Gas Laws

In this lab, students will explore the gas laws and the relationship between pressure, volume, number of moles of gas, and temperature.

First, begin by having the students discuss what PRESSURE, VOLUME, and TEMPERATURE are and how you can observe each. Temperature is measured with a thermometer, pressure with a barometer (or pressure gauge), and volume is the area occupied by a gas.

Demonstration:
Collapsing Can

Materials:
Empty soda can
Boiling water bath (or Bunsen burner)
Cool water bath
Tongs

1. Fill the soda can with about 15 mL of water.
2. Holding the can with tongs, place soda can with water in boiling water bath (or over Bunsen burner) until water is boiling.
3. Quickly invert the can in the cool water bath.

The can will collapse with a loud bang.

Explanation:
The can filled with hot steam when the water was boiling in the can. When it was suddenly submerged into cool water, the steam condensed and caused the pressure in the can to quickly decrease. The pressure outside of the can was much higher than that inside the can, so the can collapsed. .

You experience changes in pressure when you fly in an airplane, swim to the bottom of a swimming pool, or drive up a high mountain. These changes in pressure cause your ears to pop because of the pressure difference you are experiencing.

Laboratory:
I. Volume versus Temperature – Charles' Law

Materials:
Plastic pipettes with colored liquid in them
Thermometer
Ice water bath
Hot water bath

1. Pass out pipettes to each group.
2. Have the students record the volume of the liquid in the pipet at room temperature.
3. Have the students submerge the pipet in ice water and record the volume of the liquid and the temperature of the ice bath.
4. Have the students submerge the pipet in hot water and record the volume of the liquid and the temperature of the water.

On their data sheet, the students should record the temperature and volume for each part. Then have them plot temperature versus volume on the plot provided.

** Emphasize that the colored liquid in the pipet represents a gas.**

Discussion: What is the relationship between temperature and volume?
They should find a linear relationship between T and V. As temperature increases, so does the volume of the liquid.

II. Number of Moles of Gas versus Volume – Avogadro's Law

Materials:
Balloons
String
Rulers

1. Pass out balloons to each group.
2. Have the students put in one breath of air into the balloon.
3. Have the students wrap a string around the largest part of the balloon. Measure the length of the string to get the circumference of the balloon.
3. Have the students put a second breath of air into the balloon and again measure the circumference.
4. Repeat with a third and fourth breath of air.

On their data sheet, students should record the circumference of the balloon with each breath added. Assume that the balloon is a perfect sphere. Convert the circumference to volume of a sphere.

Note: volume of sphere = $4/3\ \pi r^3$ and circumference of a circle (C) = π x diameter

Therefore, volume = $4/3\ \pi\ (1/2\ C/\pi)^3 = 1/6\ C^3/\pi^2$

Emphasize that each breath represents a mole of gas.

Discussion: What is the relationship between number of moles of gas and volume?
They should find that the volume increases as the number of moles of gas increases.

III. Volume versus Pressure – Boyle's Law

Materials:
Plastic Syringe
Marshmallows

1. Have the students put a marshmallow into a syringe and put the plunger in.
2. Have the students observe what happens to the volume of the marshmallow as you press in and pull out the plunger (this acts as a way of increasing and decreasing the pressure).

On their data sheet, students should record the volume of the marshmallow at high and low pressures.

Emphasize that the marshmallow represents a gas.

Discussion: What is the relationship between volume and pressure. They should find that volume increases with decreased pressure (they are inversely proportional to one another.

FINAL DISCUSSION:

Have the students create a relationship between P, V, T, and n using their observations.

$V \propto T$
$n \propto V$
$V \propto 1/P$

$V \propto Tn(1/P)$
$PV \propto nT$

Have the students think about how these gas laws are used or seen in everyday life.
(Hot air balloons, can of soda exploding in a hot car etc.)

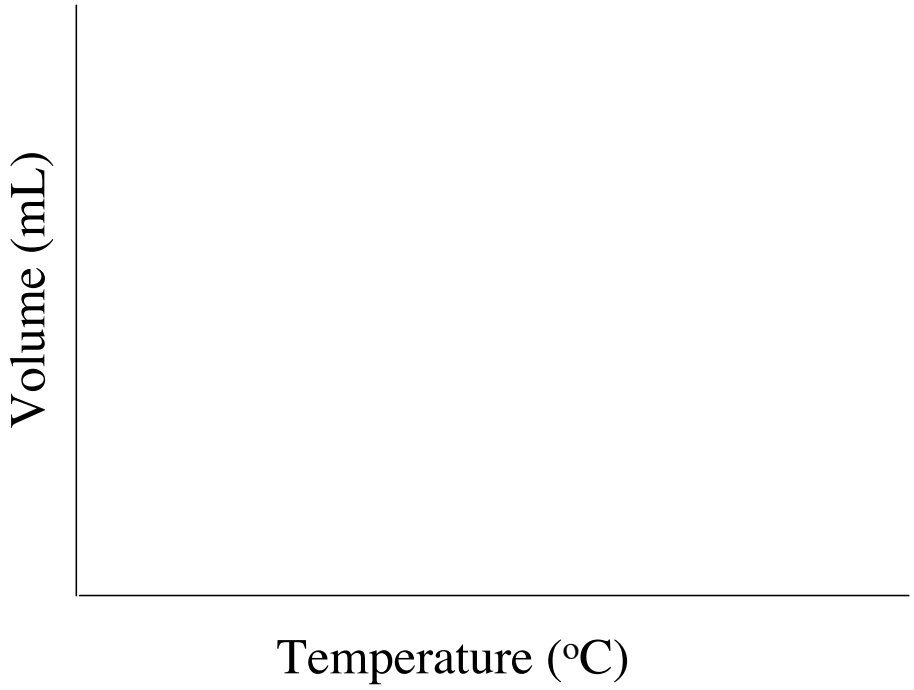
Student Data Sheet

I. Volume versus Temperature – Charles' Law

Measure the temperature and volume of the liquid in the pipet at room temperature, in ice water, and in hot water.

	Volume (mL)	Temperature (C)
Room Temperature		
Ice Water		
Hot Water		

Plot volume versus temperature on the graph below.



II. Moles of Gas versus Volume – Avogadro's Law

Measure the circumference of the balloon after 1, 2, 3, and 4 breaths (each one represents one mole of gas). Calculate the volume of the balloon for each.

	Circumference (cm)	Volume of balloon (cm^3)
1 breath		
2 breaths		
3 breaths		
4 breaths		

III. Volume versus Pressure – Boyle's Law

Record the volume of the marshmallow under high and low pressure in the syringe.

	Volume of marshmallow
High pressure	
Low pressure	

Analysis of Observations

Relationship between volume (V) and temperature (T):

Relationship between number of moles of gas (n) and volume (V):

Relationship between volume (V) and pressure (P):

How can you put all these factors together to devise a relationship between all four?