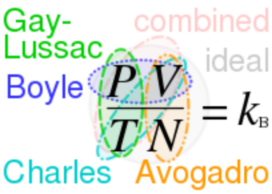
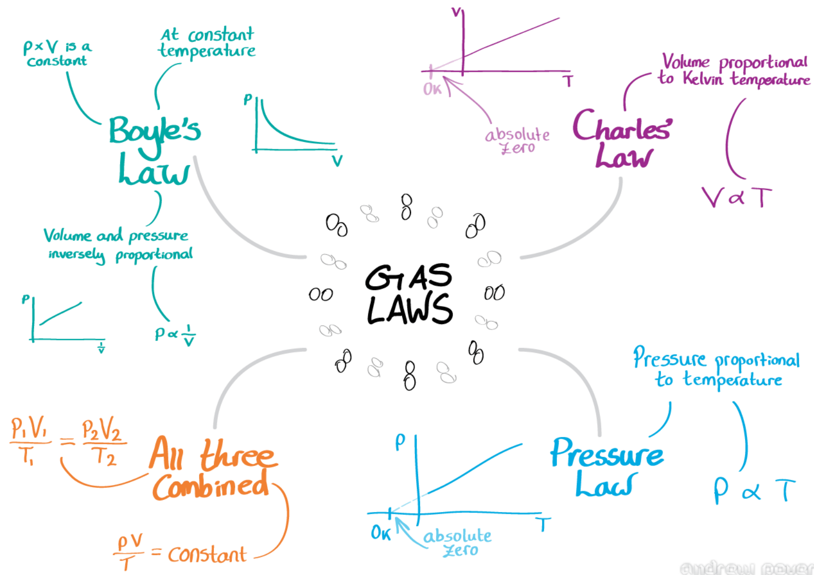


CHEMISTRY 11
GAS LAWS



Pressure is measured in:

1 atm = 760. mmHg = **101.3 kPa**

THE IDEAL GAS CONSTANT "R"

$R = 8.31 \frac{kPa \cdot L}{moles \cdot K}$

STP : 0°C = 273 K ***and*** 101.3 kPa
Standard Temperature and Pressure

RTP : 25°C = 298 K ***and*** 101.3 kPa
Room Temperature and Pressure

START BY WATCHING THIS 9 minute video: https://youtu.be/BxUS1K7xu30

From this video, we understand that we can make several (mathematical) and observational relationships between the pressure and volume of gases.

The rest of this document highlights these various mathematical relationships:

Dalton's Law of Partial Pressures:

-the total pressure exerted by the mixture of non-reactive gases is equal to the sum of the partial pressures of individual gases **P_T = Pa + Pb + Pc + ... +Pz**

Example: Determine the total pressure of a gas mixture that contains oxygen, nitrogen, and helium if the partial pressures of the gases are P_{O_2} = 20.0 kPa, P_{N_2} = 46.7 kPa, and P_{He} = 26.7 kPa.

P_{TOTAL} = P_{O_2} + P_{N_2} + P_{N_2} = 20.0 kPa + 46.7 kPa + 26.7 kPa = 93.4 kPa

(1 dec place required in the answer, to retain significant figures)

A hot air balloon will float on air…Why? Why does air become less dense as it is heated?

As the molecules gain energy from the **heat** source, they start to move faster, and they **are** moving apart. (Grade 8, Kinetic Molecular Theory). So the gases in **air**, like most other substances, expand when **heated** and contract when cooled. The faster moving gas particles have more space between the molecules. This means that the **air is less dense** than the surrounding matter and this is why the **hot air** floats upward.

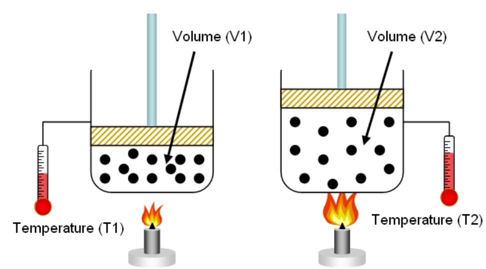
Charles proved this in an experiment

⇒Watch this 3 minute video: *https://youtu.be/BY9VGS2eXas*

Charles' Law:

-when the pressure and the number of moles of a gas are held constant, the volume of a gas is directly proportional to the **Kelvin** temperature.

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



Charles Law EXAMPLES:

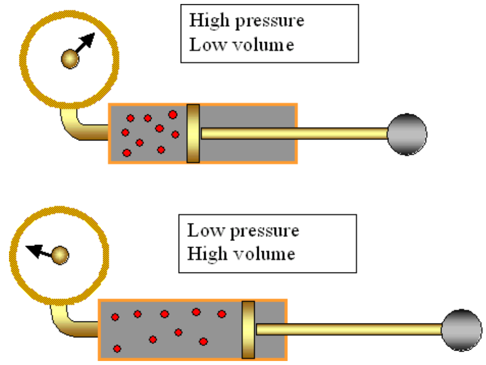
1. A 250 mL sample of gas exists at 25 °C.
What volume will the gas occupy at 50. °C if pressure remains constant?

2. Nitrogen gas occupies 400. mL at 100 °C. At what temperature would the gas occupy 200. mL?

Boyle's Law:

-when the temperature and the number of moles of a gas are held constant, the volume of a gas is inversely proportional to the pressure applied on the gas.

$$V_1P_1 = V_2P_2$$



Boyles Law EXAMPLES:

1. A sample of gas occupies 10.L at 105 kPa. At what pressure will it occupy 13.4 L? (Assume constant temperature, when no reference to energy change is mentioned).

2. A sample of gas occupies 9.8 L under a pressure of 101.3 kPa. What will its volume be at 108 kPa?

Base on Charles' and Boyle's Laws, we can logically see this relationship:

Gay-Lussac's Law:

-the pressure of a gas, at constant volume, is directly proportional to the absolute temperature.

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

Kelvin temperature!

EXAMPLE:

1. At constant volume, a gas exerts 500. kPa of pressure on a container's walls at 250. K. What will the pressure be at 350. K?

⇒ **WATCH THIS 5.5 minute video: https://youtu.be/ir64EcRkf5Q**

While watching this video, pay attention to his use of the graph to find mathematical relationships

Interested in the simulations he was using in this video?

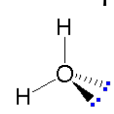
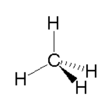
CHECK THEM OUT HERE! https://phet.colorado.edu/en/simulation/gas-properties

Ideal gas law: **PV = nRT**

- Where P = pressure in kPa
- V = Volume (of a gas) in L
- n = the **n**umber of moles
- R is the ideal gas constant
- T is the temperature in **Kelvin**

IDEAL GAS:

An Ideal gas is a state of matter above its boiling point but below its plasma point AND meets the following criteria:

IDEAL GAS	***vs.***	**REAL GAS**
no attractive forces between neighbouring molecules		liquids and solids result from attractions between molecules
all molecules are perfect spheres		H_2O "V shaped"  Water CH_4 "tetrahedral"  Methane
molecules occupy zero volume (don't occupy any space)		mass and volume are essential properties of matter
molecule collisions are perfectly elastic		energy loss during collisions causes chemical reactions

HOWEVER, despite the inadequate nature of each assumption, the combination of these allows a good model, providing the gas is not near it condensing point.

This means that in Chemistry (and sometimes in Physics) we treat gases as if they are real, so that we can determine the volume, pressure, etc.

Ideal Gas Law EXAMPLES:

1. What volume will 480 g of ammonia gas occupy at 125 ^{o}C and 180 kPa?

2. What pressure is exerted by 54.0 g of Xenon in a 1.00 L flask at 20 ^{o}C?

3. A sample of oxygen gas occupies 3.25 L 24 ^{o}C and 100.4 kPa. What is the mass of the gas?

<u>Combined gas law:</u>

If… $\frac{V_1P_1}{T_1} = R$ and $\frac{V_2P_2}{T_2} = R$ ***Then…*** $\frac{V_1P_1}{T_1} = \frac{V_2P_2}{T_2}$

Kelvin temperature!

memory hint: write the letters in alpha order for this calculation "tool." Think of a teeter totter.

P	**T**	**V**
	Δ	

If Pressure increases, then Volume decreases
If Volume decreases, then Pressure increases
etc.

<u>Combined Gas Laws EXAMPLES</u>:

1. A sample of neon occupies 100.L at 27.0°C at 133 kPa.
What volume would it occupy at standard conditions?

V1 = V2 =

T1 = T2 =

P1 = P2 =

2. A meteorological balloon occupies 140 litres at 39°C and 95 kPa.
What volume will it occupy at 85°C and 121 kPa?

V1 = V2 =

T1 = T2 =

P1 = P2 =