

Name:

Grade level:

Date:

# Discovering the Ideal Gas Law



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## **Part I: Identifying the variables within the ideal gas law**

**Directions:** Obtain a balloon filled with air from one of the workshop leaders.

**Background:** It is very powerful to have a scientific equation that can describe almost any gas. It is really amazing that one equation allows scientists to predict the behavior of a gas regardless of what it is, where it is or how long it has been there! As it turns out, gasses are easy to predict when they are acting 'normal'. A scientific way of saying that a gas is behaving normally is to say that it is 'ideal'. That is why today we will work to discover the meaning of the ideal gas law. To begin, if we want to start describing the current characteristics of a gas then we can think about some variables.

Write down a few variables you think could be measured about the gas in the balloon.

- 1.
- 2.
- 3.
- 4.

Let's discuss these as a group and narrow down the ideas. The goal is to find the few variables that we think can be used in a scientific equation.

Group conclusion:

The variables that change and are dependent upon one another are

\_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_,  
\_\_\_\_\_.

Discuss these variables with people at your table. Work together to point out a few real-world situations where these variables are encountered. For example, you can see a change in pressure when you add air to your tires.

Examples

- 1.
- 2.

3.

## **Part II: Examining relationships between the variables**

Let's think about pressure and temperature.

**Directions:** Hold your balloon and squeeze it. Think about what are you doing to the pressure when you squeeze the balloon. **Based on your observations, draw arrows as to how these two relate to one another.**

Pressure      Volume

As it turns out, these variables are related to each other mathematically by an equation with the name "Boyle's Law"

$$PV = k$$

Fun fact: Boyle was an aristocrat and well-known within the scientific community during the 1600s. This status allowed him to essentially rip off a common-man, Henry Power's, work and take credit for the discovery. In truth, it was Henry Power and Richard Towneley who developed Boyle's law. There are a number of incidents in science history where people with more power took credit for discoveries that were not their own.

Now let's think about how **temperature** and **volume** are related with some demonstrations.

**Background:** Liquid water is never *that* cold. As soon as water gets super cold, it freezes. With other substances though, they can reach temperatures far too cold for us to touch before they freeze. Nitrogen is an example of a substance with a very low freezing point (−346 °F), this means liquid nitrogen is extremely cold!

**Directions:** Bring your balloon and gather around the liquid nitrogen container.

**Observations: (You can use drawings too)**

Based on your observations, draw arrows of how temperature and volume relate to one another

Temperature      Volume

Let's think about this though... why does temperature matter?

**Directions:** Go to the front of the room and gather into either group A or group B. Each group will pretend to be gas molecules at a given temperature.

What about the gas is changing as temperature changes?

## Moles

Wrong kind of mole



Think of a dozen donuts.... That means 12 donuts.

If we order two dozen donuts we are really ordering 24 donuts. This is the same way we think about a “mole” in science, a mole is a common word that represents a specific number. That number is much larger than the 12 that a dozen represents

though. A mole is actually a gigantic number,  $6.02 \times 10^{23}$ . So when we say “a mole of helium is in the balloon”. We mean, we have  $6.02 \times 10^{23}$  atoms of helium in the balloon. Remember, an atom is the smallest possible unit of a substance. Since atoms are so small, chemists find the “mole” to be a very useful unit. It is much more convenient to talk about working with 1 mole of helium than  $6.02 \times 10^{23}$  helium atoms.

Put simply, the moles of a gas is the **quantity** of the gas present. It makes sense that the quantity of something will affect the volume it takes up, therefore it is one of the important 4 variables we mentioned during Part I.



vs.



### **Part III: Putting the variables into one relationship.**

#### **Temperature, pressure, volume and moles**

Those are the four variables are related to one another through one of the most famous equations in chemistry, the ideal gas law.

$$PV = nRT$$

\*R is a constant

#### **Demo: Soda can in water**

**Directions:** Gather around the workshop leader who has the soda can. Bring your lab notebook to write down observations and thoughts.

**What happened? (You can use drawings too)**

Circle the variables that you observed change and draw arrows indicating if they went up or down

$$P V = n R T$$

(Hint: remember that the ideal gas law is representing the GAS, if any gas gets turned into a liquid or solid then some of the gas is gone.)

Since we know all of the variables are related, what ones can you assume changed even if you wouldn't know it without this equation?

Demo: Egg in a bottle

**Observations: (you can use drawings too)**

The science behind this demo is a bit more tricky than the last one. Work with your table to generate a hypothesis of why the egg was 'sucked' into the bottle.

Initial hypothesis (1-3 sentences):

After we discuss these ideas as a class, write down a refined hypothesis.

Final hypothesis:

Final Activity: Construction of hot air balloons.

**Background:** Balloons can float using two methods, one is using a gas lighter than air (such as helium) and the second is by using hot air. You may have heard the phrase “heat rises” and this is indeed true. Hot air balloons that float with people in them have a flame source which keeps the air in the balloon continuously hot enough to keep floating.



**Directions:** Using your knowledge of the ideal gas law, your table is going to build the best hot air balloon you can. The one that floats the longest will win! All balloons will have hot air blown into them for 10 seconds first, but since we are not continuing the heat source with a flame, you will need to use your best engineering for them to retain the heat as long as possible.

Construction design you think is important for a successful hot air balloon: