ChemQuest 47

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Gas Equations

Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Hour: \_\_\_\_\_

# **Information**: Gas Pressure

Figure 1: Two containers of gas molecules

Container 1 Container 2

Gas molecules move randomly in their containers, colliding with the walls of their containers causing “gas pressure.” Pressure can be defined as the force pushing on an area. It can be described with the equation:



where P is pressure (in kPa), F is force (in N) and A is area (in m2).

The more molecules collide with the wall and the faster the molecules are going when they strike the wall, the greater the force on the wall and therefore, the higher the pressure.

# **Critical Thinking Questions**

1. Use the pressure equation to explain why it would be more likely for an ice skater to fall through the ice on a lake than it would be for someone walking across the lake with regular shoes on.
2. Which container in Figure 1 has the highest pressure? Explain.
3. If I heated container 1 and did not heat container 2, could I get the pressure in container 1 to equal container 2? Explain.
4. If container 2 was made of an elastic material and if I expanded container 2, could I make the two containers have equal gas pressures? Explain.

# **Information**: Gas Laws

Observe the following experimental data concerning a container of gas. The pressure, volume and temperature of a gas are all related. The table of data was obtained by making measurements of the pressure, volume and temperature of a sample of a gas. Several different kinds of gases were used and all had identical results. The variable that was not changed was the amount of gas present. The number of moles of gas always remained the same during these trials.

Table 1: Experimental Data for Gases

|  |  |  |  |
| --- | --- | --- | --- |
| **Trial** | **Pressure (P)** Units: kPa | **Volume (V)**  Units: L | **Temperature (T)**  Units: K |
| A | 120 | 3.2 | 324.3 |
| B | 135 | 2.5 | 285.0 |
| C | 195 | 2.3 | 378.7 |
| D | 150 | 2.0 | 254.4 |
| E | 135 | 4.2 | 480.8 |
| F | 100 | 3.0 | 254.4 |
| G | 225 | 3.2 | 608.0 |
| H | 262 | 2.8 | 620.4 |

### **Critical Thinking Questions**

1. Verify that this equation is true when the volume is unchanged:

(Hint: You must use two sets of data where the volume does not change like in trials A and G. Note: the subscript 1 refers to the pressure and temperature for the first trial you select and the subscript 2 refers to the pressure and temperature for the second trial you select.)

1. Scientists often look for relationships between variables. If you wanted to see how the volume and pressure are related you would need to compare data from different trials when the temperature does not change. Why?
2. Find two sets of data in the table that have constant temperature. Which of the following mathematical relationships is true (there may be more than one) when the temperature remains unchanged? This relationship is known as “Boyle’s Law”, named after the person who first discovered it.

a) b) (P1)(V1) = (P2)(V2) c) P1 + V1 = P2 + V2 d)

1. At constant pressure, which of the following equations is/are true? This relationship is known as “Charles’ Law”, named after the person who first discovered it.

a) b) (T1)(V1) = (T2)(V2) c) P1 + V1 = P2 - V2 d)

1. Complete the following. You may want to consider the equations from questions 5, 7 and 8.
2. At constant volume, as the temperature increases, the pressure always \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
3. At constant temperature, as the volume increases, the pressure always \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
4. At constant pressure, as the temperature increases, the volume always \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
5. If the volume is not constant, is the statement you completed in 9a always true? Justify your answer by citing experimental data from the data table.
6. If the temperature or pressure is not constant are your statements in 9b and 9c correct? Justify your answer.
7. Would the equations you discovered still be true if the temperature was measured in degrees Celsius (oC) instead of Kelvin (K)? Recall that K = oC + 273 or oC = K – 273.

13. Which of the following quantities is a constant?

 a) b) PV + T c)



14. Based on your answer to question 13, verify that this equation is true: This equation is called the “Combined Gas Law”. Notice that it contains all of the equations combined into one!

1. What needs to remain constant in order for equation 14 to be true? (You may need to refer to the information section.)
2. Prove that when the temperature remains constant, the combined gas law becomes Boyle’s Law.
3. Prove that when the pressure remains constant, the combined gas law becomes Charles’s Law.
4. You have discovered several new mathematical relationships among gases. Now is your chance to practice using these equations!
5. At constant temperature, the volume of a gas expands from 4.0 L to 8.0 L. If the initial pressure was 120 kPa, what is the final pressure?
6. At constant pressure, a gas is heated from 250 K to 500 K. After heating, the volume of the gas was 12.0 L. What was the initial volume of the gas? Notice: as the temperature doubled, what happened to the volume?
7. The volume of a gas was originally 2.5 L; its pressure was 104 kPa and its temperature was 270K. The volume of the gas expanded to 5.3 L and its pressure decreased to 95 kPa. What is the temperature of the gas?
8. At constant temperature, if you increase the volume by a factor of two (doubling the volume), the

pressure \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ by a factor of \_\_\_\_\_\_\_\_\_\_\_\_\_\_. (Refer to 18a for a hint.)

increases or decreases what number