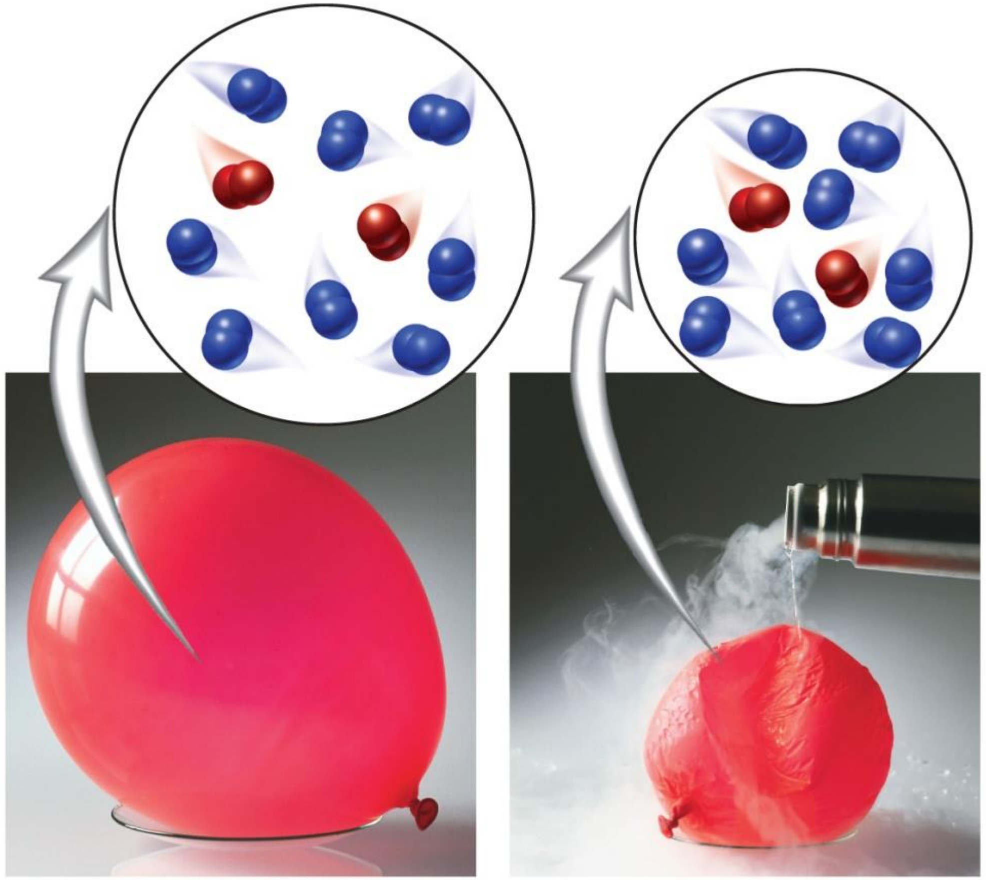
Charles' Law

http://www.middleschoolchemistry.com/atomsworld/2012/09/not-just-hot-air/



Outcomes:

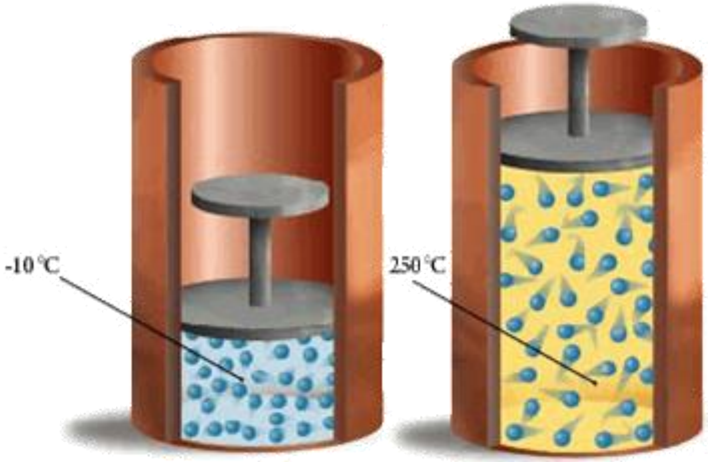
- Experiment to develop the relationship between volume and temperature of a gas using visual, numerical and graphical representations. *Include: contribution of Charles, absolute zero, Kelvin Scale*

Jacques Charles…

https://hydropole.ch/hydrogen/transport/

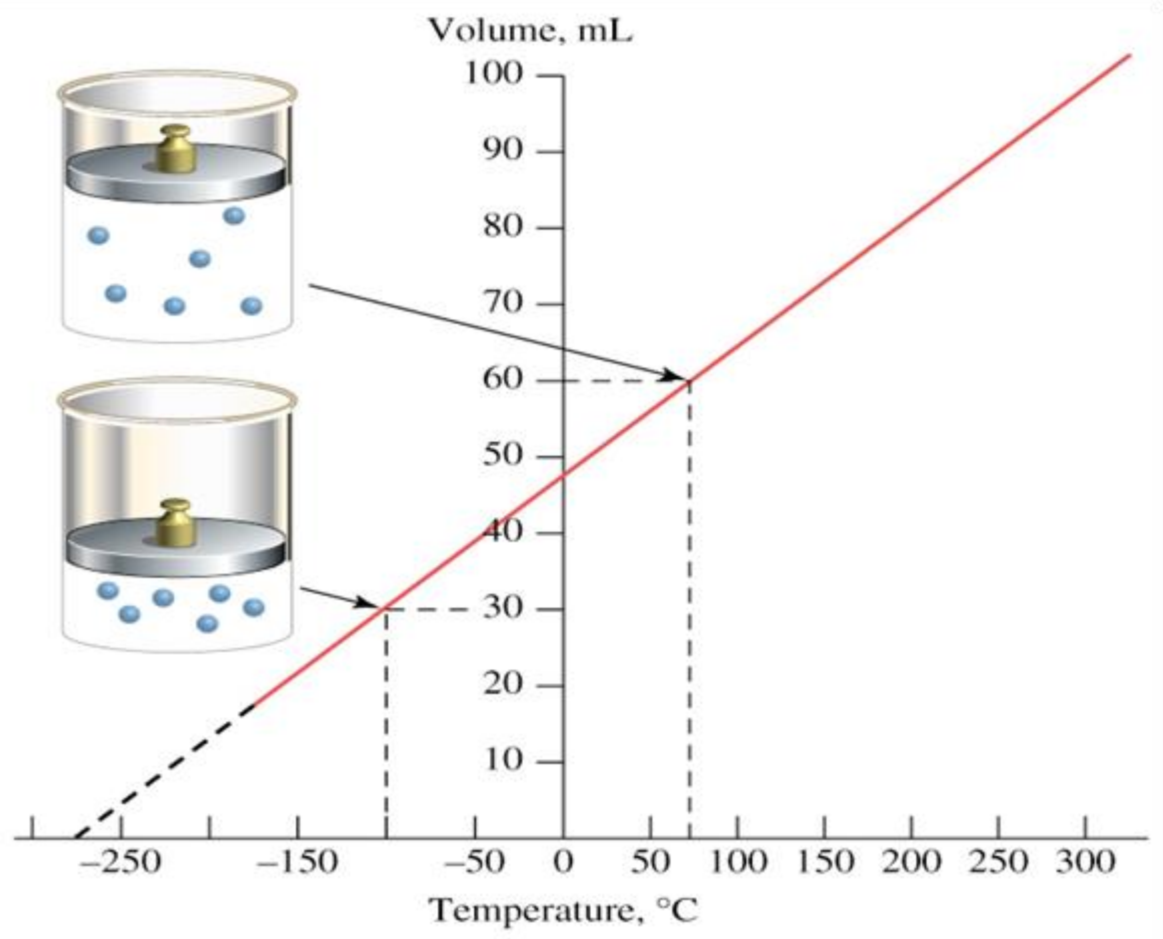
Found that there is a relationship between **TEMPERATURE** and the **VOLUME** that a gas occupies.

- He did so by **TRAPPING** a gas sample in a **CYLINDER** with a moveable **PISTON**.
- He immersed the cylinder in a **WATER BATH** and varied the **TEMPERATURE**.
- He found that as the **TEMPERATURE** was **INCREASED**, so did the **VOLUME**. (see overhead)
- Note: **AMOUNT** of gas and **PRESSURE** were held constant.



http://asset.emsofl.com/ONLINE%20CLASS/PhysLifeCD/_CDDAT/PhySci/unit01/phschool.com/SE_K_SC2_ACT3.html

Charles Law:



https://chemistry-batz.wikispaces.com/14+Gas+Laws

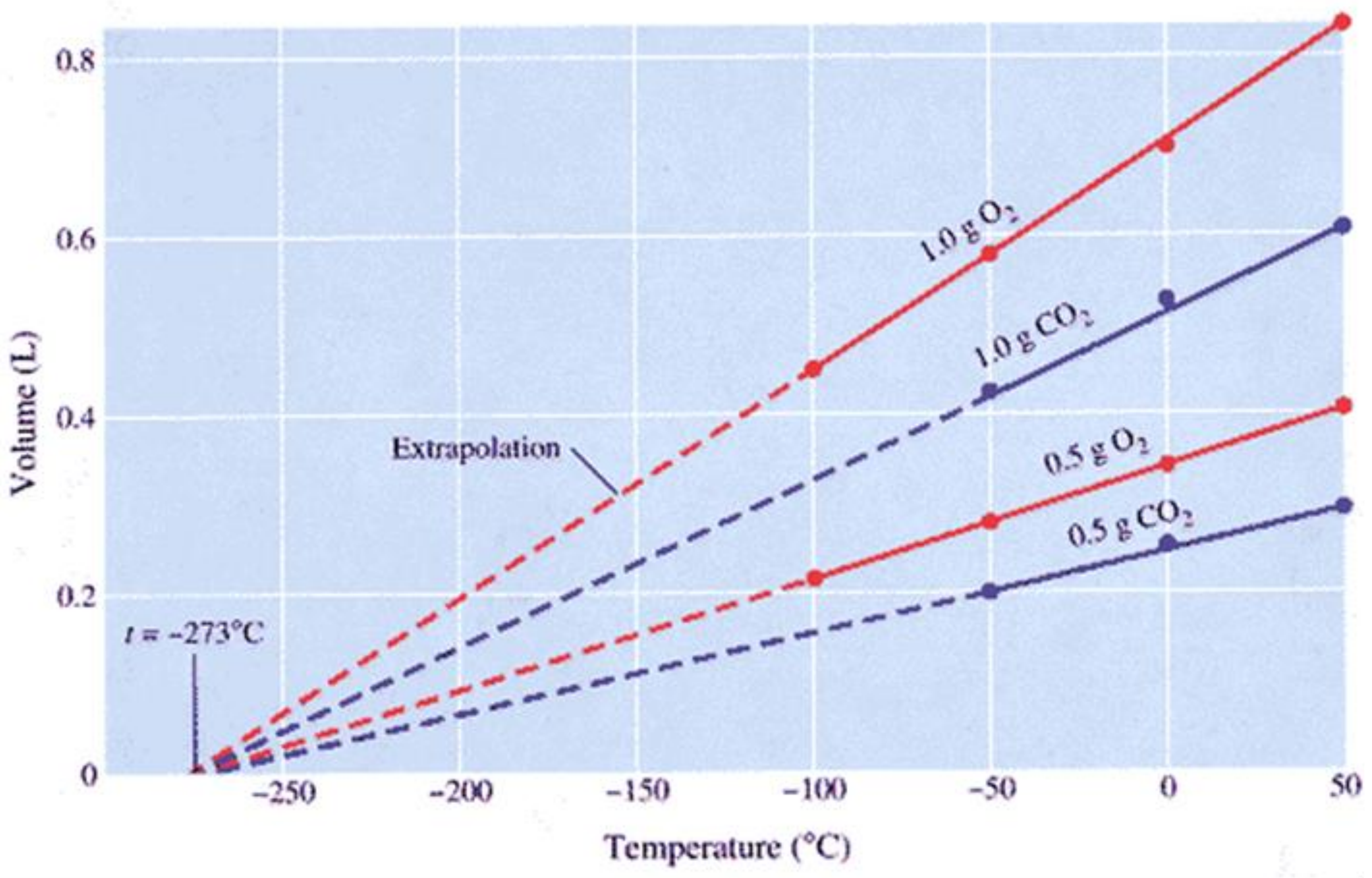
If you look at the graph, you will see that we get a **STRAIGHT** line of **POSITIVE SLOPE**.

→ Indicates that volume is **DIRECTLY PROPORTIONAL** to temperature.

Charles Law:

Charles was not able to achieve very low temperatures, but the line could be extended to see what would happen. (see second graph)

- Notice that each line, when extended, ends up at the same value…about **-273°C**! → more to come



http://www.slideshare.net/geethujojo/gas-laws-ppt

Absolute Zero:

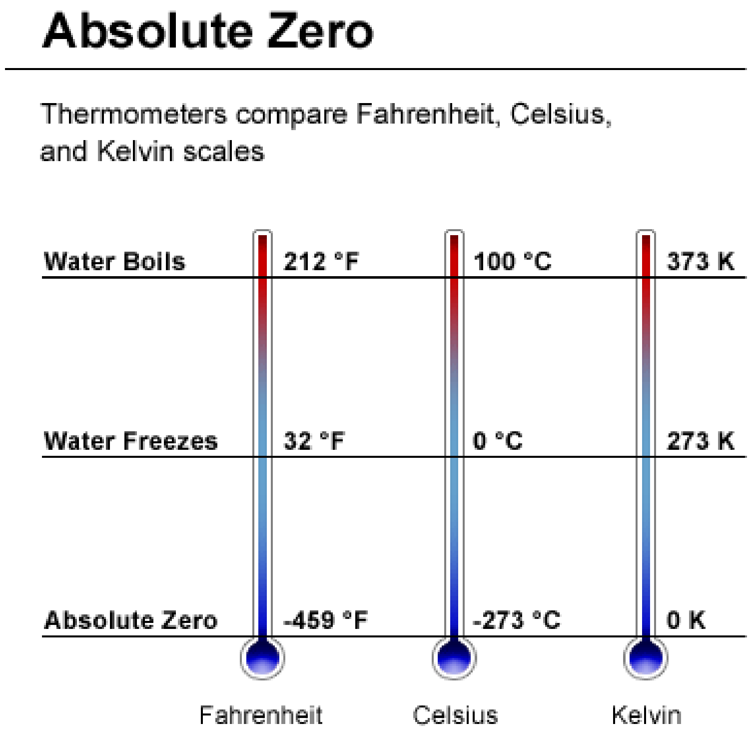
When the lines are **EXTRAPOLATED** downward, it meets the horizontal axis at **-273°C**.

- So, if the gas did not **LIQUEFY**, its volume would become **ZERO** at **-273°C**.
- This temperature is thought to be the **LOWEST POSSIBLE** temperature, called **ABSOLUTE ZERO.**

The Kelvin Scale:

Lord Kelvin (William Thompson) reasoned that at absolute zero,
all **<u>MOLECULAR</u>** **<u>MOTION</u>** **<u>STOPPED</u>**.

- He then devised a **NEW** temperature **SCALE**, that **STARTED** at absolute zero (actually -273.15°C)
- On this scale, absolute zero is **Ø K** (no ° symbol).
- The advantage of this scale is that there are no **NEGATIVE** numbers, this helps with Charles' law.



http://www.crbcsc.org/absolute-zero/

The Kelvin Scale:

Conversion:

°C = K – 273 **OR** ***K = °C + 273***

*****remember that Kelvin is always better than Celsius!***

Ex) Convert the following:

1. 25°C to Kelvin

   25 + 273 = 298 K

2. 50K to Celsius

   50K − 273 = −223 °C

Charles' Law (Finally)…

"The volume of a given gas varies directly with temperature in Kelvin, if the pressure and amount of gas are constant."

This means that the **RATIO** of **VOLUME** and **TEMPERATURE** remains **CONSTANT**, so:

$$\frac{V_1}{T_1} = k \quad \text{and} \quad \frac{V_2}{T_2} = k$$

Therefore:

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

Charles' law

Where, V = **VOLUME**, & T = **TEMPERATURE**(**IN K**)

Charles' Law Examples…

Examples:

If the temperature of 6.00L of a gas at 25.0°C is increased to 227°C, determine the volume at the new temperature.

298K → 500K

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

$$\frac{6L}{298K} = \frac{V_2}{500K}$$

$$\frac{(6L)(500K)}{298K} = V_2$$

$$V_2 = 10.07\ L$$

T ↑ V ↑

$$6.00L \times \frac{500K}{298\ K} = 10.07\ L$$

Charles' Law Examples…

Examples:

If the volume of a gas at -73.0°C is doubled to 48.0L, calculate the final temperature in °C.

200K $V_1 = 24\ L$

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

$$\frac{24L}{200K} = \frac{48L}{T_2}$$

$$T_2 = \frac{(48L)(200K)}{(24L)}$$

$$T_2 = 400K - 273 = 127°C$$

V↑ T↑

$$200K \times \frac{48L}{24L} = 400K$$

Charles' Law Examples…

Try these ones…

A gas inside a cylinder with a movable piston is heated to 315°C (588K). The volume of gas in the cylinder is 0.30L at 25°C (298K). What is the final volume when the temperature is 315°C?

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

$$\frac{0.3L}{298K} = \frac{V_2}{588K}$$

$$V_2 = \frac{(0.3L)(588K)}{298K}$$

$$V_2 = 0.59L$$

$T\uparrow V\uparrow$

$$0.3L \times \frac{588K}{298K} = 0.59L$$

Charles' Law Examples…

Try these ones…

T_1 283K

On a cool morning (10.0°C), a group of hot air balloonists start filling their balloon with air. After the balloon is three fourths full, they turn on the propane burner to heat the air. At what temperature (in °C) will the air completely fill the balloon (capacity is 1700m³). Assume pressure and amount of gas are constant.

V_2

V_1

$$1700\,m^3 \times \frac{3}{4} = 1275\,m^3$$

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

$$\frac{1275\,m^2}{283\,K} = \frac{1700\,m^3}{T_2}$$

$$T_2 = \frac{(1700\,m^3)(283\,K)}{1275\,m^3} = 377.3\,K - 273 = 104\,°C$$