Ministry of Higher Education and Scientific Research
AL-Mustaqbal University College of Science
Department of Biochemistry

Physical chemistry

Lecture 3

Gas Laws

By

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Vocabulary

Define the following vocabulary words:

- Direct Relationship
- Inverse Relationship
- Boyle’s Law
- Charles’ Law
- Lussac’s Law

Essential Questions

- What is the relationship between volume and pressure?
- What is the relationship between temperature and volume?
- What is the relationship between temperature and pressure?
- How do you manipulate the gas law equations to solve for certain variables?

Review

Temperature: the *motion* of the particles within a substance.

Volume: the amount of *space* a substance occupies.

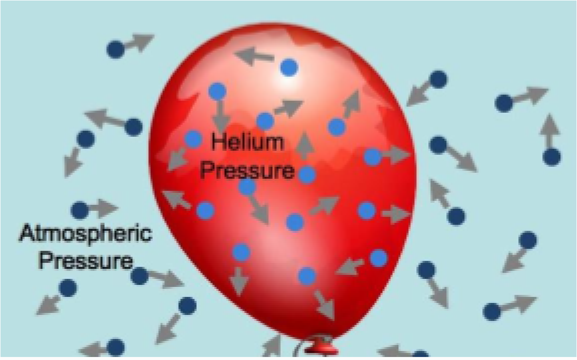
Pressure: the *collisions* of the particles in a substance.

Pressure

Pressure: the collisions of particles in a substance.

- **Tool:** Barometer
- **Units:** - Atmospheres (atm)

- Kilopascals (Kpa)
- Millimeters of Mercury (mm Hg)



Gas Laws

Three gas laws that describe the relationship between pressure, volume and temperature.

1. Boyle's Law
2. Charles' Law
3. Lussac's Law

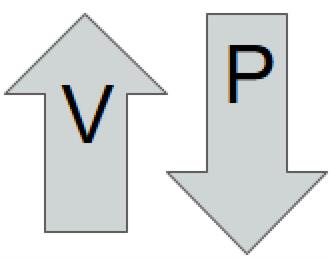
Boyle's Law

Boyle's law describes the relationship between **volume** and **pressure**. The temperature remains *constant* (not changing).

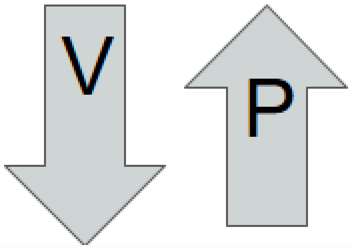
Boyle's Law is an indirect relationship (opposites)

Equation: $P_1V_1 = P_2V_2$

An increase in volume (space) results in a decrease in pressure (collisions).



A decrease in volume (space) results in a increase in pressure (collisions).



Boyle's Law - a change in pressure results in a indirect change in volume

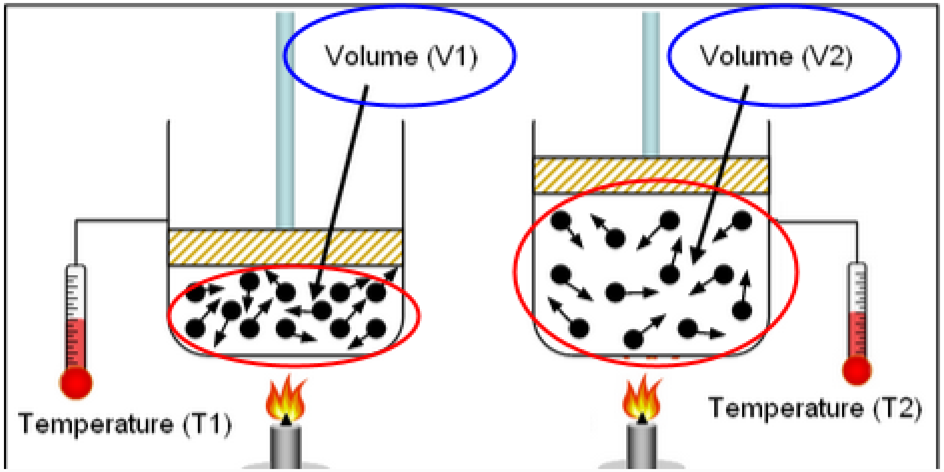
Pressure: increases
Volume: decreases
Temperature: constant

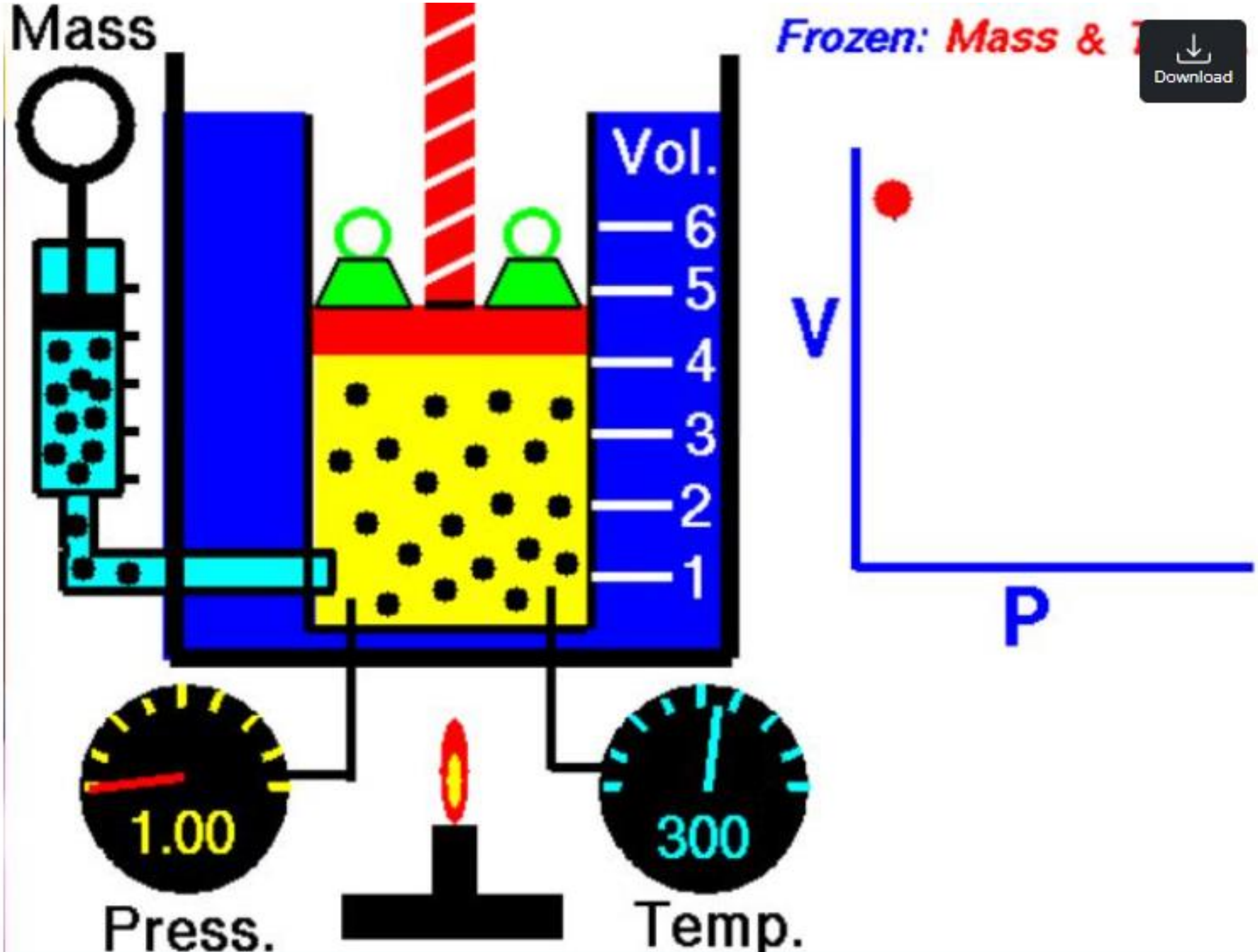
Pressure: decreases
Volume: increases
Temperature: constant

Relationship: indirect

- Opposites
- One increases; other decreases

Equation: $P_1V_1 = P_2V_2$

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Boyle's Law Example 1 (answer)

Problem: A container of gas has a volume of **5L** and a pressure of **100 kPa**. The container is taken up to a high altitude, and the pressure drops to **50 kPa**. What will be the volume of the gas at that pressure?

Equation: $P_1V_1 = P_2V_2$

Givens:

P_1 = 100 kPa

V_1 = 5 L

P_2 = 50 kPa

V_2 = ?

Work:

$P_1 \times V_1 = P_2 \times V_2$

$100 \times 5 = 50 \times V_2$

$\frac{500}{50} = \frac{50 \times V_2}{50}$

Answer (w/ Units): $10 L = V_2$

Boyle's Law Example 2 (answer)

Problem: A container of gas has a volume of **6L** and a pressure of **405 kPa**. The container is taken up to a high altitude, and the pressure drops to **50 kPa**. What will be the volume of the gas at that pressure?

Equation: $P_1V_1 = P_2V_2$

Givens:

P_1 = 405 kPa

V_1 = 6 L

P_2 = 50 kPa

V_2 = ?

Work:

$P_1V_1 = P_2V_2$

$405 \times 6 = 50 \times V_2$

$\frac{2430}{50} = \frac{50 \times V_2}{50}$

Answer (w/ Units): $48.6\,L = V_2$

Charles' Law

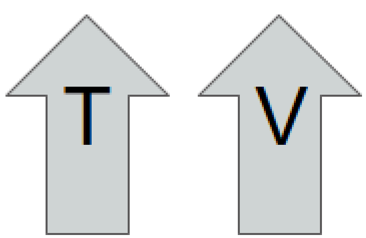
Charles' law describes the relationship between **temperature** and **volume**. The pressure remains *constant* (not changing).

Charles' Law is a direct relationship

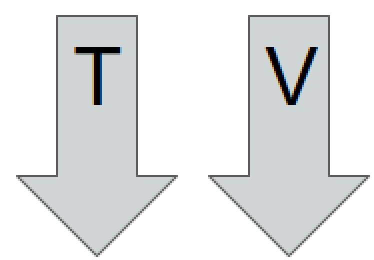
Equation: $V_1 = V_2$

T_1 T_2 — —

An increase in temperature (motion) results in an increase in volume (space).



A decrease in temperature (motion) results in a decrease in volume (space).



Charles' Law

Pressure: constant
Volume: increases
Temperature: increases

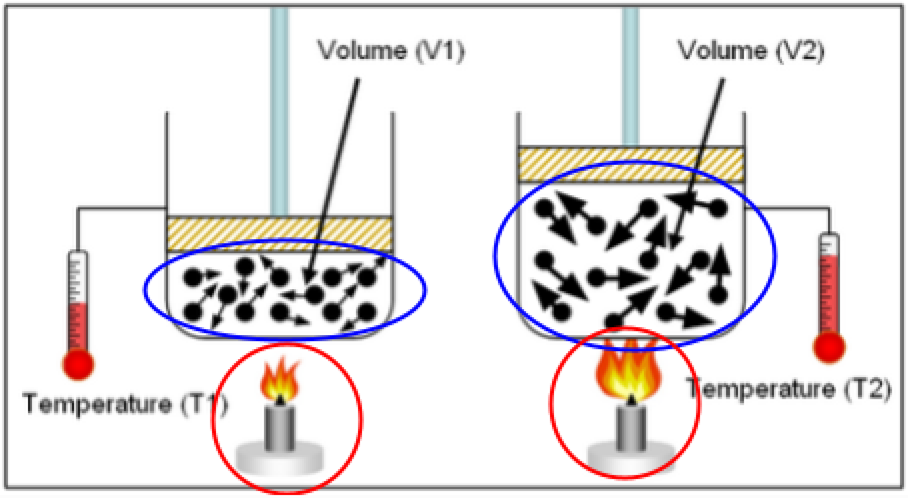
Pressure: constant
Volume: decreases
Temperature: decreases

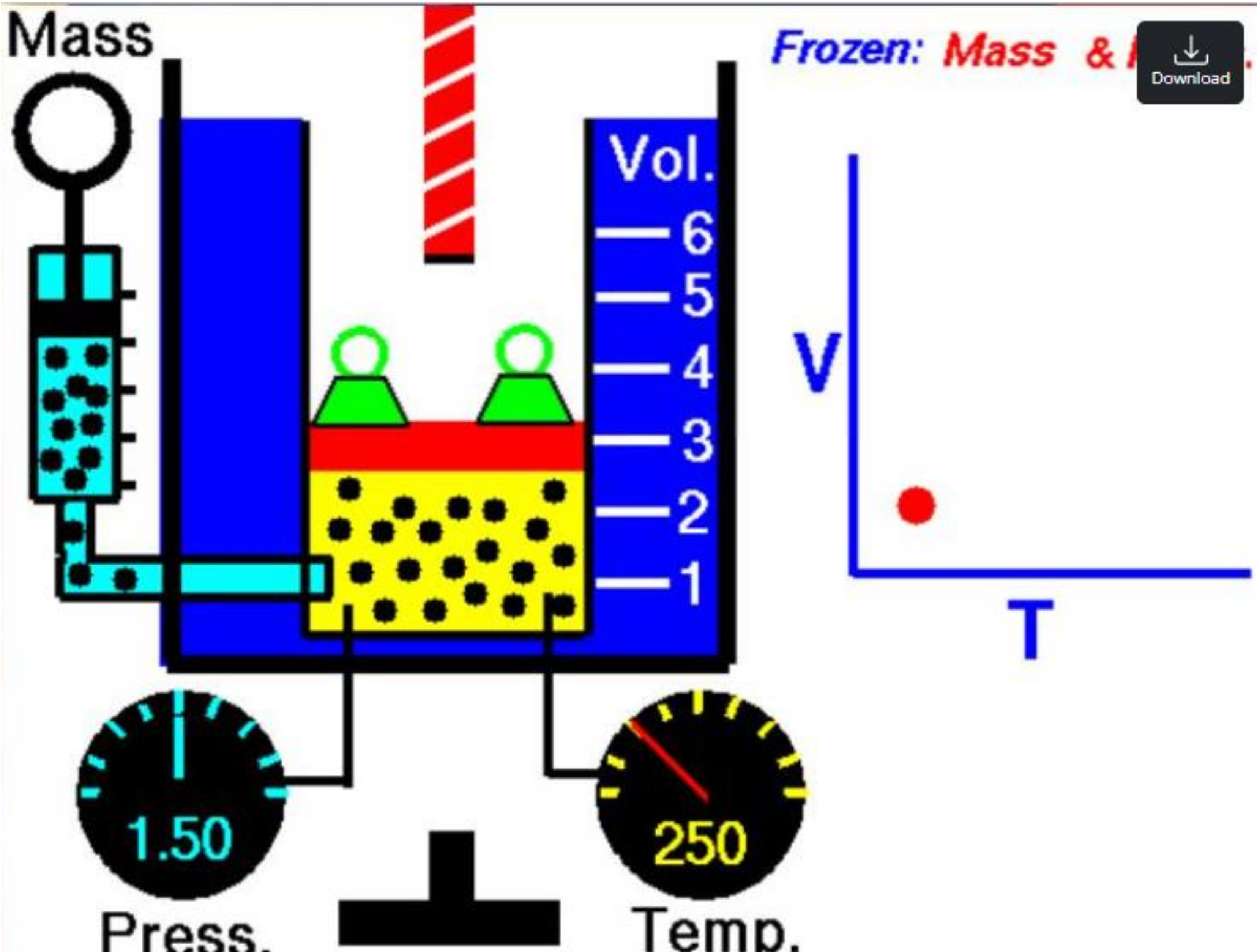
Relationship: direct

- Both increase/decrease together

Equation: $V_1 = V_2$

T_1 T_2

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Press.
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Charles' Law Example 1 (answer)

Problem: A container of gas has a volume of **2L** and a temperature of **300 K**. The container is heated to **1200K**. What will be the volume of the gas at that temperature?

Givens:

V_1 = 2 L

T_1 = 300 K

V_2 = ?

T_2 = 1200 K

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

Work:

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

$$\frac{2}{300} = \frac{V_2}{1200}$$

$$2 \times 1200 = V_2 \times 300$$

$$\frac{2400}{300} = \frac{V_2 \times 300}{300}$$

$$8\,L = V_2$$

Answer (w/ Units): **V_2 = 8 L**

Charles' Law Example 2 (answer)

Problem: A container of gas has a volume of **8L** and a temperature of **500 K**. The container is heated to **2389K**. What will be the volume of the gas at that temperature?

Givens:

V_1 = 8 L

T_1 = 500 K

V_2 = ?

T_2 = 2389 K

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

Work:

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

$$\frac{8}{500} = \frac{V_2}{2389}$$

$$8 \times 2389 = V_2 \times 500$$

$$\frac{19112}{500} = \frac{V_2 \times 500}{500}$$

$$38.224 \text{ L} = V_2$$

Answer (w/ Units): **V_2 = 38.244 L**

Lussac's Law

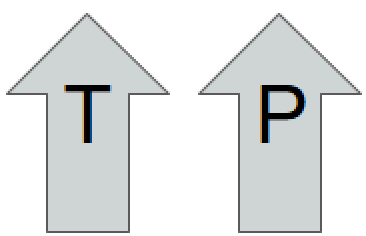
Lussac's law describes the relationship between **temperature** and **pressure**. The volume remains *constant* (not changing).

Lussac's Law is a direct relationship

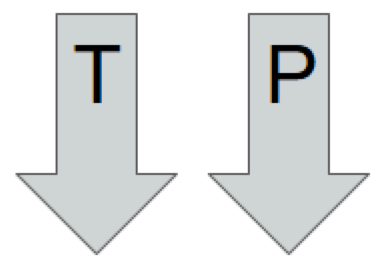
Equation: $P_1 = P_2$

T_1 T_2 — —

An increase in temperature (motion) results in an increase in pressure (collisions).



A decrease in temperature (motion) results in a decrease in pressure (collisions).



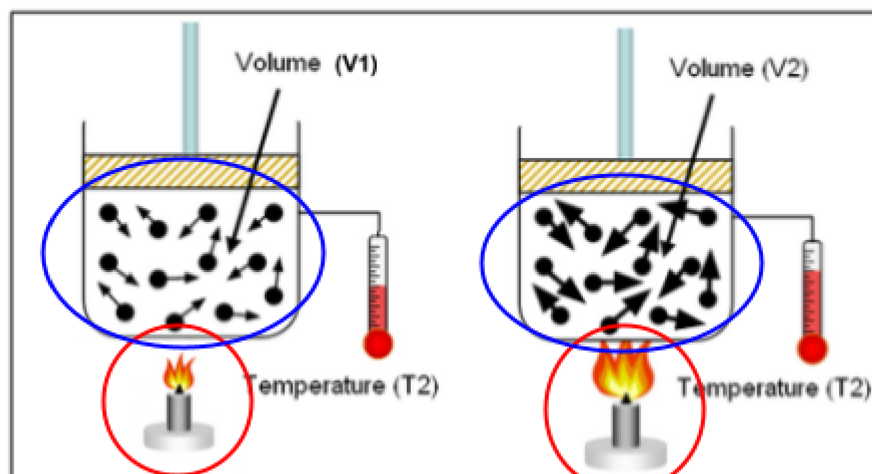
Lussac's Law

Pressure: increases	**Pressure:** decreases
Volume: constant	**Volume:** constant
Temperature: increases	**Temperature:** decreases

Relationship: direct

- Both increase/decrease together

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



Lussac's Law Example 1 (answer)

Problem: A 10L container of gas has a temperature of **500K** and a pressure of **100kPa**. The container is cooled to **100K**. What will be the pressure of the gas at that temperature?

Givens:

P_1 = 100 kPa

T_1 = 500 K

P_2 = ?

T_2 = 100 K

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

Work:

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

$\frac{100}{500} = \frac{P_2}{100}$

$100 \times 100 = P_2 \times 500$

$\frac{10000}{500} = \frac{P_2 \times 500}{500}$

20 kPa $= P_2$

Answer (w/ Units): **P_2 = 20 kPa**

Lussac's Law Example 2 (answer)

Problem: A .6L container of gas has a temperature of **355K** and a pressure of **950 kPa**. The container is cooled to **45K**. What will be the pressure of the gas at that temperature?

Givens:

P_1 = 950 kPa

T_1 = 355 K

P_2 = ?

T_2 = 45 k

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

Work:

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

$\frac{950}{355} = \frac{P_2}{45}$

$950 \times 45 = P_2 \times 355$

$\frac{42750}{355} = \frac{P_2 \times 355}{355}$

$120.42\ kPa = P_2$

Answer (w/ Units): **P_2 = 120.42 kPa**


Thank
you