Ms. Randall
Regents Chemistry
Lab Activity: Gas Laws (modified from AACT)

Background

In this investigation you will examine three gas laws including Boyle's Law, Charles' Law and Gay-Lussac's Law. You will explore how manipulating the variables of volume (L), pressure (atm) and temperature (K) can affect a sample of gas. The formula for each of the gas laws are:

Boyle's Law:	Charles' Law:	Gay-Lussac's Law:
$P_1V_1 = P_2V_2$	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

Prelab Questions

1. Solve for "*x*" in the following algebraic equations and report your final answer with the correct number of significant digits:

    a. $(1.34)(5.46) = (1.76)(x)$

    b. $\frac{4.38}{332} = \frac{x}{267}$

    c. $\frac{2.25}{295} = \frac{4.85}{x}$

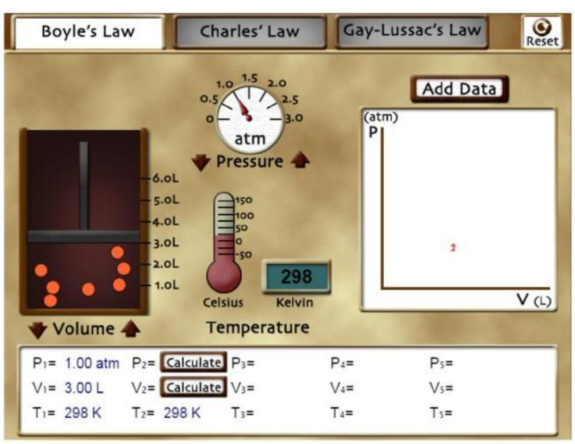
2. Briefly describe, in your own words the meaning of each of the following variables, and common units of measurement associated with each:

    a. Volume
    b. Pressure
    c. Temperature

Procedure

Visit http://www.teachchemistry.org/gaslaws. Make sure that you select the "Boyle's Law" tab to begin; it will be shown in white. You should see the picture below on your screen.

Gas Laws Simulation



A. Marshmallow in syringe

Place a marshmallow in a syringe. Either cap the end of the syringe or place your finger on it to make a seal. Now push in the syringe and observe what happens to the marshmallow. Then pull out the syringe and *record all of your observations in your lab notebook.*

a. What is increasing as you pushed the plunger in and decreasing when you pulled the plunger out on the syringe?
b. What relationship did you observe between pressure and volume?

B. Boyle's Law

1. Which one of the three variables: Pressure, Volume or Temperature cannot be changed in Boyle's Law? This variable is considered a constant.

2. Using the volume control arrows, reduce the volume of the gas to 1.70L.
   a. In your lab notebook, record your observations regarding the behavior of the particles in the gas sample as the volume is reduced. Make certain to discuss *collisions* in your comments.
   a. Calculate the new pressure value for the gas, showing all of your work.
   b. Check your final answer for part b by clicking the *calculate* button next to P_2.

3. Press the *reset* button at the top right of the screen.
   Using the pressure control arrows, reduce the pressure of the gas to 0.700atm.
   a. In your lab notebook record your observations regarding the behavior of the particles in the gas sample as the pressure is reduced.
   b. In the space below calculate the new volume value for the gas.
   c. Check your final answer for part b by clicking the *calculate* button next to V_2.

4. Press the *reset* button at the top right of the screen.
   a. Using the pressure control arrows, increase the pressure value to 1.50atm, and fill in the corresponding V_2 value in the data table below.
   b. Press the *Add Data* button. Using the pressure control arrows, increase the pressure to 2.00atm and fill in the corresponding V_3 value in the data table below into your lab notebook.
   c. Repeat step b for pressure values of 2.50atm and 2.90atm.

P_1 = 1.00atm	P_2 = 1.50atm	P_3 = 2.00atm	P_4 = 2.50atm	P_5 = 2.90atm
V_1 =	V_2 =	V_3 =	V_4 =	V_5 =

   d. Based on the data collected in the table above, what trend can be observed for volume of a gas when the pressure of the gas is increased?

Important Terms

Direct relationship: A relationship between two variables, where a change in one variable results in the same change in the other variable. For example, if one variable is increased, then the other variable will also increase.

Indirect relationship: A relationship between two variables, where a change in one variable results in the opposite change in the other variable. For example, if one variable is increased, then the other variable will decrease.

e. Considering the terms described above, do the variables of pressure and volume have a *direct* or an *indirect* relationship in Boyle's Law?
Justify your answer with data.

f. Considering what you now know about Boyle's law, make a prediction based on the following situation: What would happen to the pressure of a gas inside a sealed bottle, if the bottle was squeezed tightly, reducing the volume of the gas by half? Explain your thoughts.

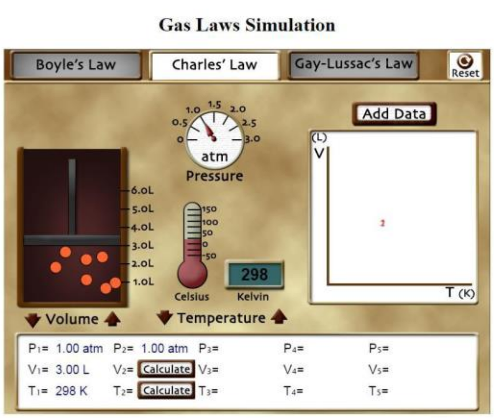
C. Balloon in Flask

Examine the balloon in the flask and think about how the balloon got inside the flask. Now place the flask on the hot plate for 2 minutes and observe. Then place the flask in the cold water for 1 minute and observe. *Record all of your observations in your lab notebook.*

a. What is "pushing" the balloon inside of the flask?
b. Where is there a greater pressure, in the room (atmospheric) or inside the flask (under balloon)?
c. What is the relationship between temperature and pressure?
d. What relationship did you observe between temperature and volume?

D. Charles' Law

Change the simulation to "Charles' Law" by clicking the tab at the top of the screen it will be shown in white. You should see the picture below on your screen. *Record all of your observations in your lab notebook.*



1. Which one of the three variables: Pressure, Volume or Temperature cannot be changed in Charles' Law? This variable is considered a constant.

2. a. Using the Temperature controls, increase the temperature of the gas. What changes do you observe in the behavior of the particles of the gas while the temperature is increased?

b. Continue to increase the temperature value until T_2 = 443K. Using the equation for Charles' law, calculate the volume of the gas at this increased temperature. Check your final answer for part b by clicking the *calculate* button next to V_2:

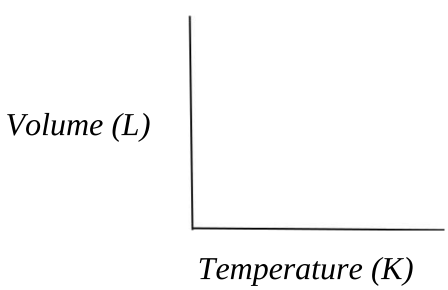
$$\frac{V_1}{T1} = \frac{V_2}{T2}$$

c. Based on the final value calculated in part b) is Charles' law considered a direct or an indirect relationship between the variables? Explain your choice with reasoning.

3. Press the *reset* button at the top right of the screen.
   Using the volume control arrows, reduce the volume of the gas to 1.86L.
   a. In the space below record your observations regarding the behavior of the particles in the gas sample as the volume is reduced.
   b. In the space below calculate the new temperature value for the gas.
   c. Check your final answer for part b by clicking the *calculate* button next to T_2.
   d. Convert the final value for T_2 into Celsius units.

4. Press the *reset* button at the top right of the screen.
   - Using the pressure control arrows, increase the temperature value to a measurement of your choosing. Then press *Add Data*. This will fix a data point on the graph for T_2.
   - Increase the temperature three additional times; select *Add Data* for each data point: T_3, T_4, and T_5.

   a. Plot these points on the graph below, estimating the five data points created:



   b. Based on the data points collected on the graph, make a statement about the trend that can be observed between the volume and temperature of a gas.

5. Considering what you now know about Charles' law, make a prediction based on the following situation: What would happen to the volume of a gas inside a sealed bottle, if the bottle was heated to double its original temperature?
   Explain your thoughts.

E. <u>Soda Can</u>

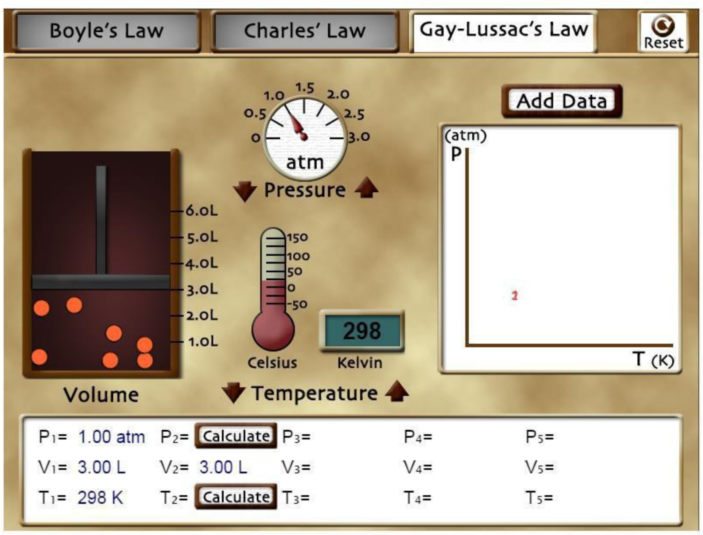
To an empty aluminum soft drink can, add a small amount of water. Heat the can on the hot plate until the water boils, and "steam" comes out of the top of the can. Using a pair of tongs, quickly invert the can in a dish of cold ice water. *Record all of your observations in your lab notebook.*

a. What occurred at the molecular level to the gas particles (steam) when you heated the can? *(Did the space between the particles in increase or decrease).*
b. What happened at the molecular level to the gas particles (steam) when the can was placed in the cold water? *(Did the space between the particles in increase or decrease).*
c. If outside pressure (Standard Pressure) remained constant, why did the can get crushed? Explain in terms of pressure.
d. What is the relationship between temperature and pressure?

<u>Gay-Lussac's Law</u>

Change the simulation to "Gay-Lussac's Law" by clicking the tab at the top of the screen it will be shown in white. You should see the picture below on your screen.

Gas Laws Simulation



2. a. The equation for Gay-Lussac's law is $\boxed{\frac{P_1}{T_1} = \frac{P_2}{T_2}}$ does it look most similar to the equation for Boyle's Law or the equation for Charles' law?

   b. What variable is held constant in Gay Lussac's law?

   c. Based on your answer to part a) what prediction can you make about the relationship between the variables of Pressure and Temperature of a gas?

3. a. Using the pressure control arrows, increase the pressure value to 1.50atm, and fill in the corresponding T_2 value in the data table below.
   b. Press the *Add Data* button. Using the pressure control arrows, increase the pressure to 2.00atm and fill in the corresponding T_3 value in the data table below.
   c. Repeat step b for pressure values of 2.50atm and 2.90atm.

P_1 = 1.00atm	P_2 = 1.50atm	P_3 = 2.00atm	P_4 = 2.50atm	P_5 = 2.90atm
T_1 =	T_2 =	T_3 =	T_4 =	T_5 =

   d. Based on the data collected in the table above, what trend can be observed for temperature of a gas when the pressure of the gas is increased? Is this considered a direct or an indirect relationship between the variables?

4. Press the *reset* button at the top right of the screen.
   Using the temperature control arrows, reduce the temperature of the gas to 158K.
   a. In the space below record your observations regarding the behavior of the particles in the gas sample as the temperature is reduced. Make certain to discuss *collisions* in your comments.
   b. In the space below calculate the new pressure value for the gas.
   c. Check your final answer for part b by clicking the *calculate* button next to P_2.

5. Considering what you now know about Gay-Lussac's law, make a prediction based on the following situation: What would happen to the pressure of a gas inside a sealed bottle, if the bottle was cooled to half of its original temperature? Explain your thoughts.

Checking Comprehension

Please create a list of the variable given in each problem and show all your work required to complete the calculation.

1. Calculate the temperature of a gas when it is expanded to 5.25L. The gas originally occupies 3.45L of space at 282K.

2. The temperature of a gas is increased from 125^{0}C to 182^{0}C inside of a rigid container. The original pressure of the gas was 1.22atm, what will the pressure of the gas be after the temperature change?

3. The volume of gas in a container was originally 3.24L, while at standard pressure, 1.00atm. What will the volume be if the pressure is increased to 1.20atm?

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Lab conclusion: Gas Laws

1. **Write a paragraph summarizing what you have learned about the scientific concept of the lab from doing the lab. Back up your statement with details from your lab experience.**

2. **When a sample of a gas is heated at constant pressure, the average kinetic energy of its molecules**

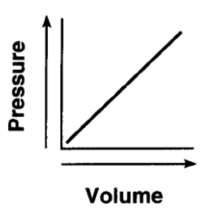
   A) decreases, and the volume of the gas increases
   B) decreases, and the volume of the gas decreases
   C) increases, and the volume of the gas increases
   D) increases, and the volume of the gas decreases

3. **Under which conditions of temperature and pressure does oxygen gas behave least like an ideal gas?**

   A) low temperature and low pressure
   B) low temperature and high pressure
   C) high temperature and low pressure
   D) high temperature and high pressure

4. **Which graph represents the relationship between pressure and volume for a sample of an ideal gas at constant temperature?**

a.



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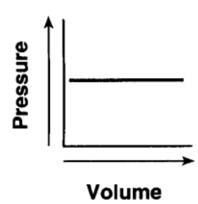

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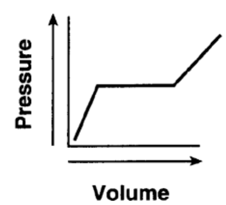

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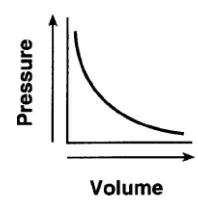
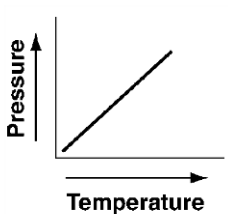


5. **Which graph shows the pressure-temperature relationship expected for an ideal gas?**

a.



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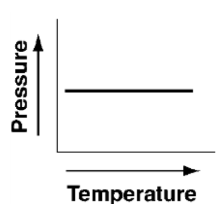
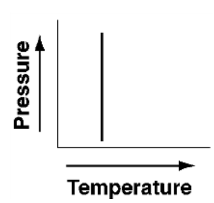


c.



d.