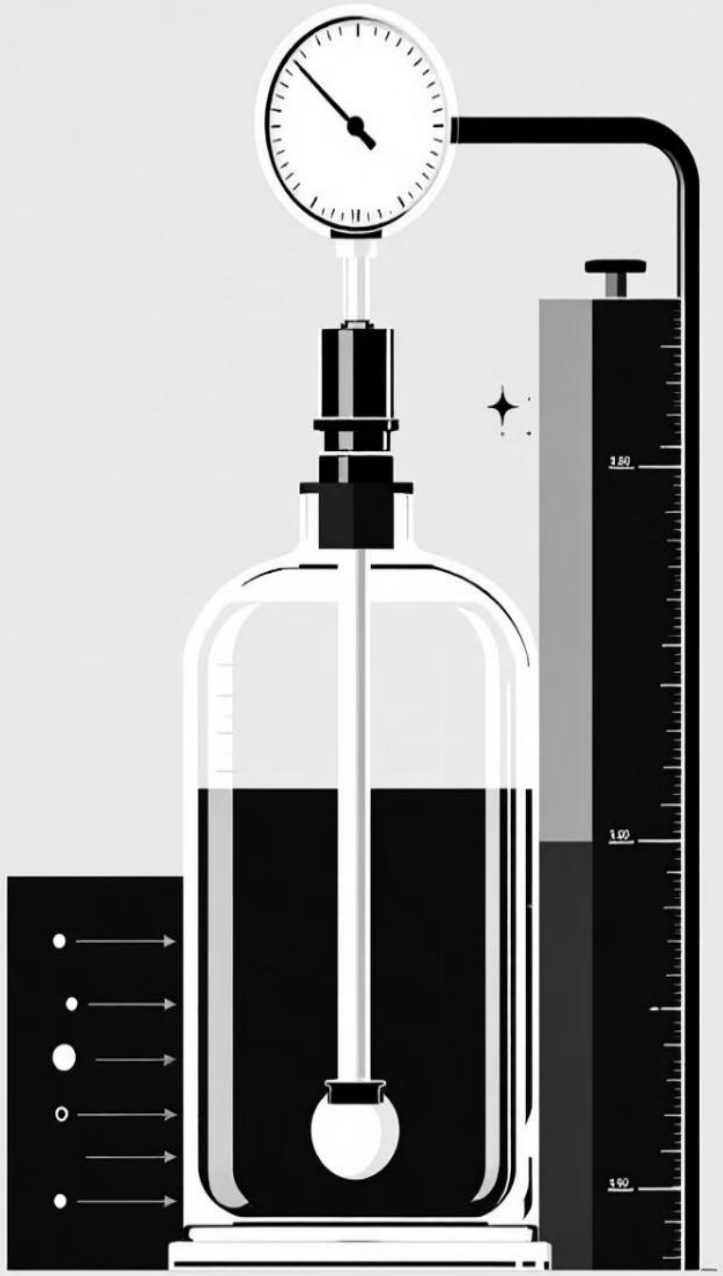

General Physics

Lecture Two / Practical

Exploring the Relationship Between Pressure and Volume

First stage

Dr. Ahmed Najm Obaid

Assis. Lect. Amin Kadhum Awad

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Introduction to Boyle's Law

History and Background

Robert Boyle, an Irish physicist, formulated this fundamental law of gases in the 17th century. Boyle's Law states that the volume of a fixed mass of gas is inversely proportional to its pressure, assuming constant temperature.

Importance in Science

Boyle's Law is a fundamental principle governing the behavior of gases. It provides a framework for understanding the inverse relationship between pressure and volume at constant temperature. This law has numerous practical applications in various fields, from scuba diving to medical devices.

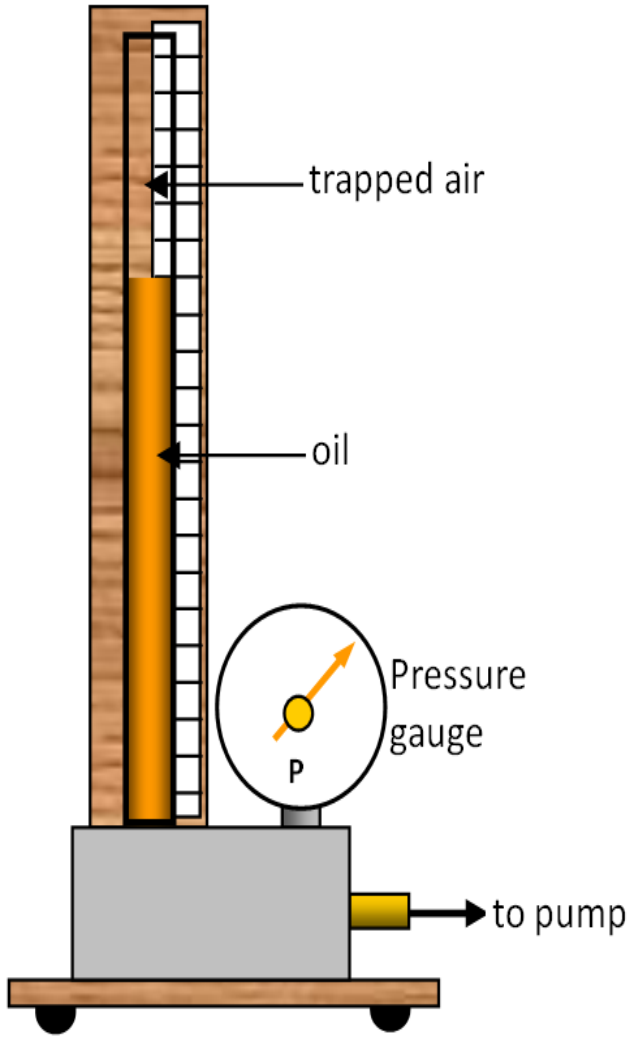
Experimental Verification of Boyle's Law

Controlled Experiment

Some air is trapped in a tube by a column of oil. The oil can be forced up the tube using the pump and so the pressure of the trapped air can be increased and its volume decreases.

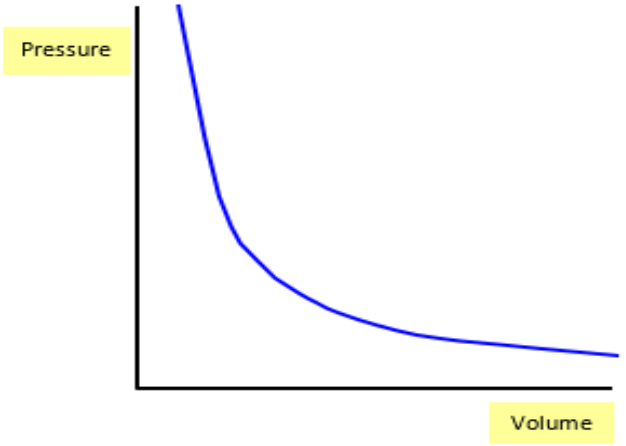
Constant Temperature

Throughout the experiment, it's crucial to ensure that the temperature of the gas remains constant. This can be achieved by immersing the syringe in a constant temperature bath.

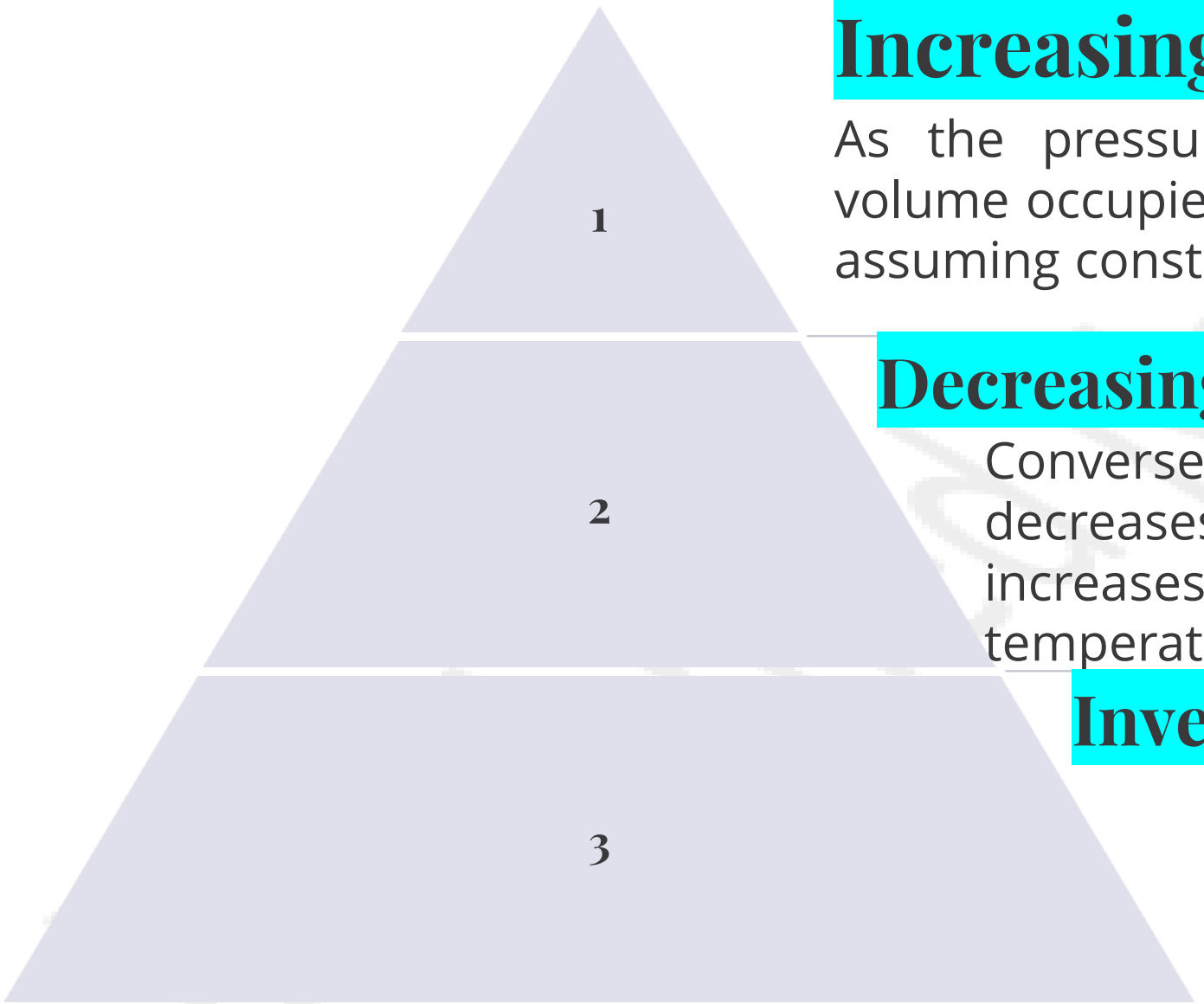


Data Analysis

The collected data of pressure and volume measurements is plotted on a graph. The shape of the graph should resemble a hyperbola, indicating the inverse relationship between pressure and volume.



The Inverse Relationship Between Pressure and Volume



Increasing Pressure

As the pressure applied to a gas increases, the volume occupied by the gas decreases proportionally, assuming constant temperature.

Decreasing Pressure

Conversely, as the pressure applied to a gas decreases, the volume occupied by the gas increases proportionally, again assuming constant temperature.

Inverse Proportionality

This relationship is known as inverse proportionality, meaning that the product of pressure and volume remains constant under these conditions.

Mathematical Representation of Boyle's Law

1

Equation

Boyle's Law is mathematically expressed as P1V1 = P2V2, where P1 and V1 are the initial pressure and volume, and P2 and V2 are the final pressure and volume.

2

Constant

The product of pressure and volume, P1V1 or P2V2, remains constant under constant temperature conditions, indicating the inverse proportionality.

3

Applications

This equation allows us to calculate the pressure or volume of a gas under different conditions, provided the temperature remains constant.

Limitations and Exceptions to Boyle's Law

1

High Pressure

Boyle's Law applies primarily to ideal gases at low pressures. At high pressures, the gas molecules interact more frequently, deviating from ideal behavior.

2

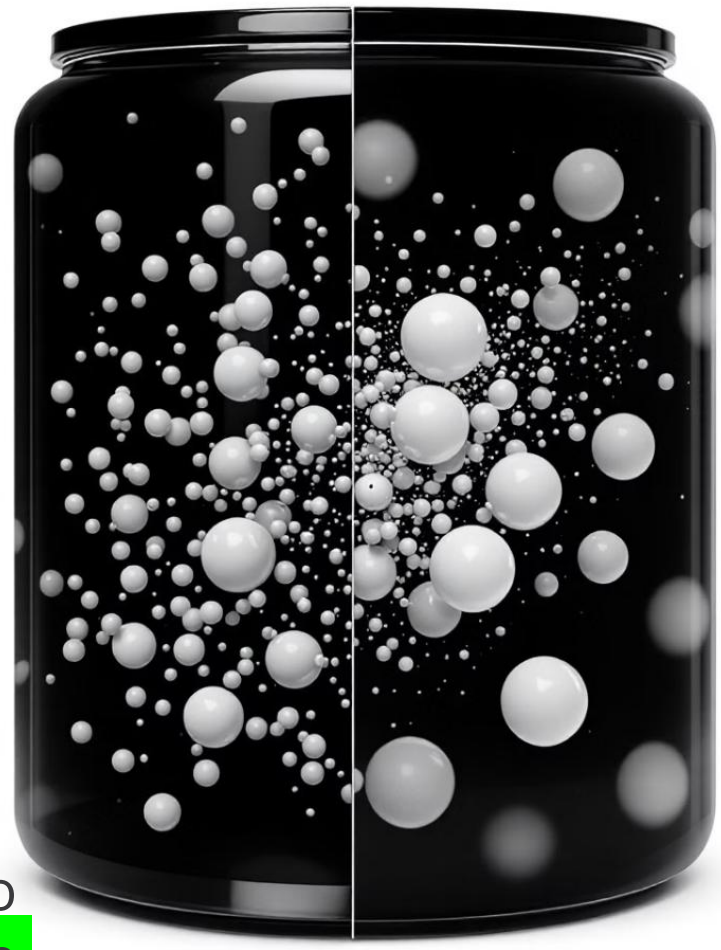
Low Temperature

At low temperatures, the gas molecules move slower, leading to increased intermolecular attraction forces, which also deviate from the ideal gas model.

3

Real Gases

Real gases exhibit deviations from Boyle's Law due to factors such as intermolecular forces and the finite volume of gas molecules, which are neglected in the ideal gas model.



Practical Applications of Boyle's Law

Scuba Diving

Boyle's Law is essential in scuba diving. As divers descend, the pressure of the surrounding water increases, causing the volume of air in their tanks to decrease.

Medical Devices

Syringes and other medical devices utilize Boyle's Law. By applying pressure to a piston, the volume of the chamber is reduced, forcing fluid out through a needle.

Tire Inflation

Inflating tires relies on Boyle's Law. Air is pumped into the tire, increasing the pressure and reducing the volume of air within the tire.

Problems

Problem 1:

A gas occupies a volume of 2.0 L at a pressure of 1.5 atm. If the pressure is increased to 3.0 atm while keeping the temperature constant, what will be the new volume of the gas?

Problem 2:

A gas has a volume of 5.0 L at a pressure of 2.0 atm. If the volume is compressed to 2.5 L while keeping the temperature constant, what will be the new pressure of the gas?

Problem 3:

A gas occupies a volume of 10.0 L at a pressure of 1.0 atm. If the pressure is reduced to 0.5 atm while keeping the temperature constant, what will be the new volume of the gas?

Problem 4:

A scuba diver's tank contains 12.0 L of air at a pressure of 200 atm. If the diver uses the air and the volume of the tank remains constant, what will be the pressure when the volume of air expands to 2400 L at the surface (assuming constant temperature)?

Problem 5:

A gas is trapped in a cylinder with a movable piston. Initially, the gas occupies a volume of 10.0 L at a pressure of 2.0 atm. If the piston is pushed down to reduce the volume to 5.0 L, what will be the new pressure of the gas?

Problem 6:

A gas occupies a volume of 3.0 L at an unknown pressure. If the volume is increased to 6.0 L and the pressure is measured to be 0.5 atm, what was the initial pressure of the gas?