Combined Gas Law

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Link: http://www.virtualhomeschoolgroup.com/file.php/1/03_Science/04_Chemistry/General_Chemistry/M12_Gases/L1_Combined_Gas_Law/Published/SWF_and_HTML5/multiscreen.html

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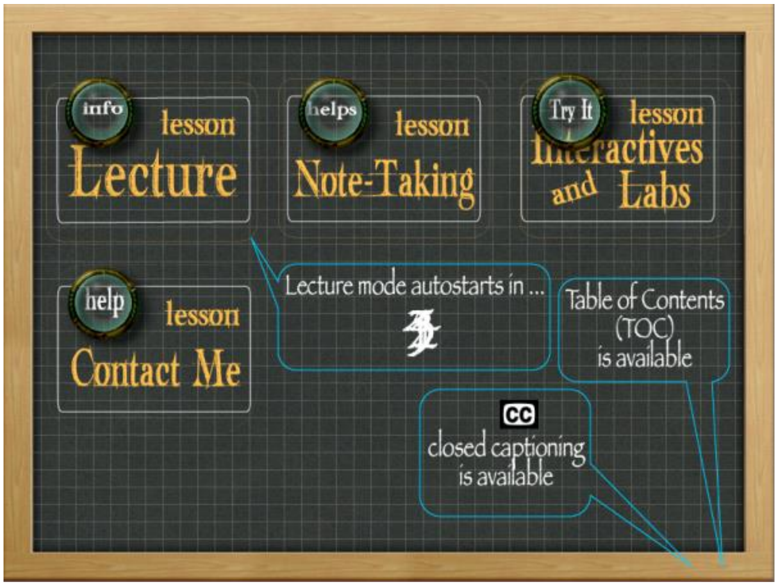

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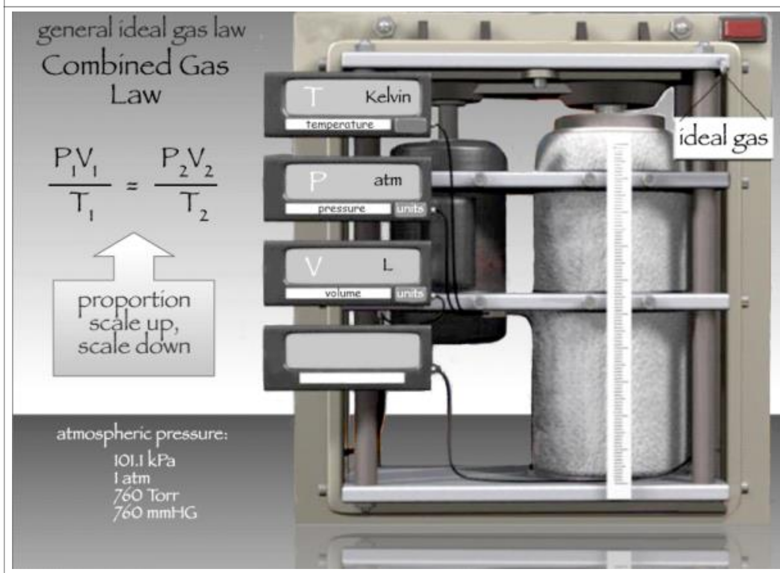

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Combined Gas Law

In this lesson you will be introduced to the combined gas law which will let you make computations relating gas temperature, pressure, and volume.

Temperature will not be in the units you are used to though. This time you will be working in Kelvin unit. You will understand why Kelvin is so special in just a bit.

Pressure can have many possible units: atmospheres, Newtons per square meter which usually just gets renamed to Pascals, millimeters of mercury, torrs, and pounds per cubic inch.

Knowing the units is nice, but what is pressure? Pressure comes from the molecular motion. The molecules are bouncing around and their bounces push against the sides of the container. It can even push on you. Atmospheric pressure is the weight and pressure of air that is all around you. At sea level, you will have defined pressure being exerted on your body but there are several units. All these units are equivalent to each other, so you can use one you are given and one you need to convert to and set them up in a factor label to convert from one to the other.

Volume can be in L or if the volume is smaller it may be in mL. It can also be I m^3 or if the volume is smaller it may be in cm^3.

The Combined Gas Law equation looks like this. It is set up so that you can be given the T, P, and V in one scenario and be able to scale up or down to new conditions in these variables.

We are going to walk through how the Combined Gas Law was created. In doing so not only do you get a little history in, but you also will see how simpler equations can often be combined into more powerful equations that are able to show multiple relationships at the same time.
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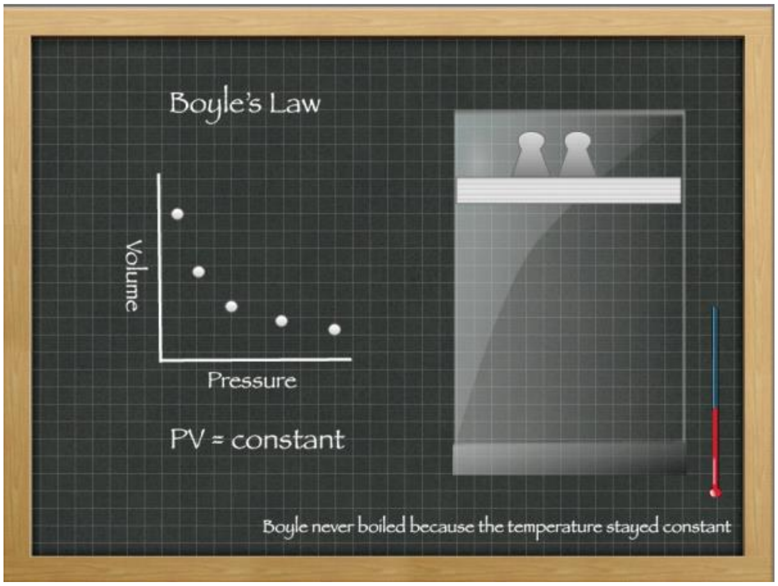
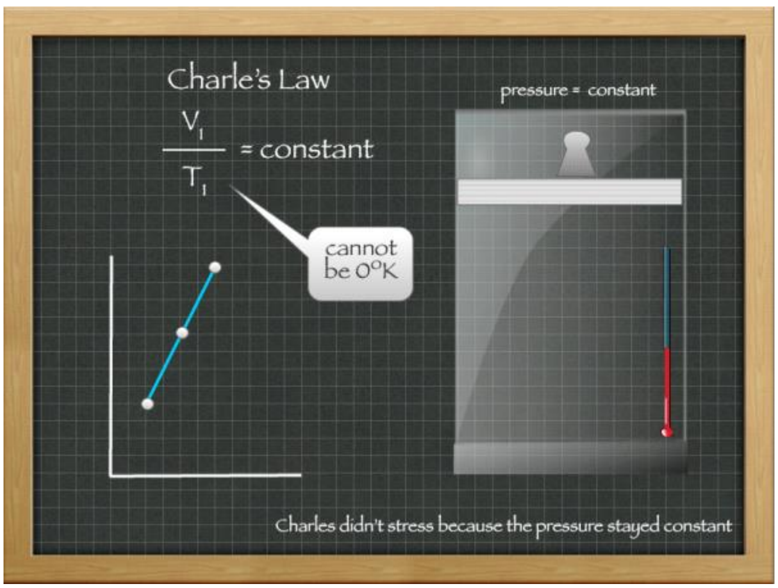
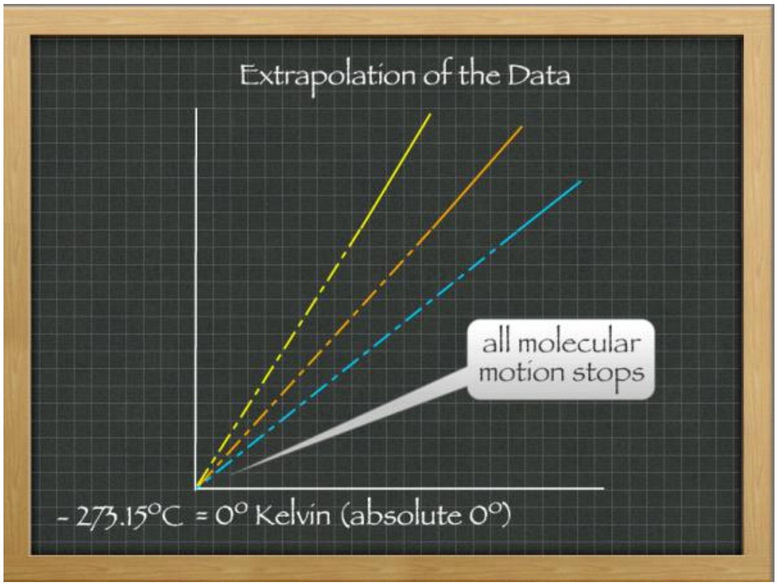
	Boyle's Law In the mid 1600's an Irish scientist named Robert Boyle did several experiments relating pressure and volume. He kept the temperature constant. What he found was that each time he added a weight which increased pressure, the volume would go down. However, as he added more pressure the volume drop changed a little less each time until eventually he had to add a lot of pressure to get even a little bit less volume. This type of a relationship between variables is called inverse variation. You will not need to memorize this equation because another scientist came along …
	Charles' Law In the late 1700s, a French scientist named Jacques Charles built upon Boyle's work. He explored how temperature fit in. He kept the pressure the same. He found that temperature and volume were related linearly, but that as you increased one, the other went up too. This is a direct relationship. You don't need to memorize this equation either because one more scientist is yet to come. Before we get to him, though, I want to tell you about how Charles figured out something else really important from this experiment and you will learn why the Kelvin scale is used for these.

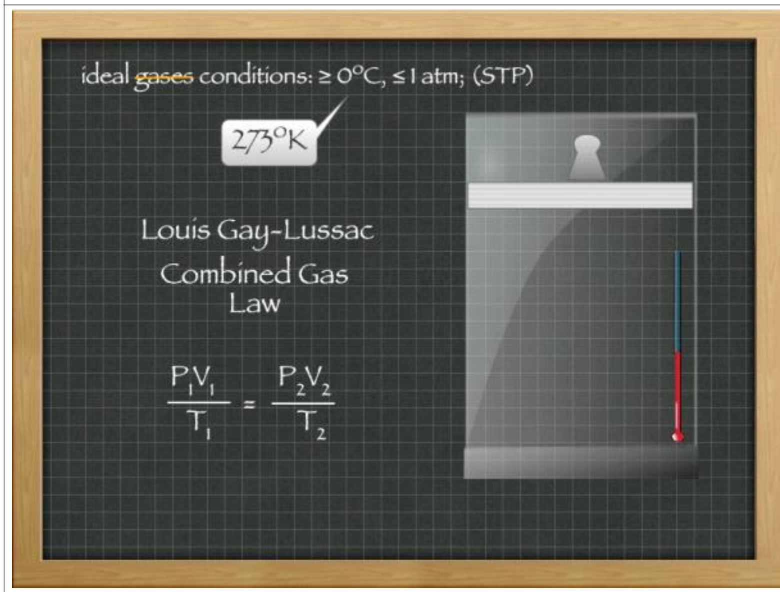


Kelvin or Absolute 0

Charles could only get his gases as low as the technology back then could get them, but when he took all of his data for all the different gases he tested he noticed that they all seem to point to the same point. He extrapolated the data to see where they all met. On his graph, it worked out to be -273.15 degrees Celsius.

Considering that the temperature and the volume were all about molecular motion, he surmised that there all the lines converged all molecular motion must stop.

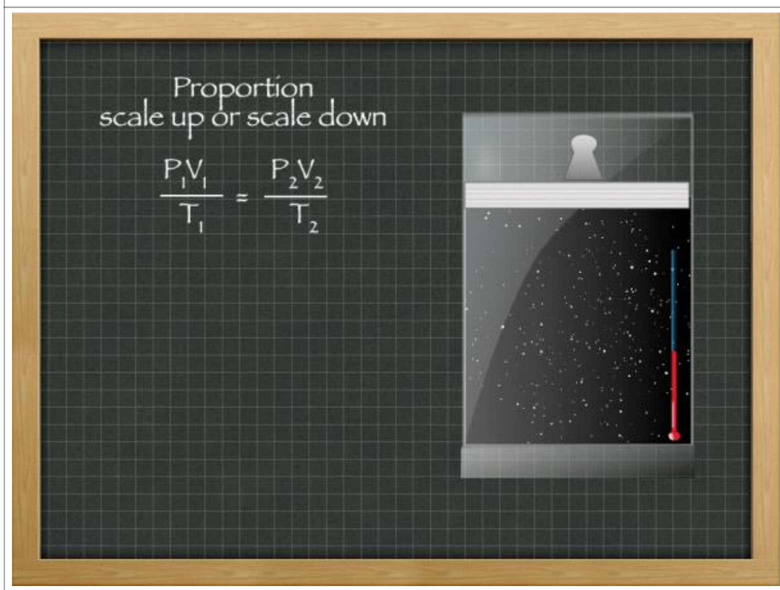
This later became known as 0 degrees Kelvin or absolute 0.



Combined Gas Law

Joseph Louis Gay-Lussac was a French scientist that kept volume constant and found a direct relationship between temperature and pressure.

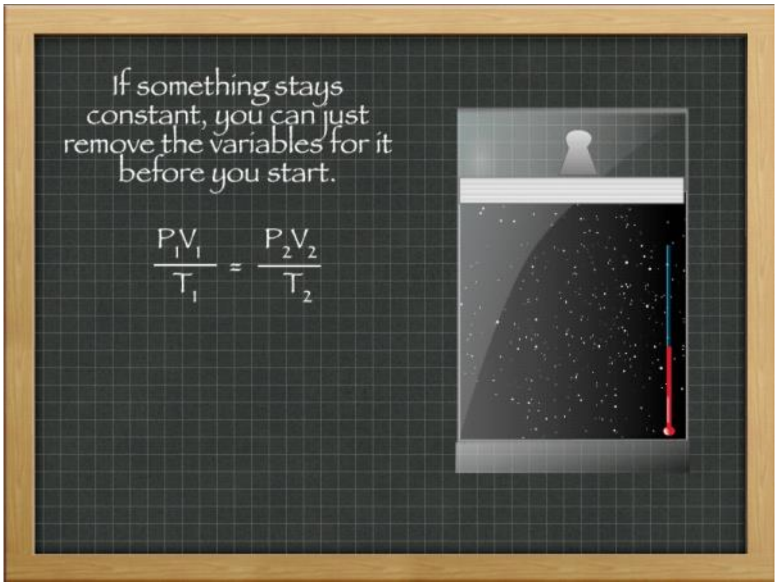
Scientists later combined all these separate gas laws into one called the combined gas law.



Scale Up or Down

Doesn't this equation look a little bit like a proportion or a ratio? It should. It is designed to examine changes as you scale up or down with the variables. All of the variables with the subscripted 1 are from the measurements that you originally start with.

All of the variables with the subscripted 2 are the variables that you have when the change stops and you get your final measurements.



Something Stays the Same

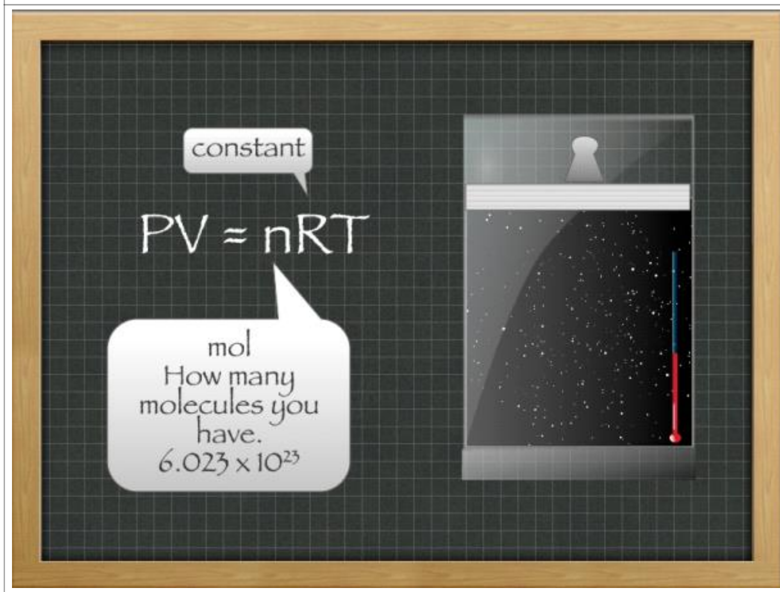
Remember that the equation is set up to let you scale up or down as variables change.

A neat thing about this equation that you will be really glad to know is that if any one of the variables stays the same, you can just remove it before you start.

This is what happens if temperature stays the same.

This results if pressure stays the same.

And, this is all you need when volume is unchanged.



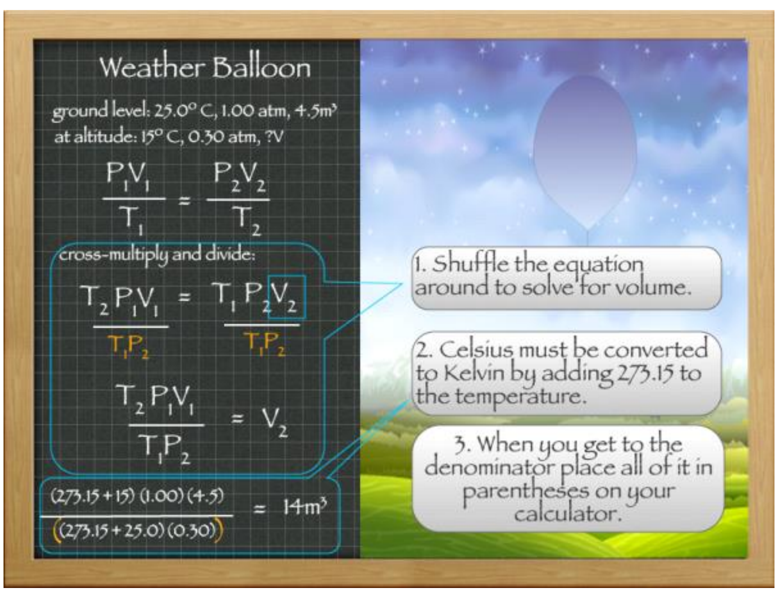
PV=nRT

Though in this lesson we will only be working with the Combined Gas Law, I want you to know about what comes next that you will soon be learning about.

With the addition of Avagadro's Law into the mix, we eventually ended up with the ideal gas law. It is PV = nRT.

N stands for moles which is a measure of how many molecules that you have. 1 mole is 6.023x10^23 molecules which is how many molecules you will have in 1 liter of a gas at standard temperature and pressure.

The R stands for a constant.



Weather Balloon

Before the weather balloon was released, the temperature at ground level was 25.0 degrees Celsius. The pressure was 1.00 atmospheres, and the volume of the balloon was 4.5 cubic meters.

Once it reached altitude, the onboard sensors reported that the temperature was 15 degrees Celsius. The pressure was 0.30 atmospheres, but there were no sensors to report the balloon volume. Compute the volume.

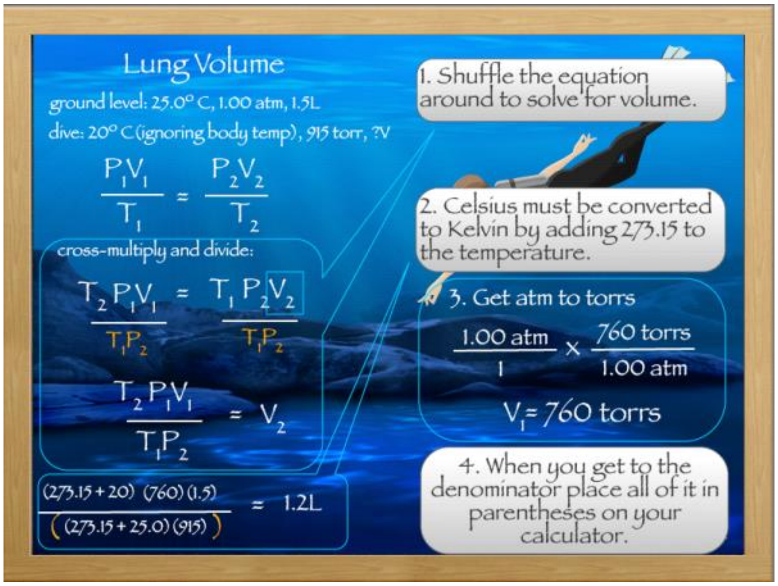
Start out by writing the combined gas law.

Cross multiply to get T2P1V1 = T1P2V2.

We will be solving for V2, so divide off the T1V1 from both sides to isolate our target variable. That gives us the equation we need to solve for our final volume.

Our next task is to substitute the correct values in for each variable. Some are not so straightforward though. Temperature for instance, needs to be in Kelvin so it must be converted from Celsius to Kelvin by adding 273.15 degrees. The rest of the values can be directly substituted.

Calculate the numerator and then hit the enter button to get a subtotal. Your denominator needs to be entirely enclosed in parentheses or else your answer will be incorrect. Your temperature conversion needs to have its own pair of parentheses too.



Lung Volume

When a diver is at the surface lung volume is about 1.5 liters, the temperature is 25.0C, and the pressure is 1 atm.

However, water pressure will reduce the lung's volume. At the deepest level of the dive, the temperature is 20 degrees Celsius (ignoring body temperature), and the pressure is 915 torr. What is the pressure?

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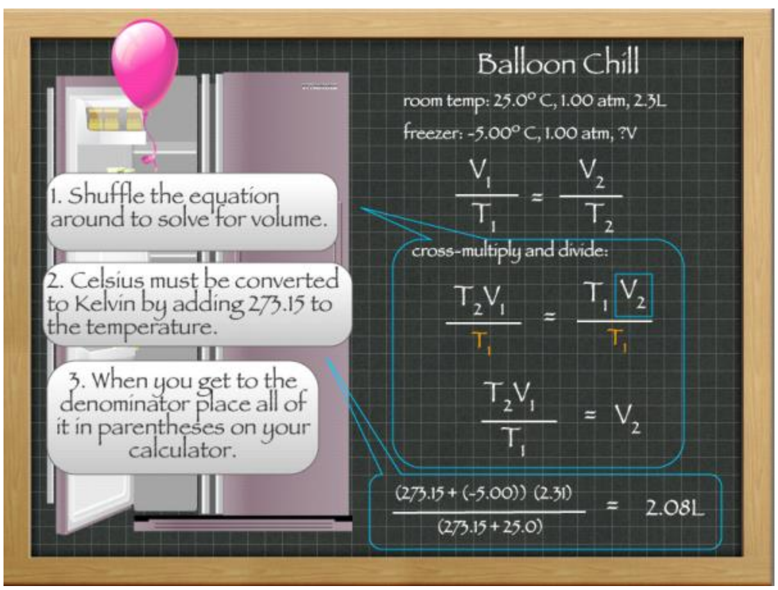

Balloon Chill

A balloon will shrink in size when it gets cold. To explore this, a student blew up a balloon took initial measurements and then placed the balloon in the freezer. What would the new volume be once the temperature reaches -5.00 degrees Celsius.

Start out by writing the combined gas law.

Cross multiply to get T2P1V1 = T1P2V2.

We will be solving for V2, so divide off the T1V1 from both sides to isolate our target variable. That gives us the equation we need to solve for our final volume.

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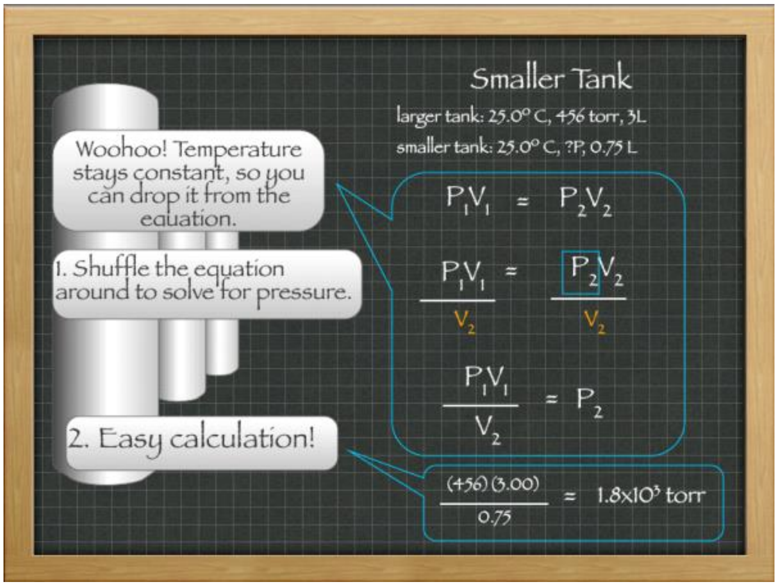
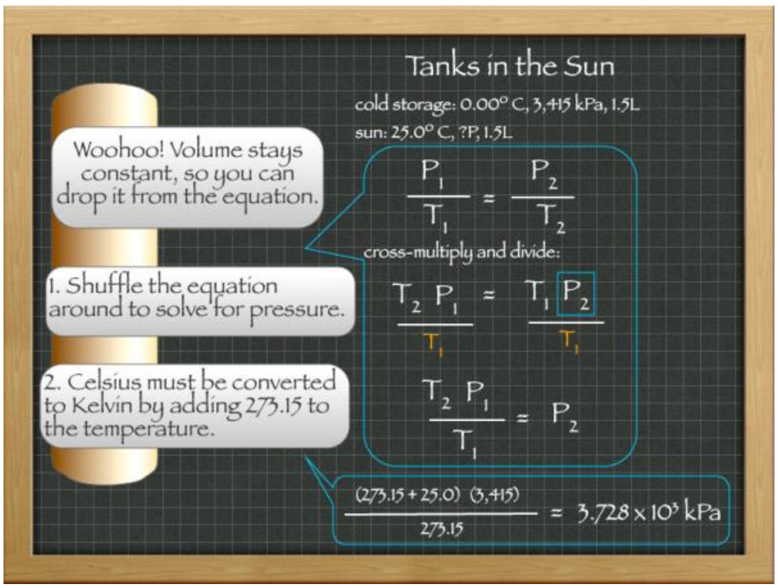


Smaller Tanks

The storage space for the company was becoming problematic. It was necessary to switch to smaller tank sizes. Here is the data. Calculate how much pressure the new tanks will have to withstand so that the same amount of gas can be stored even though the tanks are smaller?

Note that the temperature that the gas will be stored at never changes. Remember that when that happens you can drop that variable completely out.

Now we will shuffle the equation so that we can solve for the final pressure. We need to get rid of the V2 by dividing it from both sides. Here is the equation we need: the initial pressure and volume divided by the final volume.



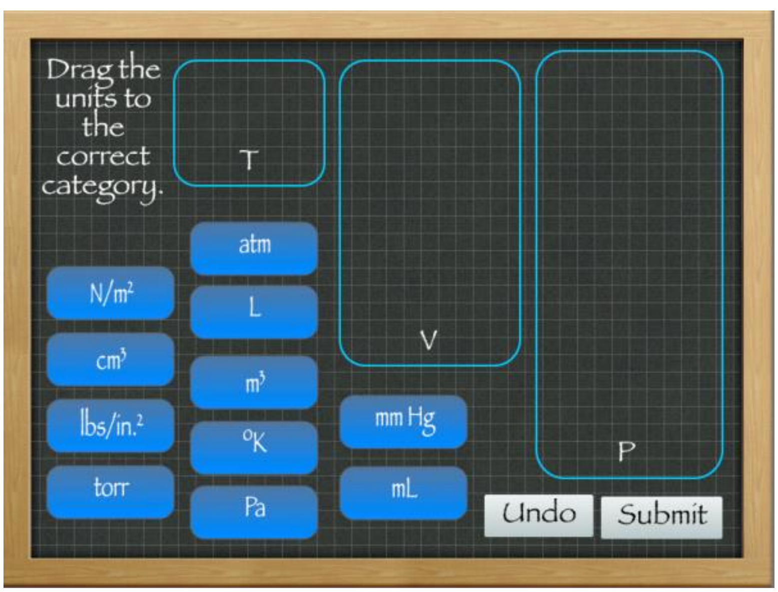
Tanks in the Sun

A company that used to store their gas tanks in in a frozen environment needed to move the tanks out in to the outdoors to make repairs to the storage facility. The tanks were in the sun throughout the day and reached 25.0 degrees Celsius. What pressure did the tanks reach at that point.

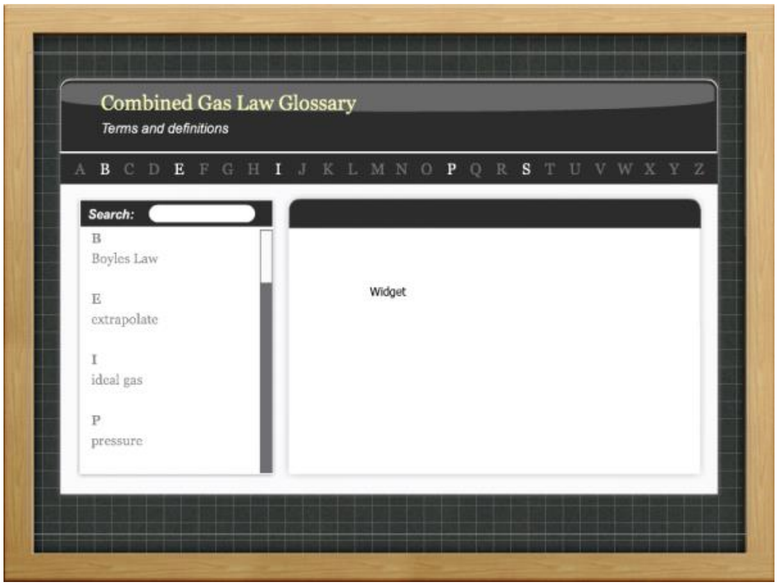
Note that the volume does not change in these tanks. When a variable is unchanged we can drop it from the equation.

Now, shuffle the equation to solve for the final pressure.

The temperature must be converted from Celsius to Kelvin. The rest is pretty straightforward.



Unit Matching



Glossary

Boyle's Law:
At a fixed temperature, the volume of a gas is inversely proportional to the pressure exerted by the gas.

Charle's Law:
The volume of an ideal gas is directly proportional to its temperature on the Kelvin scale.

Extrapolate:
to extend data that is known by continuing an existing relationship beyond gathered data. Extrapolation should only be done when a large pool of data is known that all supports the relationship that is extended

Ideal Gas:
Gases that are at or near stp. Gases that are ideal gases are nitrogen, oxygen, hydrogen, the noble gases, and some heavier gases such as carbon dioxide.

Pressure:
The force per unit of area that a gas exerts on its surroundings. Units: N/m^2, Pa, kPa, atm, torr, mmHg

STP:
standard temperature and pressure. This is 273.15 degrees Kelvin or 0 degrees Celsius and 1 atm of pressure.