

Experiment 4 Ideal Gas Law – Qualitative Study

Note 1: Parts of this lab involve using a laptop computer and the PASCO ScienceWorkshop Interface to collect data. The lab also involves use of a water bath to vary the temperature of the gas in the air chamber.

Be extremely careful to avoid spilling water on the electronic components of the lab equipment.

Note 2: In parts 1 and 3 of the lab you will be using boiling water. **Be careful.**

Note 3: Handle the air chamber (aluminum cylinder with rubber stopper) gently. Do not drop or bang it. If the rim gets bent the chamber will leak.

Before beginning the procedures for Charles' Law, start heating water in the hot pot (two groups will need to share one hot pot.) If you use all or most of the hot water while doing the experiment, refill the pot so hot water will be available for other groups and other parts of the lab.

Part 1: Charles' Law: Volume and Temperature at Constant Pressure

Procedure:

1. Set-up:

- Turn the thumbscrew at the top of the Heat Engine/Gas Law Apparatus so that the piston can move freely.
- Connect the plastic tubing (already attached to the stopper that closes the aluminum air chamber) to either of the two ports of the Heat Engine/Gas Law Apparatus.* (If the stopper does not seem to seal the chamber properly, ask your instructor to fix it.)
- Place a white sheet of paper onto the table. On top of it, place the Gas Law Apparatus so that the side of the base and the pointed side of the top are in contact with the table. (In this position, the force acting on the piston is due to atmospheric pressure only and is equal throughout the range of operation of the piston.)
- The bottom of the piston should be positioned near the 80 mm line before beginning the experiment.

2. Place the aluminum beaker provided inside the Styrofoam container. Fill the beaker about two-thirds full with boiling water. Put the air chamber in the boiling water. (You may need to gently push onto the stopper to keep the metal portion of the air chamber submerged in the water.) Add tap water until the beaker is nearly full. Insert the thermometer into the water. Close the shut-off valve on the tubing from the unused port of the Heat Engine/Gas Law Apparatus.

3. After the system has reached equilibrium, record the temperature of the system and the position of the piston. The starting temperature should be about 70°C to 80°C.

* Align the quick-release coupling on the free end of the plastic tubing with the port, push them together and then turn the coupling clockwise until it clicks (about one-eighth turn).

4. Add a small amount of ice and stir until the ice has melted. After the system has again reached equilibrium, record the new temperature and the new position of the piston.

5. Repeat step 4 until at least five sets of data have been recorded. Ideally the last set of data has a temperature below 20°C.

6. Remove the air chamber from the beaker. Empty the water from the beaker and Styrofoam container into the sink. Wipe up any spilled water.

7. Disconnect the tubing from the Heat Engine/Gas Law Apparatus, leaving it connected to the stopper in the air chamber. Open the shut-off valve from the unused port. Push the piston all the way down and then gently retighten the thumbscrew at the top of the apparatus so that the piston is no longer free to move. Reinsert the Gas Law Apparatus into its bubble wrap cover and return it to the equipment box.

Part 2: Gay-Lussac's Law: Pressure and Temperature at Constant Volume

Procedure:

1. Set up equipment needed to gather data. (Some of these steps may have been done for you before lab.)

- Connect the ScienceWorkshop Interface to the computer and turn them both on. The switch to turn on the ScienceWorkshop Interface is located on the back of the interface.
- Connect the pressure sensor to port A on the interface. Connect the tubing from the Air Chamber to the Pressure Sensor
- Open *DataStudio* by clicking on the icon on the computer desktop. Choose "Create Experiment" in the *DataStudio* window. Click on port A on the picture of the ScienceWorkshop interface. From the drop down sensor menu, select the Pressure Sensor (Absolute) .
- In the Displays window pane found at the lower left corner of the screen, click on "digits" to read the pressure.
- Click the start button to start displaying the pressure.

2. Place the air chamber in the aluminum beaker inside the Styrofoam container. Fill the beaker about two-thirds full with boiling water. Add tap water until the beaker is nearly full. Insert the thermometer into the water. You may need to push on the stopper of the Air Chamber to keep the metal portion of the Air Chamber submerged in the water.

3. Click the start button to start displaying the pressure. After the system has reached equilibrium, record the temperature and pressure of the system. The starting temperature should be about 70°C to 80°C.

4. Add a small amount of ice and stir until the ice has melted. After the system has again reached equilibrium, record the new temperature and the new pressure.

5. Repeat step 4 until at least five sets of data have been recorded. Ideally the last set of data has a temperature below 20°C.

6. Remove the air chamber from the beaker. Empty the water from the beaker and Styrofoam container into the sink. Wipe up any spilled water.

7. Disconnect the Pressure Sensor from the air chamber, but leave the Pressure Sensor connected to the ScienceWorkshop interface. Leave the *DataStudio* window open and proceed to the set-up for part 3 of the experiment.

Part 3: Boyle's Law: Pressure and Volume at Constant Temperature:

Procedure:

1. Set up equipment needed to gather data.

- The computer, interface, and Pressure Sensor should be set-up from the previous part of the lab.
- Adjust the piston of the syringe so that the volume indicates 20 mL.
- Connect the plastic tubing (already attached to the stopper that closes the aluminum air chamber) to the Pressure Sensor.

2. Note the pressure reading when the volume is 20 mL. Check that the syringe and Pressure Sensor have a secure seal by adjusting the volume from 20 mL to 10 mL. (It should get harder to push as the volume decreases.) Readjust the piston so that the volume is again 20 mL. Check that the pressure reading is the same as the pressure noted above. If it is not the same, see the instructor.

3. Wait for the pressure to stabilize (why?) and then record the value of the pressure when the volume is 20 mL.

4. Move the piston to the 18 mL mark and record the pressure. Repeat for volumes of 16 mL, 14 mL, 12 mL, 10 mL, and 8 mL.

5. Disconnect the quick-release connector from the Pressure Sensor. Disconnect the Pressure Sensor from the ScienceWorkshop interface, and place in its plastic bag.

6. Return all equipment except the computer and interface to the equipment cart.

7. Your instructor will tell you whether to do the calculations and graphs in lab.

8. After you have finished, turn off the ScienceWorkshop interface and disconnect it from the computer. Return it to the equipment cart.

9. Properly shut down the computer and return it to the computer cart. Be sure to put the computer in the slot that has the same number as the computer. Plug the power cord in that slot into the back of the computer.

Experiment 4A: Ideal Gas Law

Names: _____

Data Sheet, Calculations and Analysis**Part 1: Charles' Law**

Position of piston (cm)	Temperature ($^{\circ}\text{C}$)	Volume (cm^3)

Calculations/Analysis

1. Calculate the volume of the air in the Gas Law Apparatus and add it to your table. The diameter of the piston is 32.5 mm.
2. Graph volume versus temperature. If done in DataStudio or Excel, print out one graph for the group.
3. Does your data confirm Charles' Law?

Part 2: Gay-Lussac's Law

Pressure (kPa)	Temperature ($^{\circ}\text{C}$)

Calculations/Analysis:

1. Plot a graph of pressure versus temperature.
2. Does your graph confirm Gay-Lussac's Law?
3. From your graph (adjust axes if necessary) determine the value of the temperature when the pressure is zero. Is this what you expect? If done in DataStudio or Excel, print out one graph for the group.

Part 3: Boyle's Law

Volume (mL)	Pressure (kPa)	1/volume (1/mL)
20		
18		
16		
14		
12		
10		
8		

Calculations/Analysis:

1. Calculate the inverse of the volume and add it to your table.
2. Graph pressure versus volume. If done in DataStudio or Excel, print out one graph for the group.
3. Graph pressure versus inverse of volume. Print one graph for the group.
4. From your graphs, does pressure appear to be proportional to volume, inversely proportional to volume, or neither? Does this agree with Boyle's Law?

Attach all graphs to the data/calculations pages and turn in before leaving lab, if so directed by your instructor.