm**

Word Problems: (Science Notebook & Use GAFSA Method)

1. A tank of oxygen has an initial volume of 300ml and a pressure of 8.2 atm. What is the final pressure in torr if the volume is doubly increased?

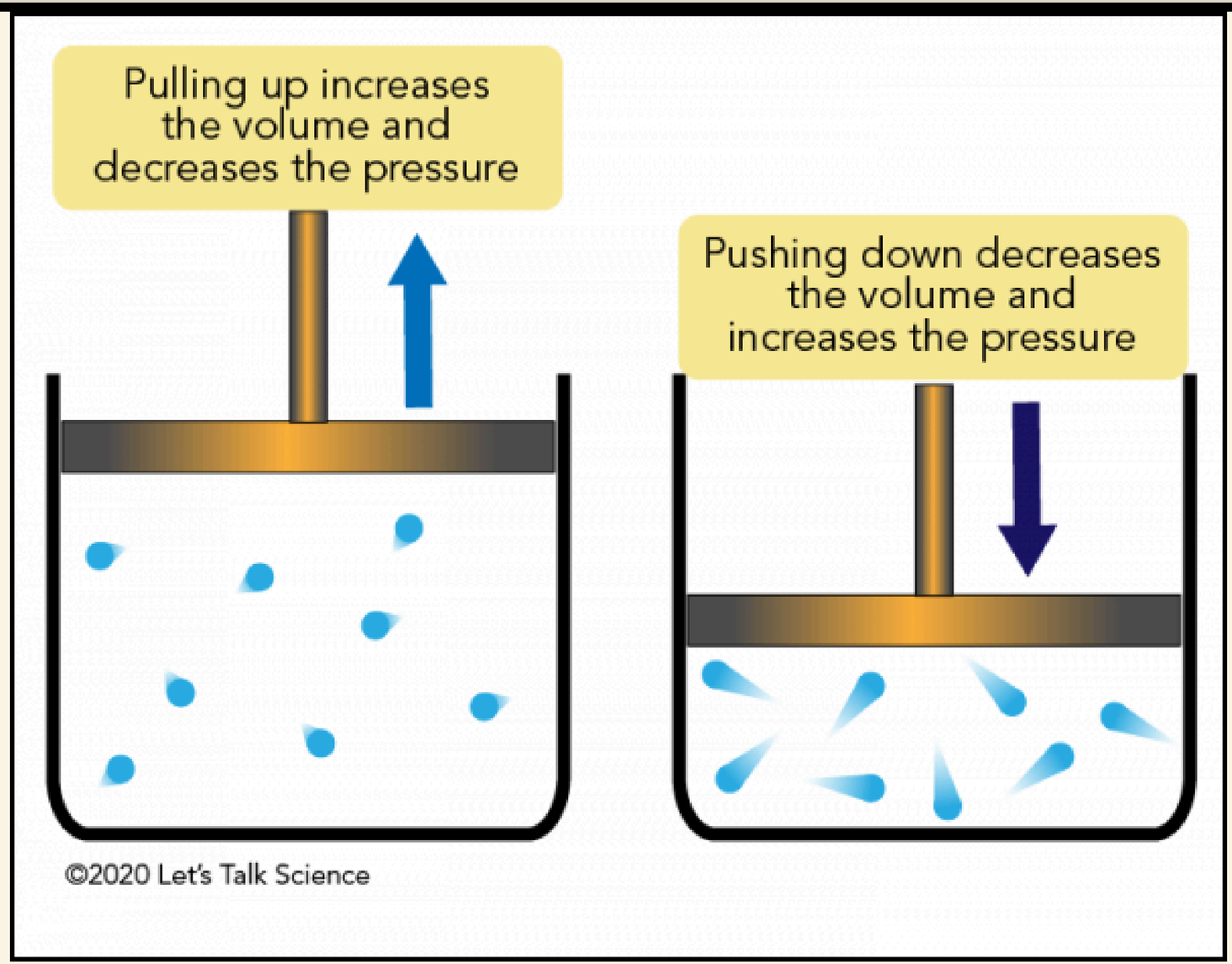
2. A gas tank can hold 25.0 L of helium (He) gas at a pressure of 6.0 atm. How many liters will the gas occupy if the pressure was decreased to 0.50 atm at constant temperature?

3. A syringe contains 10.0 mL of air at a pressure of 1.0 atm. If the plunger is pushed down until the volume is compressed to 2.5 mL, what will be the new pressure inside the syringe?

BOYLE'S LAW:
THE VOLUME-PRESSURE RELATIONSHIP

The **spray cans** used for air fresheners or paint **use the concept of Boyle's law,** pressing the spray can increase the pressure inside it. Thus, the liquid inside the can escapes through the nozzle.

BOYLE'S LAW:
THE VOLUME-PRESSURE RELATIONSHIP



KINETIC MOLECULAR THEORY ON BOYLE'S LAW

- **Molecules are crowded** into a smaller space when volume decreases.
- **Average kinetic energy** and velocity remain constant because temperature is unchanged.
- **Collision frequency increases** because more molecules strike a given area of the wall in a given time.
- **Shorter travel distance** allows molecules to strike the same unit area more often.
- **Pressure increases** as a direct result of more frequent collisions.
- **Expansion reduces collisions** because molecules move in a larger volume, causing pressure to decrease.