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| **Objectives** |
| * Use standard temperature and pressure, STP, in calculations involving Boyle's Law, Charles' Law, and the Combined Gas Law.
* Use vapor pressure in calculations involving Dalton's Law of Partial Pressure.
* Use Avogadro's Principle and molar volume to calculate the number of molecules in a volume of gas.
* Use the Ideal Gas Equation, with its modification, to calculate gas conditions.
* Use Graham's Law to compare the diffusion rates of gases.
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**The Gas Laws:**

[**Boyle's Law**](http://www.howe.k12.ok.us/~jimaskew/#boyle) **|** [**Charles' Law**](http://www.howe.k12.ok.us/~jimaskew/#charles) **|** [**Combined Gas Law**](http://www.howe.k12.ok.us/~jimaskew/#combined) **|** [**Dalton's Law of Partial Pressures**](http://www.howe.k12.ok.us/~jimaskew/#dalton)

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| A temperature and pressure are needed to describe any volume of gas.  |

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|  | **The volume of a gas means nothing unless the conditions under which it was collected are known.**  |

**Temperature** - Temperature changes cause particle motion changes which cause a volume change.
**Pressure** - Gases can be compressed, or squeezed, causing a change in the gas volume.

**Standard temperature and pressure - STP:**

**Standard temperature is o0 Celcius.**

* + **All gas calculations must use Kelvin temperatures.**
	+ K = Co + 273
	+ Notice it is K - not oK
	+ You say "Kelvins" - not "Degrees Kelvin"

**Standard pressure is 1 atmosphere (at sea-level).**



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| **1 atm = 760 mm Hg = 101 kPa = 101,300 Pascals = 1013 mb = 29.92 in Hg**  |

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* + **mm Hg** is millimeters of mercury. This describes the height of a vertical column of mercury that the pressure will support against gravity. The unit **Torr** can be used to indicate mm Hg. The barometric pressure reported in U.S. weather reports is usually expressed as **inches** of mercury. There are 25.4 millimeters in one inch.
	+ **kPa** is kiloPascals. A **Pascal** is a unit of force equal to one Newton / m2. It is describing the pressure exerted by the molecules of the gas striking a surface.
	+ **mb** is millibars. One millibar is equal to 100 Newtons / m2.
	+ When working with gas laws, all pressure units must be the same in any calculation.
	If needed, be able to **convert** from one pressure unit to another.



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|  | **To be successful working gas law problems, do the following:** Read the question to see what conditions change.Decide which gas law to use and write its equation.Reread the question to see what question is asked.Manipulate the gas law equation if needed.Plug numbers and units into the equation.Pickup your calculator and punch buttons.Write the answer to the problem and circle it.  |

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| **Boyle's Law: *used when the pressure of a gas changes.***  |

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**At constant temperature, pressure exerted by a gas varies inversely with its volume.**

* If the volume of a container decreases, pressure of the gas increases.
* If the volume of a container increases, pressure of the gas decreases.
* Boyle's Law is expressed by the equation:

**Use this webtest to practice Boyle's Law calculations.**



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| **Concept Understanding:** * 1. Do the following conversions:
		1. 27 K to Celcius
		2. 1450 oC to K
		3. 1.25 atmospheres to inches of Hg
		4. 500 millimeters of Hg to kPa
		5. Convert your answer in d to millibars.

* 1. Work the following Boyle's Law practice problems:
		1. 10 dm3 of a gas are collected at STP. What will be the volume if the pressure changes to 9.5 kPa while the temperature remains unchanged?
		2. What is the volume occupied by 5 dm3 of a gas at STP if the pressure increases to 500 kPa and the temperature remains constant?
		3. 90 cm3 of a gas are collected at 97.5 kilopascals. If the temperature does not change, at what pressure will the volume be 70 cm3?

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**Day 2**

**Lab #2**

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| **Charles' Law: *used when the temperature of a gas changes.***  |

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**At constant pressure, volume of a gas varies directly with the Kelvin temperature.**

* As the temperature of a gas increases, the volume of the gas increases.
* As the temperature of a gas decreases, the volume of the gas decreases.
* Charles' Law is expressed by the equation:

**Use this webtest to practice Charles' Law calculations.**



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| **The Combined Gas Law: *used when both pressure and temperature change.***  |

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**A combination of Boyle's Law and Charles' Law.**

* The Combined Gas Law is expressed by the equation:

**Use this webtest to practice Combined Gas Law calculations.**



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| **Concept Understanding:** * 1. Work the following Charles' Law practice problems:
		1. A gas has a volume of 495 cm3 at STP. Assuming no pressure change, what volume will the gas occupy if the temperature is doubled?
		2. A sample of hydrogen gas occupies 2.5 dm3 at 20 oC. What will be its volume at -10 oC?
		3. A gas occupies a volume of 500 cm3 at 120 oC. Assume the pressure does not change, to what temperature must the gas be cooled for the volume to drop 10%?

* 1. Work the following Combined Gas Law practice problems:
		1. Calculate the volume of a gas at STP if 5.05 dm3 of the gas are collected at 27.5 oC and 95.0 kPa.
		2. A gas occupied 355 cm3 at a pressure of 99.5 kPa and a temperature of 22 oC. The pressure increases 10 kPa and the temperature drops 7 Co. What is the new volume?
		3. Assume the respiratory rate for a person is 15 breaths per minute and one breath contains 500 cm3 of air at 20 oC and 99.5 kPa. What volume of air, in cubic meters, corrected to standard conditions, does an individual breathe in one day?

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**Day 3**

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| **Dalton's Law of Partial Pressure: *used with a mixture of gases.***  |

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* The total pressure in a container is the sum of the partial pressures of all the gases in the container.
* When a gas is collected by water displacement in the lab, the collected sample will contain water vapor. A calculation using Dalton's Law must be used to determine the pressure of the **dry gas** (the gas with no water vapor). To do this calculation, you will need the **vapor pressure of water at the collected temperature**.



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| **Concept Understanding:** * 1. Work the following Dalton' Law practice problems:
		1. The total pressure in a closed container of three mixed gases is 96.4 kPa. The partial pressure of hydrogen in the mixture is 13.5 kPa and the partial pressure of oxygen is 29.3 kPa. The third gas in the mixture is methane, what is its partial pressure?
		2. 100 cm3 of hydrogen gas are collected using water displacement in the lab. The conditions at the time are 98.5 kPa and 24 oC. What volume of dry hydrogen is collected?
		3. 325 cm3 of oxygen are collected over water at 10 oC and 98 kPa. What will be the volume of the dry gas at 101 kPa and 10 oC?

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**Conversion Answers**

1. -246 oC
2. 1723 K
3. 37.4 inches of Hg
4. 66.4 kPa
5. 664 mb

**More Conversion Practice**