Gas Laws

Aim: To examine the relationships between pressure and volume, temperature and volume, pressure and temperature.

Three main gas laws:

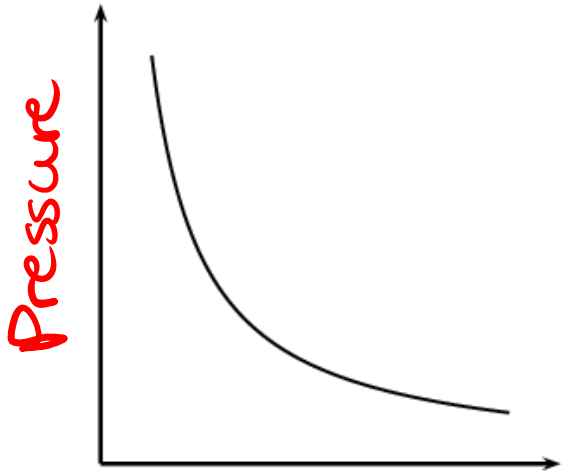
- Boyle's Law
- Charles' Law
- Gay-Lussac's Law

BOYLE'S LAW

Volume and Pressure

Boyle's Law: the relationship between pressure and volume.

Inverse Relationship between pressure and volume.



$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Combined law

Formula: $P_1V_1 = P_2V_2$

V ↓ P ↑

Ex: Water Bottle Cannon

As the space in the water bottle decreases, there are more collisions from the gas particles (more pressure).

P ↓ V ↑

Ex: Expanding balloon in the bell jar

As the pressure decreased surrounding the balloon, the volume of air inside was allowed to expand.

Boyle's Law Example Calculation

Determine the new volume of a gas when 66.0 mL at 71.0 kPa has its pressure increased to 101.3 kPa?

a) How does pressure change? How **should** volume change?

b) Calculation:

Boyle's Law Example Calculation

1 = initial
2 = final

Determine the new volume of a gas when 66.0 mL at 71.0 kPa has its pressure increased to 101.3 kPa?

a) How does pressure change? How **should** volume change?

P increases, V should decrease.

b) Calculation:

$P_1V_1 = P_2V_2 \rightarrow (71.0)(66.0) = 101.3\,X$

$4686 = 101.3\,X$

$P_1 = 71.0\ kPa$

$V_1 = 66.0\ ml$

$P_2 = 101.3\ kPa$

$V_2 = X$

$X = V_2 = 46.26\ ml$

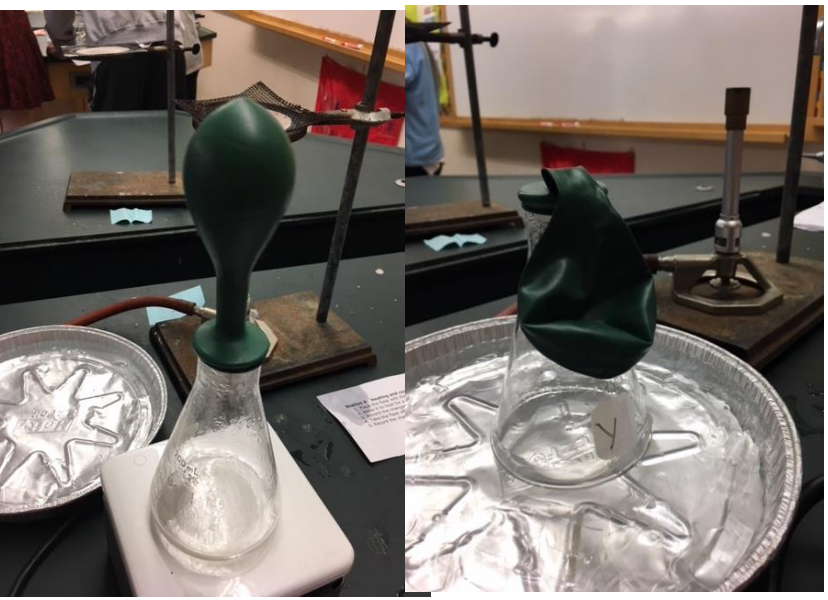
$46.3\ ml$

V decreased b/c P increased.

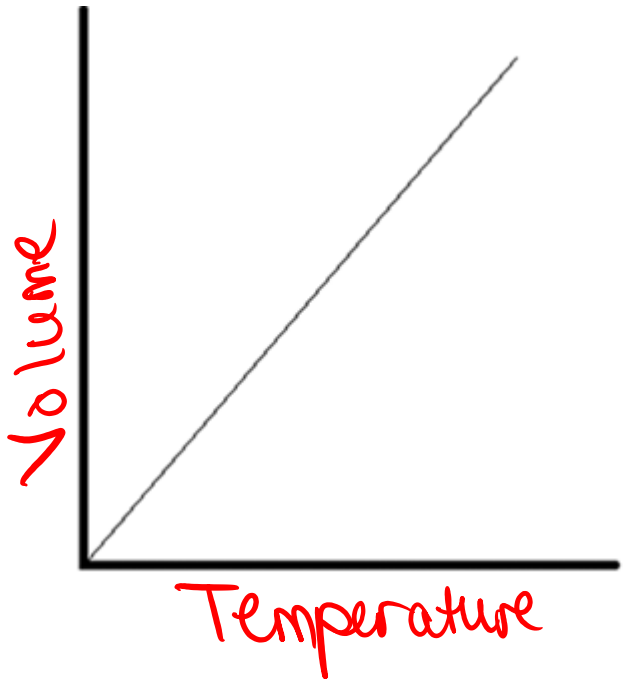
CHARLES LAW

https://www.youtube.com/watch?v=PdMtGyNEEv8

Charles Law: The relationship between temperature and volume.



Direct Relationship between temperature and volume.



$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

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

T ↑ V ↑

Ex: Balloon flask on the hotplate

- **As temperature (KE) increases, the particles move faster and occupy more volume.**

T ↓ V ↓

Ex: Balloon in liquid nitrogen

- **As temperature (KE) decreases, the particles move slower and occupy less volume.**

Charles Law Calculation

A sample of O_2 has a volume of 225 mL at 200. K. If the pressure of the sample is held constant and the temperature is raised to 400. K, what is the new volume of the gas?

a) How does temperature change? How **should** volume change?

b) Calculation:

Charles Law Calculation

A sample of O_2 has a volume of 225 mL at 200. K. If the pressure of the sample is held constant and the temperature is raised to 400. K, what is the new volume of the gas?

a) How does temperature change? How **should** volume change?

T increases so the Volume should also increase.

b) Calculation:

V_1: 225 mL

T_1: 200. K

V_2: X

T_2: 400. K

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad \frac{225}{200.} = \frac{x}{400.}$$

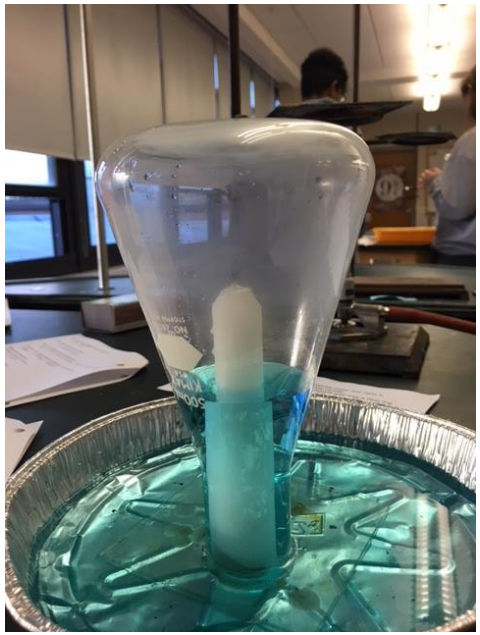
$$\frac{(225)(400)}{200} = \frac{200x}{200}$$

$x = V_2 = 450.\ mL$

V ↑ b/c T ↑

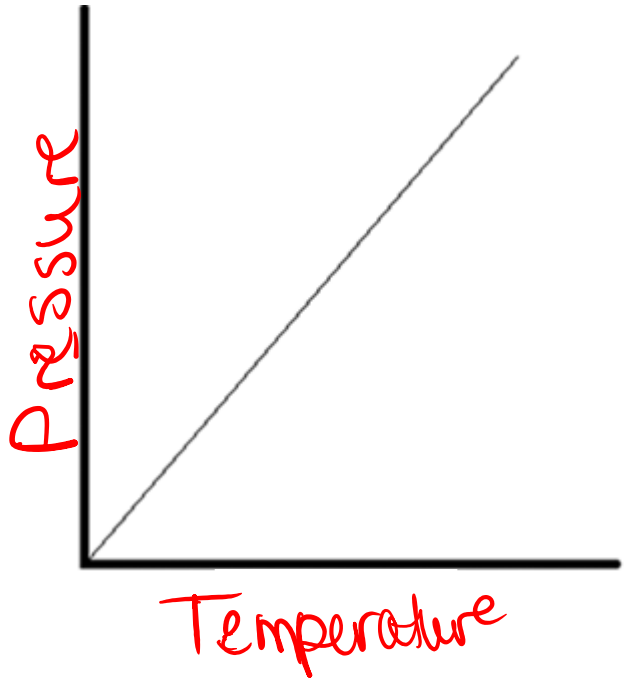
GAY LUSSAC'S LAW

https://www.youtube.com/watch?v=nD22mD17Q_k
@1:45 min



Gay-Lussac's Law: The relationship between temperature and pressure.

Direct Relationship between temperature and pressure.



$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

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

T ↑ P ↑

Ex: Can of beans on a camp fire.

As temperature increases the molecules move faster resulting in more collisions and higher pressure.

T ↓ P ↓

Ex: Water in flask

As temperature decreases the molecules move slower resulting in less collisions and lower pressure.

Gay-Lussac's Law Calculation

In a rigid container, a gas exerts a pressure of 55.0 kPa at 87°C. What would the pressure be at -88°C?

a) How does temp. change? How **should** pressure change?

b) Calculation:

Gay-Lussac's Law Calculation

In a rigid container, a gas exerts a pressure of 55.0 kPa at 87°C. What would the pressure be at -88°C?

a) How does temp. change? How **should** pressure change?

Temperature decreases so the pressure should decrease. (less movement, less particle collisions, lower pressure)

b) Calculation:

b) Calculation:

P1= 55.0 kPa
T1= 87 °C + 273= 360 K
P2= ?
T2=-88 °C + 273= 165 K

$$\frac{P1}{T1} = \frac{P2}{T2}$$

$$\frac{55.0\ kPa}{360\ K} = \frac{P2}{165\ K}$$ **cross multiply**

$$P2 = \frac{55.0 \times 165}{360} = 25.0\ kPa$$

P decreased because T decreased.

- How can I get the egg into the flask without touching it?

https://www.youtube.com/watch?v=tupFLbifx5M

DEMOS

Egg in a Bottle

https://www.youtube.com/watch?v=28TIyWdfxxc

CAN CRUSH