Name: ____________________ Date: ____________________

Boyle's Law

READ

The relationship between the volume of a gas and the pressure of a gas, at a constant temperature, is known as Boyle's law. The equation for Boyle's law is at right.

Units for pressure include: atmospheres (atm), pascals (Pa), or kilopascals (kPa). Units for volume include: cubic centimeters (cm^3), cubic meters (m^3), or liters.

BOYLE'S LAW

Initial volume → V_1; *Initial pressure* → P_1; *New pressure* → P_2; *New volume* → V_2

$$P_1V_1 = P_2V_2$$

Mass and temperature constant

EXAMPLE

A kit used to fix flat tires consists of an aerosol can containing compressed air and a patch to seal the hole in the tire. Suppose 10.0 liters of air at atmospheric pressure (101.3 kilopascals, or kPa) is compressed into a 1.0-liter aerosol can. What is the pressure of the compressed air in the can?

Looking for

Pressure of compressed air in a can ($\mathbf{P_2}$)

Given

P_1 = 101.3 kPa; V_1 = 10.0 liters; V_2 = 1.0 liters

Relationship

Use Boyle's Law to solve for $\mathbf{P_2}$. Divide each side by $\mathbf{V_2}$ to isolate $\mathbf{P_2}$ on one side of the equation.

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

Solution

$$P_2 = \frac{101.3\text{ kPa} \times 10.0\text{ L}}{1.0\text{ L}} = 1{,}013\text{ kPa}$$

The pressure inside the aerosol can is 1,013 kPa.

PRACTICE

1. The air inside a tire pump occupies a volume of 130.0 cubic centimeters at a pressure of one atmosphere. If the volume decreases to 40.0 cubic centimeters, what is the pressure, in atmospheres, inside the pump?

2. A gas occupies a volume of 20 cubic meters at 9,000 pascals. If the pressure is lowered to 5,000 pascals, what volume will the gas occupy?

3. You pump 25.0 liters of air at atmospheric pressure (101.3 kPa) into a soccer ball that has a volume of 4.5 liters. What is the pressure inside the soccer ball if the temperature does not change?

4. Hyperbaric oxygen chambers (HBO) are used to treat divers with decompression sickness. As pressure increases inside the HBO, more oxygen is forced into the bloodstream of the patient inside the chamber. To work properly, the pressure inside the chamber should be three times greater than atmospheric pressure (101.3 kPa). What volume of oxygen, held at atmospheric pressure, will need to be pumped into a 190-liter HBO chamber to make the pressure inside three times greater than atmospheric pressure?

5. A 12.5-liter scuba tank holds of oxygen at a pressure of 202.6 kPa. What is the original volume of oxygen at 101.3 kPa that is required to fill the scuba tank?

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Pressure-Temperature Relationship

READ

The pressure-temperature relationship shows a direct relationship between the pressure of a gas and its temperature when the temperature is given in the Kelvin scale. Another name for this relationship is the Gay-Lussac Law. The pressure-temperature equation is below.

PRESSURE-TEMPERATURE RELATIONSHIP

Initial pressure (atm) → P_1, *Initial temperature* (K) → T_1; P_2 ← *New pressure*, T_2 ← *New temperature*

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

Volume and mass constant

Converting from degrees Celsius to Kelvin is easy — you *add* 273 to the Celsius temperature. To convert from Kelvins to degrees Celsius, you *subtract* 273 from the Kelvin temperature.

EXAMPLE

A constant volume of gas is heated from 25.0°C to 100°C. If the gas pressure starts at 1.00 atmosphere, what is the final pressure of this gas?

Looking for The new pressure of the gas (P_2)	**Solution** $T_1 = 25°C + 273 = 298$ $T_2 = 100°C + 373 = 313$ $P_2 = \frac{1 \text{ atm} \times 373}{298} = 1.25 \text{ atm}$ The new pressure of the volume of gas is 1.25 atmospheres.
Given $T_1 = 25°C$; $P_1 = 1$ atm; $T_2 = 100°C$	
Relationships Use pressure-temperature relation to solve for P_2. Multiply each side by T_2 to isolate P_2 on one side of the equation. $P_2 = \frac{P_1 T_2}{T_1}$ Convert temperature values in Celsius degrees to Kelvin: $T_{Kelvin} = T_{Celsius} + 273$	

PRACTICE

1. At 400 K, a volume of gas has a pressure of 0.40 atmospheres. What is the pressure of this gas at 273 K?

2. What is the temperature of the volume of gas (starting at 400 K with a pressure of 0.4 atmospheres), when the pressure increases to 1 atmosphere?

3. Use the pressure-temperature relationship to fill in the following table with the correct values. Pay attention to the temperature units.

	P_1	T_1	P_2	T_2
a.	30.0 atm	- 100°C		500°C
b.	15.0 atm	25.0°C	18.0 atm	
c.	5.00 atm		3.00 atm	293 K

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Charles' Law

READ

Charles' law shows a direct relationship between the volume of a gas and the temperature of a gas when the temperature is given in the **Kelvin scale**. The Charles' law equation is below.

CHARLES' LAW

Initial volume (m^3) → V_1 ← ← V_2 ← *New volume* (m^3)

Initial temperature (K) → T_1 ← ← T_2 ← *New temperature* (K)

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

Pressure and mass constant

Converting from degrees Celsius to Kelvin is easy — you *add* 273 to the Celsius temperature. To convert from Kelvins to degrees Celsius, you *subtract* 273 from the Kelvin temperature.

EXAMPLE

A truck tire holds 25.0 liters of air at 25°C. If the temperature drops to 0°C, and the pressure remains constant, what will be the new volume of the tire?

Looking for

The new volume of the tire (V_2)

Given

$V_1 = 25.0$ liters; $T_1 = 25°C$; $T_2 = 0°C$

Relationships

Use Charles' Law to solve for V_2. Multiply each side by T_2 to isolate V_2 on one side of the equation.

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

Convert temperature values in Celsius degrees to Kelvin: $T_{Kelvin} = T_{Celsius} + 273$

Solution

$T_1 = 25°C + 273 = 298$

$T_2 = 0°C + 273 = 273$

$$V_2 = \frac{25.0\ L \times 273}{298} = 23.0\ L$$

The new volume inside the tire is 23.0 liters.

PRACTICE

1. If a truck tire holds 25.0 liters of air at 25.0°C, what will be the volume of air in the tire if the temperature increases to 30.0°C?

2. A balloon holds 20.0 liters of helium at 10.0°C. If the temperature increases to 50.0°C, and the pressure does not change, what will be the new volume of the balloon?

3. Use Charles' Law to fill in the following table with the correct values. Pay attention to the temperature units.

	V_1	T_1	V_2	T_2
a.		840 K	1,070 mL	147 K
b.	3250 mL	475°C		50°C
c.	10 L		15 L	50°C