Gas Laws Lab:

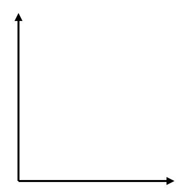
Name:____________________
Hour: _____

Pre-lab Discussion:

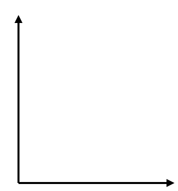
Brainstorm ways to alter the pressure of the gas in a sealed syringe. Think in terms of particle collisions and movement.

Draw a *predictive* graph for each relationship:

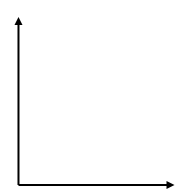
1. How does the _____________ of a container affect the pressure inside of it?

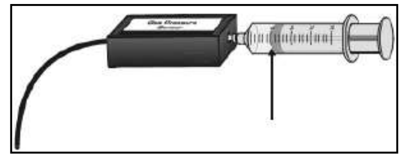


2. How do the ________________ in a container affect the pressure inside of it?



3. How does the ________________ of a container affect the pressure inside of it?





Pressure and Volume (Part 1):

1. Prepare the Gas Pressure Sensor and an air sample for data collection.
   - A. Connect the Gas Pressure Sensor to your chromebook
   - B. Launch the Graphical Analysis software
   - B. With the syringe disconnected from the sensor, move the piston of the syringe until the front edge of the inside black ring (see figure above) is positioned at the 10.0 mL mark.
   - C. Attach the syringe to the valve of the sensor. Twist to screw on, but do not tighten too much or the sensor may break!
2. Set up the data-collection mode.
   - A. On the meter screen, tap Mode (lower left hand corner) Change the mode to "Events with Entry."
   - B. Enter the name (Volume) and Units (mL). Select Done.
3. Start data collection by clicking collect at the top of the screen . Move the piston so the front edge of the inside black ring is positioned at the 5.0 mL line on the syringe. Hold the piston firmly in this position and Tap [KEEP] (top of screen) and enter 5, the gas value (in mL) on the screen. Select "keep point" to store this pressure-volume data pair.
4. Repeat step 3 for the rest of the increments of the volumes in the table below.
5. Stop data collection by stop at the top of the screen.

Draw a sketch of your graph: **Label your axes.**

Volume (mL)	Pressure (kPa)
5	
7	
9	
11	
13	
15	
17	

Describe the relationship in words:

As the volume increases, the pressure…

{ P = }

Determine the equation for your data. Click on the graph on the lower left of the screen. Select apply curve fit. Change "linear" to "inverse". The equation is y = a/x. The value for a will appear in a box on the graph.

Pressure and Number of Particles (Part 2):

Use the same procedure for attaching the probes and interface to the LabQuest as described in Part 1 of the lab. Instead of “Volume,” use “Number” and instead of “mL” use “puffs.”

1. Vary the number of particles of the gas by adjusting the syringe to various volumes *while open to the air* .
2. Then attach the syringe to the pressure sensor and *adjust* to a fixed volume (10 mL).
3. When the adjustment is done, tap “keep” enter the number of particles in the syringe (in “puff” units), and hit “done” (One “puff” is the same as one mL of open air.) The computer will record the count and pressure in the data table and automatically graph the data.

Number (puffs)	Pressure (kPa)
3	
5	
7	
9	
11	
13	
15	

Draw a sketch of your graph: **Label your axes.**

Describe the relationship in words:

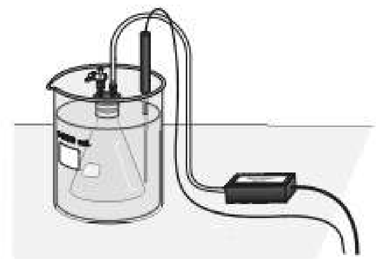
As the number of particles increases, the pressure…

Determine the equation of the line for your graph. See Part 1 for instructions.
Use P for Pressure and n for Number of particles.

$$\left\{ P = \right\}$$

Pressure and Temperature (Part 3):

1. Set up the equipment as shown in the figure to the right. (It should already be set-up for you.)
2. With both probes plugged into USB ports, start the graphical analysis software on your chromebook. The system should default to two graphs. One temperature vs time and one pressure vs. time. Change the x axis on the pressure vs. time graph to temperature. You do not need the second graph.
3. Change the mode to "Events". When you are ready to collect a data point click "collect" and then "keep", you will see three columns in the table. Enter the temperature shown in the 3rd column into the first column and click "Keep data point".



4. Vary the temperature of the gas by changing the temperature of the *water bath* the flask is immersed in. The water bath should be gently agitated by stirring or by gently 'bobbing' the flask in the water while keeping the flask well submerged. (Do not let the water level go above the top of the flask.) This will bring the system to equilibrium faster. The temperature probe is placed *in a test tube in the water bath* rather than directly in the gas itself, which means the system must be allowed to equilibrate for a few minutes before tapping [KEEP].
5. Half the class will start with a hot water bath (80-85˚C; at the top temperature, you will have to hold the stopper onto the beaker to keep it from popping off), half the class will start with an ice-water bath (0 ˚C) and then slowly decrease or increase the temperature by *replacing* the water in your beaker with room temperature water. Take seven data points, make sure to get a range of at least 40 °C.

Temp (˚C)	Pressure (kPa)

Draw a sketch of your graph. **Label your axes.**

Describe the relationship in words:

As the temperature increases, the pressure…

Use the computer to come up with an equation for this line. (See Part 1 for instructions.)

Use P for Pressure and T for Temperature.

$\{P = \qquad\qquad\qquad\}$

Kinetic Molecular Theory:

Particles of a gas:

1.

2.

3.

4.

5.

POST LAB QUESTIONS:

1. What provides the pressure in a container in terms of particles?

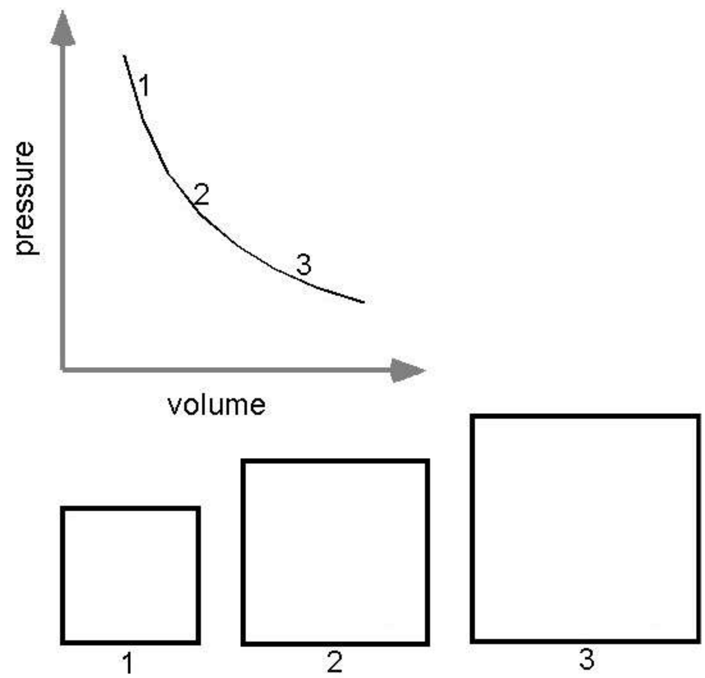
2. At 0 ˚C, there is a pressure, according to your graph. How can you have pressure without any temperature? Use your equation from Part 3 to find what temperature the pressure goes to 0 kPa.

3. What is absolute zero? What happens to particles at absolute zero?

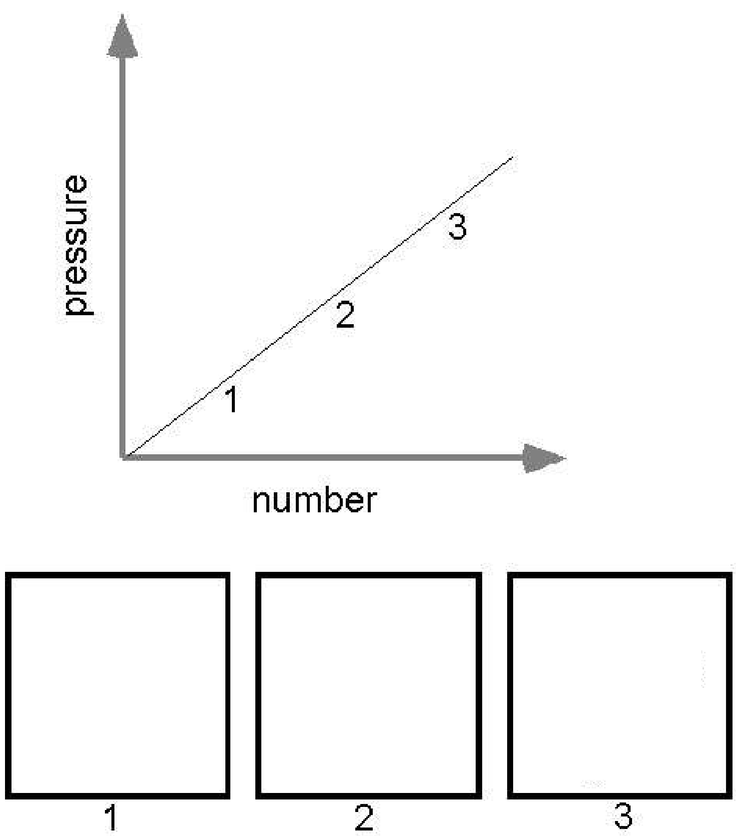
4. Modify your equation in Part 3 to use temperature in Kelvin.

Draw particle diagrams for three different points along your graphs.

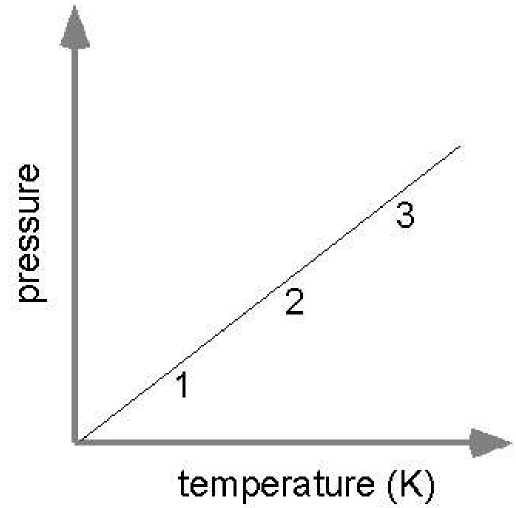
- Represent the speed of the particles by the length of the arrows. Longer arrows = faster particles.
- Only change the variables that are labeled on the axes.



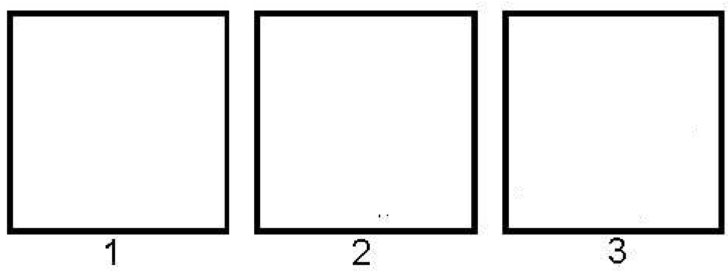
5. Describe how the pressure changes in terms of particles in part 1.



6. Describe how the pressure changes in terms of particles in part 2.



7. Describe how the pressure changes in terms of particles in part 3.



8. Explain your y-intercept from Part 2. What *should* it be? (Use particle collisions to explain.)

9. Using the equations from the lab, write an equation relating all four variables: pressure, temperature, number of particles and volume. (Use R as the unknown constant.)

10. Using values for one mole of a substance (n) at 273 Kelvin and 101.325 kPa, calculate this constant (R).

11. Using the motion of particles, what would you expect the relationship between volume and temperature to be? (As you increase temperature, what happens to the volume of a gas?) Explain.

12. Compare your Part 3 equation with another group that did the other temperature to start. How do they compare?

PVTn Problems:

How to do PVTn problems:

1. Read the scenario. Underline the numbers that are mentioned in the problem.
2. Place the numbers in the corresponding boxes. Convert all temperatures to Kelvin first.

How do you know what box? *Look at the units!*

P psi, atm, kPa, mm *Standard pressure = 1 atm = 760 mmHg = 14.7 psi*	**V** mL, L, cm^3
T ^oC: Convert to Kelvin: $K = {}^oC + 273$ *Standard temperature = 273 K*	**n** units, "puffs"

3. Figure out what variables remain *constant* in the situation. (Usually there won't be anything mentioned for that variable if it remains constant.) Put dashes in the boxes corresponding to those variables.

4. How do the variables change? Draw an *arrow* in the "Effect" box that describes the change.

5. How will the effect from the given variables change the variable you are solving for? Remember how everything relates from the lab! (Are the variable directly or inversely proportional?) Draw a corresponding *arrow* in the "Effect" box for the variable you are solving for.

6. Set-up the math:

"Initial" for variable you are *solving for* x "initial" *or* "final" variable that changes / "initial" *or* "final" variable that changes

If the variable you are solving for decreases, put the smaller number in the numerator. If the variable you are solving for increases, put the larger number in the numerator. If you have two given changes, you will have to multiply by *two* fractions.

PVTn Problems

1. A sample of gas occupies 150 mL at 298 K. What is its volume when the temperature is increased to 323 K? (P and n = constant)

	P	T	V	n
Initial				
Final				
Effect				

2. The pressure in a bicycle tire is 105 psi at 298 K in Fresno. You take the bicycle up to Huntington, where the temperature is 268 K. What is the pressure in the tire? (V and n = constant)

	P	T	V	n
Initial				
Final				
Effect				

3. What would be the new pressure if 250 cm^3 of gas at *standard pressure* is compressed to a volume of 150 cm^3? (_______ = constant)

	P	T	V	n
Initial				
Final				
Effect				

WHAT UNIT DOES THE TEMPERATURE NEED TO BE IN??

4. What would be the new volume if 250 cm^3 of gas at 25˚C and 730 mm pressure were changed to standard conditions of temperature and pressure? (____= constant)

	P	T	V	n
Initial				
Final				
Effect				

5. Sam's bike tire contains 15 moles of air particles and has a volume of 160mL. Under these conditions the pressure reads 13 psi. The tire develops a leak. Now it contains 10 moles of air and has contracted to a volume of 150mL). What would the tire pressure be now?

	P	T	V	n
Initial				
Final				
Effect				

6. A closed flask of air (0.250L) contains 5.0 moles of particles. The pressure probe on the flask reads 93 kPa. A student uses a syringe to add an additional 3.0 moles of air through the stopper. Find the new pressure inside the flask.

	P	T	V	n
Initial				
Final				
Effect				

7. A 350 mL sample of gas has a temperature of 303 K and a pressure of 1.20 atm. What temperature would be needed for the same amount of gas to fit into a 250 mL flask at standard pressure?

	P	T	V	n
Initial				
Final				
Effect				

8. A 475 cm^3 sample of gas at standard temperature and pressure is allowed to expand until it occupies a volume of 600. cm^3. What temperature would be needed to return the gas to standard pressure?

	P	T	V	n
Initial				
Final				
Effect				