**Today’s task:** Investigate the Gas Laws. These laws are mathematical expressions that describe the various behaviors of gases when conditions are changed. Next week, we’ll bring all of these laws together into the “Ideal Gas Law.” For now, we’ll look at pairs of variables, such as volume and pressure, and how changing one variable of a gas affects the other.

## Bellwork:

Some of your classmates were able to boil water at 80°C in lab yesterday. By pulling back on a partially-filled syringe, how did they change the atmospheric pressure inside the syringe? How did this lead to the water boiling?

## Units of Gas Variables

## The Gas Laws

Using what we know about the relationships between conditions which affect gas behavior, fill out the chart below:

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables that affect motion of gas particles** | **Thinking it through:****As one goes up, the other goes…** | **Relationships between variables** | **Mathematical equation** |
| P vs. V | P V | Inversely proportional | P1V1 = P2V2 |
| P vs. T |  |  |  |
| V vs. T |  |  |  |
| n vs. V |  |  |  |

#### Boyle’s Law: Pressure vs. Volume

Example problem: For a basketball with a volume of 2.42 L, the pressure of the gas inside is determined to have a pressure of 87.6 kPa, what happens to the volume of this gas if the pressure is raised to 101.3 kPa (“standard pressure”)?

*Reasoning: In order to increase the gas pressure in the container, we must decrease the volume of the container such that the gas particles are forced to hit the container walls* more often*. Thus, we expect the new volume to have a value smaller than 0.242 L.*

**P1V1 = P2V2**

P1 = 87.6 kPa

V1 = 2.42 L

P2 = 101.3 kPa

V2 = ?

**Problems to complete:**

1. If a gas occupies 2.5 L at standard pressure, what volume will it occupy if the pressure is decreased to 92.9 kPa?

Will the volume increase or decrease? \_\_\_\_\_\_\_\_\_\_\_\_\_ Answer: \_\_\_\_\_\_\_\_\_\_\_\_\_

1. A gas is collected in a 9.5 L container and under a pressure of 4.5 atm. In order to get the volume of this gas to 22.4 L, what does the pressure of the container to be changed to?

Will the pressure increase or decrease? \_\_\_\_\_\_\_\_\_\_\_\_\_ Answer: \_\_\_\_\_\_\_\_\_\_\_\_\_

1. If 1.0 L of gas at 2.0 atms is brought to 4.0 atms, what is the resulting volume given temperature is held constant?

Will the volume increase or decrease? \_\_\_\_\_\_\_\_\_\_\_\_\_ Answer: \_\_\_\_\_\_\_\_\_\_\_\_\_

#### Gay Lussac’s Law: Pressure vs. Temperature

Example problem: A student has a helium balloon which is at standard pressure (101.3 kPa). However, it’s not as inflated as she wants it to be, so she heats it over a hot plate from 25°C to 50°C. What will the new internal pressure of the balloon be, assuming the volume of the balloon removes the same?

*Reasoning: The new pressure of the gas should be larger than the original volume, because increasing the temperature causes the gas molecules to move* faster *and thus they will hit sides of the balloon more often.* *Thus, we expect to have a higher pressure than 101.3kPa.*

P1 = 101.3 kPa

T1 = 25 + 273 K = 298 K

P2 = ?

T2 = 50 + 273 K = 323 K

**Problems to complete:**

1. If a gas is cooled from 323.0 K to 273.15 K and the volume is kept constant, what final pressure would result if the initial pressure was 1.12 atm?

Will the pressure increase or decrease? \_\_\_\_\_\_\_\_\_\_\_\_\_ Answer: \_\_\_\_\_\_\_\_\_\_\_\_\_

1. If a gas in a cooled container is pressurized from 15.0 atm to 16.0 atm and its final temperature was 300 K, what was the initial temperature of the gas?

Will the temperature increase or decrease? \_\_\_\_\_\_\_\_\_\_\_\_\_ Answer: \_\_\_\_\_\_\_\_\_\_\_\_\_

1. A sample of oxygen gas initially at 0.97atm is cooled from 21ºC to -68ºC at a constant volume. What is its final pressure (in atm)?

Will the pressure increase or decrease? \_\_\_\_\_\_\_\_\_\_\_\_\_ Answer: \_\_\_\_\_\_\_\_\_\_\_\_\_

#### Charles’ Law: Volume vs. Temperature

Example problem: A student fills a balloon with 7.12 L of air at room temperature (25°C) and then places it in Mr. Erickson’s freezer and is allowed to cool to -10°C. What will the new volume of the balloon be, assuming that the pressure?

*Reasoning: The new volume of the gas should be smaller than the original volume, because decreasing the temperature causes the gas molecules to move* more slowly *and thus they will fill the balloon less.* *Thus, we expect to have a smaller volume than 7.12 L.*

**Problems to complete:**

1. A 7.12 L volume of gas is collected at 715°C. What volume would this sample occupy at standard temperature (0°C) if the pressure stays constant?

Will the volume increase or decrease? \_\_\_\_\_\_\_\_\_\_\_\_\_ Answer: \_\_\_\_\_\_\_\_\_\_\_\_\_

1. A gas occupies a volume of 4.50 L at 27°C. At what temperature would the volume be 6.00 L if the pressure stays constant?

Will the temperature increase or decrease? \_\_\_\_\_\_\_\_\_\_\_\_\_ Answer: \_\_\_\_\_\_\_\_\_\_\_\_\_

1. If a 25.0 L balloon at 25.0 degrees Celsius is heated to 100.0 degrees Celsius, what is the resulting volume given pressure is held constant?

Will the volume increase or decrease? \_\_\_\_\_\_\_\_\_\_\_\_\_ Answer: \_\_\_\_\_\_\_\_\_\_\_\_\_