Gas Variables

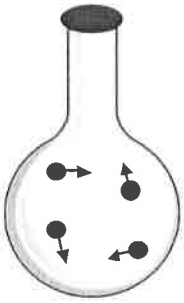
How are the variables that describe a gas related?

Why?

Imagine buying a balloon bouquet at a party store. How will the helium gas in the bouquet behave if you carry it outside on a hot summer day? How will it behave if you carry it outside during a snowstorm? What happens if the balloons are made of latex, which can stretch? What happens if the balloons are made of Mylar®, which cannot stretch? What if you add just a small amount of gas to each balloon? What if you add a lot of gas? In this activity, you will explore four variables that quantify gases—pressure (P), volume (V), temperature (T), and moles (n) of gas. These four variables can be related mathematically so that predictions about gas behavior can be made.

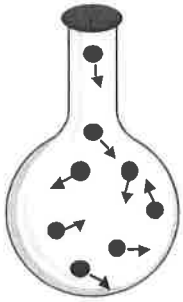
Model 1 – Gases in a Nonflexible Container

Experiment A (Adding more gas)



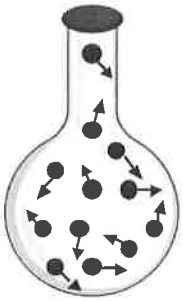
A1

Volume = 1 unit
External pressure = 1 atm
Internal pressure = 1 atm
Temperature = 200 K



A2

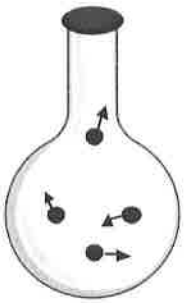
Volume = 1 unit
External pressure = 1 atm
Internal pressure = 2 atm
Temperature = 200 K



A3

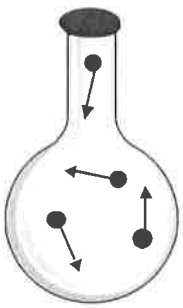
Volume = 1 unit
External pressure = 1 atm
Internal pressure = 3 atm
Temperature = 200 K

Experiment B (Heating the gas)



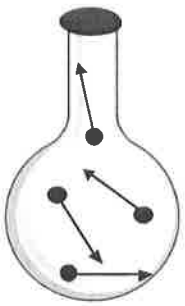
B1

Volume = 1 unit
External pressure = 1 atm
Internal pressure = 1 atm
Temperature = 200 K



B2

Volume = 1 unit
External pressure = 1 atm
Internal pressure = 2 atm
Temperature = 400 K



B3

Volume = 1 unit
External pressure = 1 atm
Internal pressure = 3 atm
Temperature = 600 K

**Note:* Volume in this model is recorded in *units* rather than liters because 4 molecules of gas at the conditions given would occupy a very small space ($\sim 1 \times 10^{-22}$ μL). The particles shown here are much larger compared to the space between them than actual gas particles.

1. In Model 1, what does a dot represent?

2. Name two materials that the containers in Model 1 could be made from that would ensure that they were "nonflexible?"

3. In Model 1, the length of the arrows represents the average kinetic energy of the molecules in that sample. Which gas variable ($P_{internal}$, V, T or n) is most closely related to the length of the arrows in Model 1?

4. Complete the following table for the two experiments in Model 1.

	Experiment A	**Experiment B**
Independent Variable		
Dependent Variable		
Controlled Variable(s)		

5. Of the variables that were controlled in both Experiment A and Experiment B in Model 1, one requires a nonflexible container. Name this variable, and explain why a nonflexible container is necessary. In your answer, consider the external and internal pressure data given in Model 1.

Read This!

Pressure is caused by molecules hitting the sides of a container or other objects. The pressure changes when the molecules change *how often* or *how hard* they hit. A nonflexible container is needed if the gas sample is going to have an internal pressure that is different from the external pressure. If a flexible container is used, the internal pressure and external pressure will always be the same because they are both pushing on the sides of the container equally. If either the internal or external pressure changes, the flexible container walls will adjust in size until the pressures are equal again.

6. Name the two factors related to molecular movement that influence the pressure of a gas.

7. Provide a molecular-level explanation for the increase in pressure observed among the flasks of Experiment A.

8. Provide a molecular-level explanation for the increase in pressure observed among the flasks of Experiment B.

9. Predict what would happen to the volume and internal pressure in Experiment A of Model 1 if a flexible container were used.

10. Predict what would happen to the volume and internal pressure in Experiment B of Model 1 if a flexible container were used.

11. For each experiment in Model 1, determine the relationship between the independent and dependent variables, and write an algebraic expression for the relationship using variables that relate to the experiment ($P_{internal}$, V, T or n). Use k as a proportionality constant in each equation.

	Experiment A	**Experiment B**
Direct or Inverse Proportion?		
Algebraic Expression