Lab 6. Pressure, Temperature, and Volume of Gases: How Does Changing the Volume or Temperature of a Gas Affect the Pressure of That Gas?

Introduction

There are three states of matter: solid, liquid, and gas. Each state of matter has physical properties that distinguish it from the other states; for example, matter in the solid phase has a definite shape, whereas matter in the liquid or gas phase will take on the shape of its container. The physical properties associated with the states of matter allow us to predict how different substances may react under various conditions. Particles in a gas move about more freely than those in a solid or liquid and therefore react to changes in temperature and pressure in a manner that is different than solids or liquids.

The *volume* of a sample of gas, or the amount of space that a sample of gas occupies, is particularly influenced by a variety of factors such as temperature or pressure. Just like the shape of a sample of gas or liquid is determined by its container, the volume of a sample of gas is influenced by its surroundings. A small sample of gas, like air, may be confined to a small container such as a balloon, or if the balloon pops the sample of gas can expand to occupy the entire volume of a classroom. Consider a tank of helium gas used to fill birthday balloons. There is a large amount of gas stored inside the tank, but several birthday balloons filled with a sample of the gas can easily expand to a size much larger than the tank. Understanding the physical properties of gases and how a gas interacts with its surroundings helps to explain this phenomenon. In this investigation you will explore the relationship between volume, temperature, and pressure for a gas within a closed system.

Your Task

Determine how changes to the volume and the temperature of a gas within a closed system affect the pressure of that gas. Then develop a general mathematical model that can be used to apply and describe these relationships with respect to all gases.

The guiding question for this lab is, **How does changing the volume or temperature of a gas affect the pressure of that gas?**

Materials

You may use any of the following materials during your investigation:

Consumable	Equipment
Ice	- Gas pressure sensor - Temperature sensor - Sensor interface - Syringe - Erlenmeyer flask - Single-hole rubber stopper - Rubber tubing - Beaker (500 ml) - Hot plate

Safety Precautions

Follow all normal lab safety rules. In addition, take the following safety precautions:

- Wear indirectly vented chemical-splash goggles and chemical-resistant gloves and apron while in the laboratory.
- Handle all glassware with care.
- Use caution when working with hot plates because they can burn skin. Hot plates also need to be kept away from water and other liquids.
- Wash your hands with soap and water before leaving the laboratory.

Investigation Proposal Required?   ☐ Yes   ☐ No

Getting Started

To determine the relationship between the pressure, the volume, and the temperature of a gas, you will need to set up an apparatus that will allow you to first measure changes in gas pressure when the volume of gas changes. This can be accomplished with the apparatus shown in Figure L6.1. You will then need to be able to measure changes in gas pressure when the temperature of the gas changes. This can be accomplished with the apparatus shown in Figure L6.2. Once you have set up these apparatuses, you must determine what type of data you need to collect, how you will collect the data, and how you will analyze the data.

To determine *what type of data you need to collect*, think about the following questions:

- What type of measurements or observations will you need to record during your investigation?
- When will you need to make these measurements or observations?

To determine *how you will collect the data*, think about the following questions:

- What will serve as your dependent variable(s)?
- What will serve as a control (or comparison) condition?
- What types of treatment conditions will you need to set up and how will you do it?
- How will you make sure that your data are of high quality (i.e., how will you reduce error)?

FIGURE L6.1

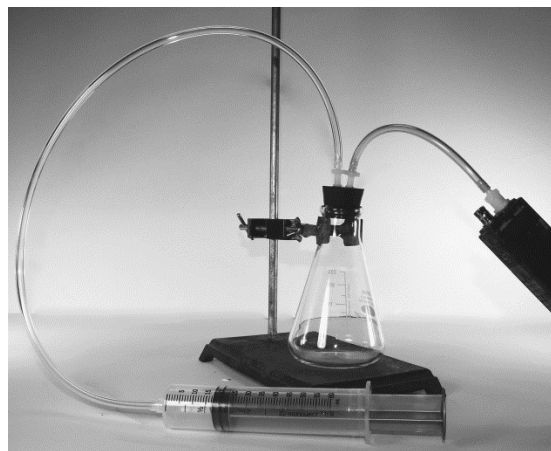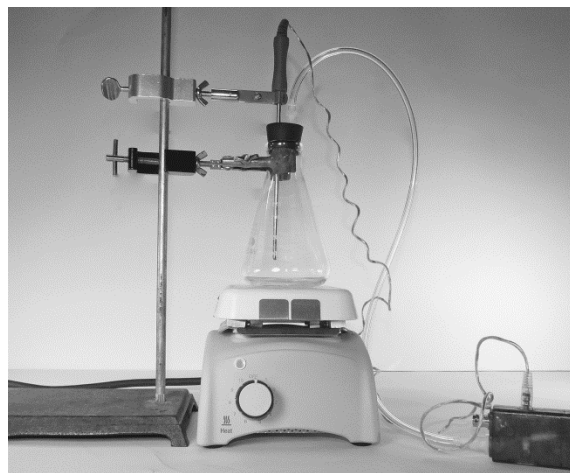**Apparatus used to measure changes in gas pressure in response to changes in the volume of the gas**

FIGURE L6.2

Apparatus used to measure changes in gas pressure in response to changes in the temperature of the gas

To determine *how you will analyze the data*, think about the following questions:

- How will you determine if there is a difference between the treatment conditions and the control condition?
- What type of calculations will you need to make?
- What type of graph could you create to help make sense of your data?

Once you have finished collecting your data, your group will need to develop a mathematical model that describes how the pressure of a gas is affected by changes in the volume and the temperature. When developing a mathematical model, variables that are inversely related are multiplied and variables that are directly related are divided. Keep these mathematical relationships in mind as you develop your model.

The last step in this investigation is to test your model. To accomplish this goal, you can use your model to make predictions about the pressure of a gas in a closed system under different conditions. If you are able to make accurate predictions with your model, then you will be able to generate the evidence you need to convince others that your model is valid.

Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

- the importance of developing causal explanations for observations,
- how models are used to help understand natural phenomena,
- the difference between laws and theories in science, and
- the difference between data and evidence in science.

Initial Argument

Once your group has finished collecting and analyzing your data, you will need to develop an initial argument. Your argument must include a *claim*, which is your answer to the guiding question. Your argument must also include *evidence* in support of your claim. The evidence is your analysis of the data and your interpretation of what the analysis means. Finally, you must include a *justification* of the evidence in your argument. You will therefore need to use a scientific concept or principle to explain why the evidence that you decided to use is relevant and important. You will create your initial argument on a whiteboard. Your whiteboard must include all the information shown in Figure L6.3.

FIGURE L6.3

Argument presentation on a whiteboard

The Guiding Question:	
Our Claim:	
Our Evidence:	Our Justification of the Evidence:

Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group stays at the lab station to share that group's argument, while the other members of the group go to the other lab stations one at a time to listen to and critique the arguments developed by their classmates. The goal of the argumentation session is not to convince others that your argument is the best one; rather, the goal is to identify errors or instances of faulty reasoning in the initial arguments so these mistakes can be fixed. You will therefore need to evaluate the content of the claim, the quality of the evidence used to support the claim, and the strength of the justification of the evidence included in each argument that you see. To critique an argument, you might need more information than what is included on the whiteboard. You might therefore need to ask the presenter one or more follow-up questions, such as:

- What did your group do to analyze the data, and why did you decide to do it that way?
- Is that the only way to interpret the results of your group's analysis? How do you know that your interpretation of the analysis is appropriate?
- Why did your group decide to present your evidence in that manner?
- What other claims did your group discuss before deciding on that one? Why did you abandon those alternative ideas?
- How confident are you that your group's claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your original argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

Report

Once you have completed your research, you will need to prepare an *investigation report* that consists of three sections that provide answers to the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in two pages or less. The report must be typed and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!