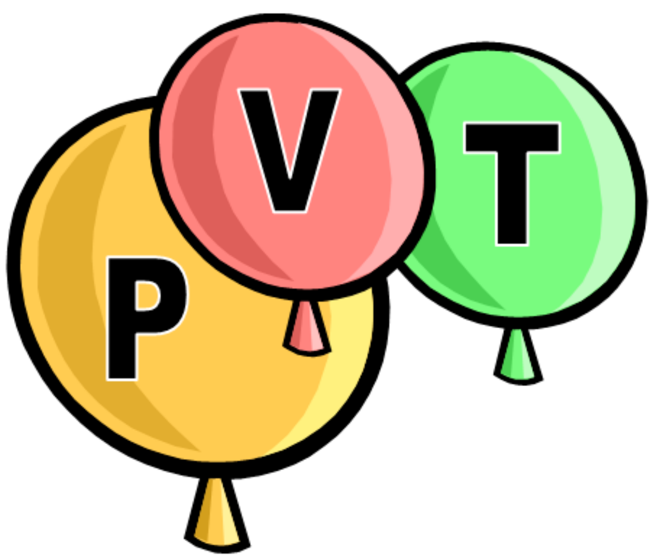
Chemistry B
Gas Laws Packet



Worksheet #1: Introduction to Gas Laws

In Chemistry A you learned that gases have no definite shape, no definite volume, and highly compressible. Next we will learn several of the major laws that describe how gases behave.You are expected to **MEMORIZE** the bolded parts of the description:

Behavior of Gases

1. **Gases are composed of tiny particles called molecules** which are in rapid, random, straight-line motion, colliding with each other and the walls of the container they are in.

2. **Gases exert pressure by collisions** with the walls of their container.

3. **Gases are mainly empty space**; only about 1/1000th of the total volume is actually filled by the molecules. The gas fills the rest of the volume by moving through it.

When you describe a gas it is necessary to specify the conditions of the gas you are considering; these conditions are described by four variables:

Gas Variables

Pressure (P)	**Volume (V)**	**Temperature (T)**	**Number of moles (n)**

Pressure is defined as the force exerted per unit of surface area (force/area) and the SI unit for pressure is the pascal (Pa). Atmospheric pressure is commonly measured using a barometer. The mercury barometer was invented by Torricelli in 1643; the atmospheric pressure is directly proportional to the height of a column of mercury in a glass tube that is inverted in a pan of mercury. Because of this **gas** pressure has commonly been expressed in units of **inches of mercury (in Hg), centimeters of mercury (cm Hg), or millimeters of mercury (mm Hg) which is also called the torr** in honor of Torricelli. Very often gas pressure is measured in industry and in our daily lives with a device called a pressure gauge and units of **pounds per square inch (psi).**

When dealing with gases **there is a reference pressure called standard pressure which is defined as the normal pressure of the atmosphere at sea level on a fair weather day. Standard pressure can be expressed in all of the units listed above plus the unit atmosphere (atm).** These values are: 29.9 in Hg, 76.0 mm Hg, 760 mm Hg, 760 torr, 101,325 Pa, 14.7 psi, and 1.00 atm. **For now we will only use three of these values to use in our problems:**

Standard Pressure Values to MEMORIZE

1.00 atmosphere (atm)	**760 torr**	**14.7 psi** (lbs/in^2)

Temperature is a measure of the average kinetic energy and is measured in units called degrees. In our laboratory work we will always record our temperature readings in Celsius degrees. However, when we study gases we must use the Kelvin scale. **This scale starts at absolute zero, the coldest temperature possible, where there is no motion of the gas molecules. There are no negative values in Kelvin**, **it cannot be colder that 0 K**. Whenever you do a calculation involving gas temperature you must use the Kelvin scales so you frequently need to convert Celsius to Kelvin and Kelvin to Celsius.

Conversions between Celsius and Kelvin Temperatures

$$K = {}^{0}C + 273 \qquad {}^{0}C = K - 273$$

(No degree sign is used with the Kelvin scale and the values are just called Kelvin, not degrees.)

Just as there is a reference pressure called standard pressure, **there is a reference temperature called standard temperature. This value is the normal freezing point of water at standard pressure** and you need to memorize the value of the standard temperature.

Standard Temperature Values to MEMORIZE

0^{0}C	**273 K**	**32^{0}F**

Chemists and physicists frequently combine the concepts of standard temperature and standard pressure into a single abbreviation, **STP** which means **standard temperature and standard pressure.**

STP - MEMORIZE
(Standard Temperature and Pressure)

The following are the values we will commonly use for STP but, of course, any of the units for standard temperature or standard pressure can be used.

0^{0}C or 273 K	AND	1.00 atm or 760 torr or 14.7 psi

Questions:

1. What are the three behaviors of gases that you need to MEMORIZE?

   A.____

   B. ____

   C. ____

2. If most of the space a gas occupies is empty space, how does it "fill" the rest of the space in its container?

3. When you describe a sample of gas there are four variables you commonly mention. Give the letter and name for each of these variables.

   ________________ ________________ ________________ ________________

4. Define standard pressure:____

____

Give its values in the **three** standard units.

_________atmospheres (atm) ___________ torr _________ psi (lbs/in^2)

5. In scientific terms, temperature is actually a measure of __________________________________

6. Give the value of **standard temperature** in Celsius, Fahrenheit and Kelvin. (Note that there is no degree sign for Kelvin)

_____________^{0}C ____________^{0}F _______________ K

7. What do the letters STP stand for?

_______________________ ________________________ and _____________________________

8. What is happening to the SPEED and MOTION of the molecules when you heat a sample of gas? (Don't say "they get hot")

____

9. Gases are very compressible meaning you can "squeeze" a sample of gas down into a much smaller volume. When you compress a gas what is it that is actually decreasing? (Don't say "the volume" but instead explain it in terms of the MOLECULES of the gas)

____

10. If you have a 10 liter sample of gas in a balloon and you apply pressure to squeeze the gas down to a volume of 5 liters, at constant temperature, what will happen to the number of collisions between the gas molecules and the walls of the balloon? Circle one:

INCREASE DECREASE STAY THE SAME

11. In the example above, the volume got smaller and the pressure got _______________ at constant temperature. Circle one:

BIGGER SMALLER

12. If you have a 10 liter sample of gas in a balloon and you reduce the pressure so that the gas expands to a volume of 20 liters, at constant temperature, what will happen to the number of collisions between the gas molecules and the walls of the container? Circle one:

INCREASE DECREASE STAY THE SAME

13. In the above case, the volume got larger and the pressure got ______________________ at constant temperature. Circle one:

BIGGER SMALLER

Worksheet #2: Boyle's Law (Constant Temperature Problems)

In 1650 Sir Robert Boyle summed up a series of experiments on gases with the statement that is now known as **Boyle's Law**. He said *"The volume and pressure of a sample of gas are inversely proportional at constant temperature."* That is, **when the pressure gets bigger the volume gets smaller and vice versa as long as you keep the same temperature and the same number of molecules** (that is what we mean by "the sample"). We can represent this law with an equation:

Boyle's Law
at constant temperature:

$$\frac{V_1}{V_2} = \frac{P_2}{P_1} \quad \text{or} \quad P_1 V_1 = P_2 V_2$$

Our strategy for solving these problems will be:

(1) Read the problem and pull out the information about volume, temperature and pressure (always assume the temperature is not changing).
(2) Determine if you are solving for volume or for pressure.
(3) Choose the equation in the correct format (use your equation sheet OR algebra)
(4) Plug the numbers into the equation and solve it.
(5) Round to two decimals, add a label, and box the final answer.

EXAMPLE PROBLEM #1:
A 5.00 L sample of a gas had a pressure of 380.0 torr at a temperature of 25.0^0C. Calculate the volume this sample of gas would occupy at standard pressure. *Hint: we know standard pressure in many units, but for this problem it makes sense to use 760 torr since that is the unit used in the problem.*

V_1 = 5.00 L $\quad$ $T_1 = 25.0^0$C $\quad$ P1 = 380.0 torr

V_2 = ? $\quad$ $T_2 = 25.0^0$C $\quad$ P2 = 760.0 torr

$$V_2 = \frac{P_1V_1}{P_2} \qquad V_2 = \frac{5.00\text{ L x } 380.0\text{ torr}}{760.0\text{ torr}} = 2.5 = 2.50\text{ L}$$

EXAMPLE PROBLEM #2
A 14.00 L sample of gas has a pressure of 3.00 atm at a temperature of 25.0^0C. The volume of the sample of gas increased to 42.0 L while the temperature remained constant. What was the final pressure of the gas?

V_1 = 14.00 L $\quad$ $T_1 = 25.0^0$C $\quad$ P1 = 3.00 atm

V_2 = 42.0 L $\quad$ $T_2 = 25.0^0$C $\quad$ P2 = ?

$$P_2 = \frac{P_1V_1}{V_2} \qquad P_2 = \frac{3.00\text{ atm x } 14.0\text{ L}}{42.0\text{ L}} = 1 = 1.00\text{ atm}$$

Worksheet #2 Continued: Boyle's Law Problems

Most commonly we find our gas law problems presented in "story problem" format. Before attempting to solve the problem you first organize the information and then set up the calculation.

1. A sample of gas had a volume of 20.0 liters at 0^0C and 1520 torr. What would be the volume of this gas sample at 0^0C and 760 torr?

   $V_1 =$ $T_1 =$ $P_1 =$

   $V_2 =$ $T_2 =$ $P_2 =$

   $V_2 =$

2. If a sample of gas has a volume of 12.0 liters at 25.0^0C and 0.500 atmospheres pressure, what volume would it occupy at 25.0^0C and 2.00 atm pressure?

   $V_1 =$ $T_1 =$ $P_1 =$

   $V_2 =$ $T_2 =$ $P_2 =$

   $V_2 =$

3. A 60.0 mL sample of gas at 40.0 lbs/in^2 pressure suddenly experiences a pressure drop to a standard pressure while the temperature remains constant at 25.0^0 C . What is the new volume?

   $V_1 =$ $T_1 =$ $P_1 =$

   $V_2 =$ $T_2 =$ $P_2 =$

   $V_2 =$

4. A sample of gas has a pressure of 2.00 atm and a volume of 400 mL at 40^0C. What volume would this sample occupy at 40^0C and 5.00 atm?

   $V_1 =$ $T_1 =$ $P_1 =$

   $V_2 =$ $T_2 =$ $P_2 =$

   $V_2 =$

5. A sample of gas at 25.0^{0}C and 750 torr had a volume of 80.0 mL. The volume was changed to 120.0 mL while the temperature remained constant. What was the new pressure?

$V_1 =$ $T_1 =$ $P_1 =$

$V_2 =$ $T_2 =$ $P_2 =$

$P_2 =$

6. A gas sample was held at a pressure of 30.0 psi and 100^{0}C. The temperature was held constant while the pressure was increased to 120 psi and the volume changed to 8.0 cubic feet. What was the original volume?

$V_1 =$ $T_1 =$ $P_1 =$

$V_2 =$ $T_2 =$ $P_2 =$

$V_1 =$

7. A student collected 88.0 mL of carbon dioxide at 28.0^{0}C and 730 torr. What volume of carbon dioxide would the student have at 28.0^{0}C and 760 torr?

$V_1 =$ $T_1 =$ $P_1 =$

$V_2 =$ $T_2 =$ $P_2 =$

$V_2 =$

Extra Challenge:

8. A sample of gas had a volume of 45.0 L at a given temperature and pressure. The pressure suddenly was tripled while the temperature remained constant 25.0^{0}C. What was the final volume?

$V_1 =$ $T_1 =$ $P_1 =$

$V_2 =$ $T_2 =$ $P_2 =$

$V_2 =$

Worksheet #3: More Boyle's Law Problems

Solve the following problems directly on this sheet. You must use the technique shown in class: organize the information and set up the correct equation. Give your final, boxed answer rounded to two decimals.

1. A sample of gas had a volume of 85.6 mL at 0.0^0C and 625 torr. What would be the volume of this gas sample at STP?

2. A sample of gas has a volume of 62.0 liters at 25.0^0C and 15.0 psi. How many psi of pressure would be needed to compress this gas to a volume of 12.0 liters if the temperature remains constant?

3. A gas sample has a volume 48.5 mL at 0.0^0C and 0.875 atm. What volume would this gas sample occupy at standard temperature and 1.59 atm pressure?

4. A sample of gas had a volume of 12.0 liters at 25.0^0C and 14.7 psi. If it was compressed to a volume of 1.65 liters, with the temperature remaining constant, what was the new pressure?

5. A sample of gas had a volume of 1.75 liters at 40.0^0C and 5.00 atm pressure. What would be the volume of this gas sample at this temperature and standard pressure?

6. A student collected a 90.5 mL sample of gas at 20.0^0C and 728 torr. What would be the volume of this gas sample at this temperature and standard pressure?

7. A student had a gas sample with a volume of 3.25 liters at STP. What pressure, in torrs, would be needed to compress this gas to 0.550 liters, assuming constant temperature?

8. A student had a sample of gas at 25.0^0C and 825 torr. When the pressure changed to 675 torr the volume became 78.9 mL, while the temperature remained constant. What was the **original** volume of this gas sample?

9. A sample of gas was enclosed in a cylinder with one wall made to move in and out like a piston. This moveable wall guaranteed that the pressure inside the container was equal to the pressure outside the container. The gas sample had a volume of 3.00 liters at 20.0^0C and 0.985 atm. A tornado swept through the room, lowering the pressure to 0.425 atm but leaving the temperature constant. What was the new volume of the gas?

Worksheet #4: Graphing Boyle's Law (Pressure vs. Volume)

An important concept you must consider when you study gases is the relationship between pressure and the volume of a sample of gas at constant temperature.

Make a graph of the following data of pressure versus volume for a 3.00 mole sample of gas at 25.0^{0}C. Graph the pressure as the independent variable and volume the dependent variable. Be sure to label the axes and include a title.

Pressure (atm)	Volume (L)	Pressure (atm)	Volume (L)	Pressure (atm)	Volume (L)
1.00	73.35	4.50	16.30	8.00	9.17
1.50	48.90	5.00	14.67	8.50	8.63
2.00	36.68	5.50	13.34	9.00	8.15
2.50	29.34	6.00	12.22	9.50	7.72
3.00	24.45	6.50	11.29	10.00	7.34
3.50	20.96	7.00	10.48		
4.00	18.34	7.50	9.78		

Answer the following questions directly on this sheet. Refer to Worksheet #1 if you have trouble.

1. Define pressure.

2. Describe the motion of the molecules in a sample of gas and explain how the moving gas molecules create pressure inside their container.

3. Look at your graph and see what happens to the volume of a gas as its pressure increases at constant temperature. Is this relationship as directly proportional or inversely proportional? Explain your answer.

4. We commonly talk about standard pressure when we are working with gases. Express standard pressure in several common units:

_____________ atm _______________ torr _________________ psi

Worksheet #5: Charles' Law (Constant Pressure Problems)

So far we have studied the relationship between gas pressure and volume. **Now we will look at the relationship of temperature and volume for a sample of gas at constant pressure.** This relationship was first determined in 1787 by Jacques Charles and so it is called Charles' Law. Charles' Law states that *"the volume and temperature of a sample are directly proportional at a constant pressure"*. In other words, **when the temperature increases, so does the volume and visa versa as long as you keep the temperature the same**. We can represent this law with an equation:

Charles' Law
at constant pressure:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad \text{or} \quad V_1 T_2 = V_2 T_1$$

When we work with gas law problems that involve a temperature change we must work with the Kelvin temperature scale. We saw on the last sheet that gas volume varies in 1:1 ratio with the Kelvin temperature; that is, **if you double the Kelvin temperature you double the volume, triple the Kelvin temperature the gas volume triples, etc.** The Kelvin scale begins at absolute zero and is equal to 273 K at 00C, so you **add 273 to the Celsius temperature to convert it to Kelvin.**

Convert 25.0^0C to Kelvin ________________________ Convert 332 K to ^{0}C ___________________

EXAMPLE 1: A sample of gas has a volume of <u>55.8 mL</u> at <u>25.0^0C</u> and <u>760 torr</u>. What <u>volume</u> would this gas sample occupy at <u>STP</u>?

V_1= T_1= + 273 = K P_1=

V_2= T_2= + 273 = K P_2=

V_2 =

EXAMPLE 2: A gas sample had a volume of <u>25.0 L</u> at <u>100.0^0C</u>. What <u>volume</u> would this gas occupy at <u>200.0^0C</u>, assuming the pressure remains constant at 760 torr?

V_1= T_1= + 273 = K P_1=

V_2= T_2= + 273 = K P_2=

V_2 =

EXAMPLE 3: A gas had a volume of 75.0 mL at 40.0^0C and 755 torr. The volume increased to 145 mL while the pressure remained constant. What was the final **Celsius** temperature?

V_1= T_1= + 273 = K P_1=

V_2= T_2= + 273 = K P_2=

T_2 =

EXAMPLE 4: A gas had a volume of 25.0 liters at 400.0^0C and standard pressure. The gas was cooled until the volume was 12.5 L at standard pressure. What was the final Celsius temperature of the gas?

V_1= T_1= + 273 = K P_1=

V_2= T_2= + 273 = K P_2=

T_2 =

Worksheet #6: More Charles' Law Problems

Solve the following problems directly on this sheet. You must use the technique shown in class: organize the information and set up the correct equation. Give your final, boxed answer rounded to two decimals.

1. A sample of gas has a volume of 425 mL at 25^0C and 760 torr. What volume would this gas sample have at STP?

2. A sample of gas occupied 250.0 mL at 30.0^0C. What volume will it have at 60.0^0C, assuming the pressure remains constant?

3. A 5.76 liter sample of a gas at 22.0^0C and 748 torr pressure was heated to a final volume of 17.28 liters, with the pressure remaining constant. What was the final Celsius temperature?

4. An 800. mL sample of oxygen at 90.0^0C and 752 torr was cooled at constant pressure until it has a volume of 400.0 mL. What was the final Celsius temperature of this gas?

5. A sample of gas had a volume of 2.50 ft^3 at 14.7 psi pressure and 45.0^0C. What would be the volume, in cubic feet, of this gas sample at STP?

6. A 125 mL sample of gas at 28.0^0C and 98.5 kPa was heated until the volume doubled, with the pressure constant. What was the final Celsius temperature?

Worksheet #7: Graphing Charles' Law (Temperature vs. Volume)

Directions:

1. Graph the data in the first two columns of the table below.
2. The data in the table represents the change in volume of an enclosed sample of gas as it cooled with the pressure remaining constant. Ignore the last column in the table for now.
3. Plot the temperature as the independent (x) variable. Rotate the sheet of graph paper so you can make the temperature scale longer. The temperature scale must range from -300^{0}C to 100^{0}C. This means you will show first and second quadrants of the graph but the majority of your graph paper will be in the second quadrant.
4. Make your graph large enough to fill most of the sheet of graph paper.
5. Because it will be very difficult to accurately plot the volume, plot points but then draw a circle around each point so that you will be able to at least connect the circles for a straight line.

Temperature (^{0}C)	Volume (L)	Temperature (K)
100	10.00	
75	9.33	
50	8.66	
25	7.66	
0	7.32	
-25	6.65	
-50	5.98	
-75	5.31	
-100	4.64	
-125	3.97	
-150	3.30	
-175	2.63	
-200	1.96	

6. When the student continued cooling the gas he found that at just below -200^{0}C the gas sample became a liquid so he could no longer gather data for us to graph. HOWEVER, we can predict what this line would look like. This prediction is called *extrapolation*. Use a dotted line for your extrapolation and extend the line until it crosses the x-axis. Where on the x-axis does it cross?

   ____

7. Look at your graph and complete the statement: As the Celsius temperature of a sample of gas increases the volume ___________________, at constant pressure. This means volume and temperature of a sample of gas are ______________________ proportional at constant pressure.

8. According to the graph, what would be the apparent volume, in liters, of this sample of gas at the x-intercept? ________________________ Why would this never happen in the real world?

   ____

9. Complete the last column of the table by filling in the Kelvin temperatures using the relationship $K = {}^0C + 273$

Worksheet #8: Combination Gas Law Problems

It is very common to have **both the temperature and the pressure change** in a sample of gas. A problem like **this involves applying both Charles' law and Boyle's law in the same problem**; that is called the **Combination Gas Law**. We can represent this law with an equation that combines the previous two we have used:

Combination Gas Law
with changing temperature AND pressure:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

EXAMPLE 1: A sample of gas has a volume of 46.5 mL at 28.0^{0}C and 785 torr pressure. What volume would this gas occupy at STP?

V_1= T_1= + 273 = K P_1=

V_2= T_2= + 273 = K P_2=

V_2 =

EXAMPLE 2: A sample of gas has a volume of 72.8 mL at 735 torr and -40.0^{0}C. What volume would this gas sample occupy at STP?

V_1= T_1= + 273 = K P_1=

V_2= T_2= + 273 = K P_2=

V_2 =

Worksheet #9: More Combination Gas Law Problems

Solve the following problems directly on this sheet. You must use the technique shown in class: organize the information and set up the correct equation. Give your final, boxed answer rounded to two decimals.

1. A student collected a 46.0 mL sample of gas at 28.0^0C and 748 torr. What volume would this gas sample occupy at STP?

2. A sample of gas had a volume of 15.0 liters at 20.0^0C and 0.875 atm. What volume would this gas sample occupy if it was heated to 40.0^0C and the pressure dropped to 0.500 atm.

3. A 44.0 mL sample of gas at -40.0^0C and 12.0 psi was brought to standard conditions; that it, STP. What was the new volume of the sample?

4. A 475 ft^3 sample of gas was held at 15.0 atm and 22.0^0C. The gas pressure dropped to 1.00 atm and the temperature rose to 88.0^0C. What was the new volume?

5. A student collected a 47.5 mL sample of gas in the lab at 732 torr pressure and 29.0^0C. What volume would this gas sample occupy at STP?

Gas Laws Review Sheet #1: Conceptual Gas Laws Questions

1. What does temperature measure? ___________________________

2. What is the lowest temperature possible, expressed in Celsius and Kelvin? ___________________

3. What is the volume of an "ideal gas" at absolute zero? ___________________________

4. How do gases create pressure? ____

5. If you graph two variables and get a straight line are the variables directly proportional or inversely proportional? ___________________________

6. If you graph two variables get a curved line are the variables directly proportional or inversely proportional? ___________________________

7. State Boyle's Law and sketch the shape of the P-V graph.

8. State Charles' Law and sketch the shape of the T-V graph.

9. Describe the motion of gas particles at STP.

10. Describe the motion of "ideal gas" particles at absolute zero.

EXTRA CHALLENGES:

11. Explain how a vacuum cleaner works and tell whether it would work in a vacuum.

12. If an astronaut on a space walk rips his space suit, will he explode, implode or survive?

Gas Law Review Worksheet #2: Boyle's, Charles', and Combination Gas Law Problems

Solve the following problems directly on this sheet. You must use the technique shown in class: organize the information and set up the correct equation. Give your final, boxed answer rounded to two decimals.

1. A 15.0 liter sample of gas at 35.0^{0}C was heated to 70.0^{0}C while the pressure was held constant. What was the final volume of this gas sample at the new temperature?

2. A sample of gas occupies 4.00 liters at 0.0^{0}C and 2.50 atm. What volume would this sample occupy at STP?

3. A sample of gas had a volume of 15.0 liters at 20.0^{0}C and 0.875 atm. What volume would this sample occupy if it was heated to 40.0^{0}C and the pressure dropped to 0.500 atm?

4. A 6.50 liter sample of gas at STP was heated until its volume was 24.0 liters at a constant pressure of 14.7 psi. What was the final **Celsius** temperature?

5. If a sample of gas has a volume of 22.4 liters at 28.0^{0}C, to what Celsius temperature must it be cooled to decrease the volume to 20.0 liters, assuming constant pressure?

6. A student collected a 46.0 mL sample of gas at 26.0^{0}C and 748 torr. What volume would this sample fill at STP?

7. What pressure would be needed to compress 5,000 ft^3 of methane (natural gas) at 30.0^0C and 0.985 atm, to a volume of 2,500 ft^3, assuming constant temperature?

8. A gas sample with a volume of 1275 mL of 220.0^0C and 1.00 atm was cooled to standard conditions. What was the new volume?

9. A 44.0 mL sample of gas at -40.0^0C and 12.0 psi was allowed to warm and expand until it reached STP. What was the final volume of this gas sample?

10. If a gas sample has a volume of 175 mL at STP, what volume would it fill at 14.7 psi and 25.0^0C?

11. When a sample of gas suddenly had it's pressure triple and it's Celsius temperature drop to one half of its original value, the volume became 45.0 liters. What was the **original** volume of this gas sample?

12. A 5.00 liter sample of gas was collected at 273^0C and 1.50 atm. What volume would this sample fill at 546^0C and 4.50 atm?

Gas Laws Review Sheet #3: Extra Practice Problems- Answers Included

1. If a sample of gas has a volume of 88.8 mL at -12.0ºC and 785 torr, what volume would it have at STP? (95.9 mL)

2. A 64.2 mL gas sample was collected at 28.0ºC and 0.975 atm. What volume would this sample have at STP? (56.8 mL)

3. A 45 mL gas sample at a Kelvin temperature was cooled until the new Kelvin temperature was one fifth the original temperature, while the pressure remained constant. What was the final volume of this gas? (9.0 L)

4. A sample of gas at 546ºC and 4.50 atm was cooled to 273ºC and the pressure dropped to 1.50 atm. The new volume is 2.50 L. What was the original volume of the sample? (1.25 L)

5. A student had 5.65 L of carbon dioxide at 25.0ºC. How hot would he need to heat it, expressed in Celsius degrees, to change it to 10.0 L, assuming the pressure remains constant? (254ºC)

6. If a gas fills 28.0 ft^3 at STP, what volume will it occupy at -25.0ºC and 0.400 atm? (63.6 ft^3)

7. With temperature kept constant, the pressure of an 18.0 L sample of gas increased to three times the original pressure. What was the new volume of the gas? (6.00 L)

8. A student collected a 53.0 mL sample of gas at 24.0ºC and 733 torr. What volume would this sample fill at STP? (47.0 mL)

9. A 42.1 mL sample of gas at STP was suddenly cooled until it reached a temperature of -40.0ºC and a pressure of 12.0 psi. What was the original volume of the sample of gas? (44.0 mL)

10. A student collected a 29.5 mL sample of a gas at 28ºC and 760. torr pressure. What volume would this gas sample occupy at STP? (26.8 mL)

Use as intro to ideal gas laws ws #11

The kinetic molecular theory of gases describes gases as molecules in rapid, random straight line motion, having perfectly elastic collisions with each other and the walls of their container. These collisions create what we call the pressure of the gas. These molecules are far apart; only about 1/1000th of the space is actually molecules. The rest of the space is "occupied" by the molecules moving rapidly through it. Scientists talk about an imaginary or "ideal gas" in which the molecules have no volume; they are just points moving rapidly though space. Of course such a gas does not exist but we can consider not moving, and so they were not traveling through or occupying any space or colliding with any walls. This means the volume and pressure of this "ideal gas" would be zero.

When we talked about energy we described kinetic energy as energy that matter possesses due to motion. We learned that we can calculate kinetic energy with the equations $KE = ½ mv^2$ where "m" is mass and "v" is velocity. This means that when you increase the speed of a particle of matter you increase its kinetic energy. Since temperature is a measure of average kinetic energy when you increase the temperature of matter you increase the speed of its particles and when you cool a sample of matter you decrease the speed of its particles.
What does temperature measure? ___________ How do you calculate kinetic energy? __________ When you cool a sample of gas, what happens to the average speed of the molecules? ___________ How slow can molecules go? ____________ If you cool a gas until all of the molecules stop moving what will be the value of the kinetic energy? __________ What do we call the temperature at the point where the molecules are no longer moving? ____ Could there be a temperature lower than the point where the molecules stop moving? ____________ Why or why not? ____ Why do we call the coldest temperature "absolute" zero? _______________________________________ Give the value of absolute zero in __________ K, _________ A, and __________ ^{0}C. What would be the volume of an "ideal gas" at absolute zero? _____________ What would be the pressure of an "ideal gas" at absolute zero? ______________ How did scientists determine the value of absolute zero? ____ If we only have "real gases", why do we bother with gas laws that are based upon the behavior of "ideal gases"? ____ When don't they obey these laws and what do they do when they "disobey" they gas laws? ______________________________________ ____

Worksheet #11: UNIVERSAL GAS LAW OR IDEAL GAS LAW

The universal gas law is an equation which relates all four variable for a single sample of gas. We don't use this equation when we are dealing with changes in volume or temperature or pressure. We use this equation when we know any three of the variables (P,V,T and n) describing a gas sample and we want to solve for the fourth.

1. Give the other name for the universal gas law:____

   ____

   The universal gas law is: $PV = nRT$

   where P = pressure, V = volume, n = number of moles, T = temperature (again, it must be in Kelvin), and R is a proportionality constant called the universal gas constant. R = 0.0821 L atm/K mole

   We can solve the equation to find P, $P = nRT/V$

   We can solve the equation to find V, $V = nRT/P$

   We can solve the equation to find n, $n = PV/RT$

   We can solve the equation to find T, $T = PV/nR$

Because the value of R is given in liters and atmospheres we must factor-label any other volume or pressure units to agree with R.

2. What would be the volume, in liters, of 3.00 moles of gas at 30.0^0C and 2.75 atm pressure? (Ans. = 27.1 L)

3. What would be the pressure, in atmospheres, if an 8.25 liter container holds 2.64 moles of argon at 28.0^0C? (Ans. = 7.91 atm)

4. How many moles of gas are there in a 0.750 liter container with a pressure of 2.25 atmosphere at 225.0^0C? (Ans. = 0.0413 moles)

5. How many moles of gas are there in an 875 mL container with a pressure of 925 torr at 25.0^0C? (Note: substitute the mL and torr in the equation, then add factor-label terms at the end to convert the mL to liters and torr to atm.) (Ans. = 0.0435 moles)

6. What is the temperature, in Celsius degrees, of an 8.40 liter sample of gas with a pressure of 752 torr and a total of 0.333 moles of gas? (You solve for Kelvin, then find Celsius.) (Ans. = 31^0C)

7. A 6.00 liter container held 3.00 moles of oxygen, 11.1 moles of nitrogen and 0.143 moles of argon at a temperature of 20.0^0C. What was the total pressure, in atmospheres, in the container? (Note: find the total moles of gas, then solve for pressure.) (Ans. = 57.1 atm)

All of the following problems involve the application of the universal gas law. PV = nRT where

$$R = 0.821 \frac{\text{L atm}}{\text{mol K}}$$

1. A sample of atgon has a pressure of 1.75 atm, a volume of 18.0 liters, and was at a temperature of 50.0^0C. How many moles were in the sample?

   Ans. 1.19 moles Ar

2. A 0.444 mole sample of methane had a volume of 3.00 liters and was at 200.0^0C. What was the pressure of this natural gas sample?

   Ans. 5.75 atm

3. A container held 26.0 moles of fluorine at a temperature of 75.0^0C and a pressure of 50.0 atm. What was the volume of this fluorine sample?

   Ans. 14.9 L Fl_2

4. A 0.0800 mole sample of ozone was in a 8.75 liter container and has a pressure of 0.300 atm. What was the Celsius temperature of the ozone sample?

   Ans. 127^0C