UNIT 10 - GASES

Temperature & Pressure Conversions WKSHT

1.) 2.00 atm to mm Hg
2.) 115 kPa to atm
3.) 500. mm Hg to atm
4.) 3.5×10^4 torr to mm Hg
5.) 35 °C to Kelvin
6.) 120 °C to Kelvin
7.) -25 °C to Kelvin
8.) -227 °C to Kelvin
9.) 1800. mm Hg to kPa
10.) 93,500 Pa to atm
11.) 950. torr to atm
12.) 0.490 atm to kPa
13.) standard temperature in Kelvin & Celsius
14.) 298 K to °C
15.) 100. K to °C
16.) 5 Kelvin to °C

Ideal Gas Equation 1 WKSHT

1.) What is the pressure exerted by 2.0 moles of an ideal gas when it occupies a volume of 12.0 L at 373 K?
2.) A flashbulb of volume 2.6 cm^3 contains O_2 gas at a pressure of 2.3 atm and a temperature of 26°C. How many moles of O_2 does the flashbulb contain?
3.) If 0.20 moles of helium occupies a volume of 64.0 liters at a pressure of 0.15 atm, what is the temperature of the gas?
4.) What is the volume of 0.35 moles of gas at 1.7 atm of pressure and a temperature of 100 K?
5.) What is the pressure of 1.5 moles of an ideal gas at a temperature of 150 K and occupies a volume of 20.0 liters?
6.) How many moles of gas occupy 16.2 liters at a pressure of 1.05 atm and a temperature of 37°C?

Answers: 1.) 5.1 atm; 2.) 2.4×10^{-4} moles; 3.) 580 K; 4.) 1.7 L; 5.) 0.92 atm; 6.) 0.668 moles

Ideal Gas Equation 2 WKSHT

1.) Calculate the volume of exactly 1.00 mole of a gas at STP.
2.) How many moles of nitrogen are present in 17.8 liters at 27 °C and 1.3 atm pressure?
3.) What is the pressure of 2.3 moles of carbon dioxide at 235 K occupying 23.7 liters of space?
4.) If there are 4.02×10^{23} molecules of N_2O in a sample, how many moles are there?
5.) Using your answer from # 6, calculate the pressure of the gas if it occupies 27,025 cm^3 of space at 38.0 °C.
6.) How many grams of ammonia gas (NH_3) are present in 35.0 dm^3 of space at 78.3 K and 0.853 atm of pressure?
7.) What is the temperature of 34.2 grams of sulfur dioxide occupying 30.0 liters of space and having a pressure of 800. torr?
8.) What is the pressure (in mm Hg) of 79.4 grams of boron trifluoride in a 20.0 L container at a temperature of 245 K?
9.) How many grams are in a sample of arsenic trifluoride that has a volume of 17,600 mL and a temperature of 92 °C and a pressure of 108,732 Pa?
10.) How many kilopascals of pressure are exerted by 23.8 liters of oxygen with a mass of 175 grams at a temperature of 58 °C?
11.) How many moles of argon are in 30.6 liters at 28 K and 658 mm Hg of pressure?
12.) How many grams of argon are found in # 11?

Answers: 1.) 22.4 L; 2.) 0.94 moles; 3.) 1.9 atm; 4.) 0.668 moles; 5.) 0.631 atm; 6.) 78.9 g; 7.) 720. K; 8.) 897 mm Hg; 9.) 83 g; 10.) 632 kPa; 11.) 12 moles; 12.) 480 g

Applications of Ideal Gas Equation WKSHT

1.) What pressure is exerted by 1.0 mole of an ideal gas contained in a 1.0 L vessel at 0.0 °C?
2.) What is the density of a sample of ammonia gas, NH_3, if the pressure is 0.928 atm and the temperature is 63.0 °C?
3.) Calculate the molar mass of a gas if 4.5 L of the gas at 785 torr and 23.5 °C has a mass of 13.5 grams.
4.) 0.453 moles of a gas confined to a 15.0 L container exerts a pressure of 1.24 atm on the walls of the container. What is the temperature of the gas (in °C)?
5.) 5.4 grams of carbon dioxide are confined to a 20.0 L container at a temperature of 32.5 °C. What pressure

does the gas exert?

6.) 2.125 grams of a gas in a 1.25 L container exert a pressure of 0.838 atm at 40.0 °C. What is the molar mass of the gas?
7.) To what temperature must 10.0 grams of NH_3 have to be heated in a 15.0 L container in order for it to exert a pressure of 3.50 atm?
8.) 2.0×10^{-5} grams of hydrogen gas at 155 °C exert a pressure of 322.5 torr on the walls of a small cylindrical tube. What is the volume of the tube?

Answers: 1.) 22 atm; 2.) 0.572 g/L; 3.) 71 g/mole; 4.) 227 °C; 5.) 0.15 atm; 6.) 52.1 g/mole; 7.) 1090 K; 8.) 8.3×10^{-4} L

Gas Law Problems WKSHT

1.) The gas pressure in an aerosol can is 1.5 atm at 25 °C. Assuming that the gas inside obeys the ideal gas equation, what would the pressure be if the can were heated to 450 °C?
2.) A pocket of gas is discovered in a deep drilling operation. The gas has a temperature of 480 °C and is at a pressure of 12.8 atm. Assume ideal behavior. What volume of the gas is required to provide 18.0 L at the surface at 1.00 atm and 22 °C?
3.) A fixed quantity of gas is compressed at constant temperature from a volume of 368 mL to 108 mL. If the initial pressure was 5.22 atm, what is the final pressure?
4.) A gas originally at 15 °C and having a volume of 182 mL is reduced in volume to 82.0 mL while its pressure is held constant. What is its final temperature?
5.) At 36 °C and 1.00 atm pressure, a gas occupies a volume of 0.600 L. How many liters will it occupy at 0.0 °C and 0.205 atm?
6.) What is the temperature at which 9.87×10^{-2} moles occupies 164 mL at 0.645 atm?
7.) Chlorine is widely used to purify municipal water supplies and to treat swimming pool waters. Suppose that the volume of a particular sample of Cl_2 is 6.18 L at 0.90 atm and 33 °C. What volume will the Cl_2 occupy at 107 °C and 0.75 atm?
8.) A gas exerts a pressure of 1.5 atm at 27 °C. The temperature is increased to 108 °C with no volume change. What is the gas pressure at the higher temperature?

Answers: 1.) 3.6 atm; 2.) 3.59 L or 3.6 L; 3.) 17.8 atm; 4.) 130 K or 130. K; 5.) 2.59 L or 2.6 L; 6.) 13.1 K
7.) 9.2 L; 8.) 1.9 atm

GAS STOICHIOMETRY (standard conditions) WKSHT.

**** assume all reactions in this section occur at STP ****

1.) How many liters of oxygen can be formed from the decomposition of 2.00 grams of $KClO_3$.
$\_\_\ KClO_3 \rightarrow \_\_\ KCl + \_\_\ O_2$
2.) How many grams of $CaCO_3$ are required to produce 6.00 L of CO_2?
$\_\_\ CaCO_3 \rightarrow \_\_\ CaO + \_\_\ CO_2$
3.) Determine the volume of hydrogen gas produced when 0.250 moles of zinc react with excess HCl.
$\_\_\ Zn + \_\_\ HCl \rightarrow \_\_\ ZnCl_2 + \_\_\ H_2$
4.) How many liters of nitrogen are required to combine with 3.0 L of hydrogen in the following reaction:
$\_\_\ N_2 + \_\_\ H_2 \rightarrow \_\_\ NH_3$
5.) How many liters of oxygen are needed to combine with 7.0 liters of propane in the following reaction:
$\_\_\ C_3H_8 + \_\_\ O_2 \rightarrow \_\_\ CO_2 + \_\_\ H_2O$
6.) From the following reaction: $\_\_\ CH_4 + \_\_\ O_2 \rightarrow \_\_\ CO_2 + \_\_\ H_2O$
How many liters of CO_2 are formed from 32.0 grams of CH_4?
7.) How many grams of Na are needed to produce 5.0 L of hydrogen?
$\_\_\ Na + \_\_\ H_2O \rightarrow \_\_\ NaOH + \_\_\ H_2$
8.) Determine the volume of CO_2 produced from burning 0.750 moles of C.
$\_\_\ C + \_\_\ O_2 \rightarrow \_\_\ CO_2$

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Answers: 1.) 0.551 L; 2.) 26.8 g; 3.) 5.60 L; 4.) 1.0 L; 5.) 35 L; 6.) 44.8 L; 7.) 10. g; 8.) 16.8 L

DALTON'S LAW & GRAHAM'S LAW WKSHT.

1. Determine the partial pressure of each gas in a container with 2.0 moles of N_2, 3.0 moles of O_2, and 7.0 moles of H_2 that has a total pressure of 850 mm Hg. (You will have 3 separate answers for this question.)
2. A mixture of nitrogen and oxygen has a total pressure of 730 mm Hg. If the nitrogen has a partial pressure of 420 mm Hg, find the pressure of the oxygen.
3. At an altitude of 30,000 ft., the total air pressure is only about 450. mm Hg. If the air is 21.0 % oxygen, what is the partial pressure of oxygen at this altitude?
4. A mixture of 3 gases have the following pressures: oxygen = 355 mm Hg, helium = 468 mm Hg, and nitrogen = 560 mm Hg. Find the % of each gas in the mixture.
5. Compare the rate of effusion of CH_4 and CO_2. (Give answers to # 5, 6, & 7 to 3 SF's.) (Your answers for # 5, 6, &, 7 should read " ___ effuses ___ times faster than ___.")
6. Compare the rate of effusion of helium and nitrogen.
7. How much faster does ammonia (NH_3) effuse than HCl?
8. An unknown gas effuses 4.0 times faster than O_2. Find the molar mass of the unknown gas.

Answers: 1.) N_2 = 142 mm Hg, O_2 = 213 mm Hg, H_2 = 496 mm Hg 2.) 310 mm Hg
3.) 94.5 mm Hg 4.) O_2 = 25.7%, He = 33.8 %, N_2 = 40.5 %
5.) CH_4 effuses 1.66 times faster than CO_2. 6.) He effuses 2.65 times faster than N_2.
7.) NH_3 effuses 1.46 times faster than HCl 8.) 2.0 g/mole

UNIT 10 REVIEW WORKSHEET

1.) Convert the following pressure measurements to atmospheres.
(A) 151.98 kPa (B) 456 mm Hg (C) 912 torr
2.) What are the conditions for gas measurement at STP?
3.) The volume of a sample of methane gas measures 350. mL at 27.0 ^oC and 810. mm Hg. What is the volume (in liters) at -3.0 ^oC and 650. mm Hg pressure?
4.) How many grams of nitrogen gas are contained in a 32.6 liter container at 34.4 ^oC and 579 torr?
5.) A mixture of four gases in a container exerts a total pressure of 955 mm Hg. In this container, there are 4.50 moles of nitrogen gas, 4.25 moles of carbon dioxide gas, 2.75 moles of hydrogen gas, and 2.00 moles of oxygen gas. What is the partial pressure of each gas?
6.) Compare the rates of effusion of carbon dioxide gas and carbon monoxide gas.
7.) An unknown gas effuses 1.37 times faster than chlorine gas. What is the molar mass of the unknown gas?
8.) Given the following unbalanced reaction:
___ C_5H_{12} + ___ O_2 → ___ CO_2 + ___ H_2O
How many liters of oxygen are needed to produce 45.7 liters of CO_2?
9.) Given the unbalanced equation:
___ Mg + ___ O_2 → ___ MgO
How many liters of oxygen gas are required to produce 45.8 grams of magnesium oxide?
10.) An aerosol can contains gases under a pressure of 4.50 atm at 20.0 ^oC. If the can is left on a hot, sandy beach, the pressure of the gases increases to 4.80 atm. What is the temperature on the beach (in ^oC)?

ANSWERS:
1.) (A) 1.5003 atm (B) 0.600 atm (C) 1.20 atm
2.) 0 ^oC (or 273 K) & 1 atm 3.) 0.393 L 4.) 27.6 g
5.) N_2 = 318 mm Hg, CO_2 = 301 mm Hg, H_2 = 195 mm Hg, O_2 = 141 mm Hg
6.) CO effuses 1.25 times faster than CO_2.
7.) 37.8 g/mole 8.) 73.1 L 9.) 12.8 L 10.) 40.0 ^oC

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GASES - A FANTASTIC SUMMARY & REVIEW!

Law	Ideal Gas Equation	Combined Gas Law
equation	$P\ V = n\ R\ T$	$\frac{P_1\ V_1}{T_1} = \frac{P_2\ V_2}{T_2}$
explanation	one gas at one set of conditions	one gas that is changing conditions
when to use it	when the problem gives 3 of these: P, V, n, T	more than one temperature, pressure, and/or volume in the problem
specific units req'd?	pressure = atm volume = liters quantity (n) = moles temperature = Kelvins	temperature = Kelvins pressure & volume can be any unit, but must be the same unit on both sides of the equation

Law	Boyle's Law	Charles' Law	Gay-Lussac's Law
equation	$P_1\ V_1 = P_2\ V_2$	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$
explanation	pressure & volume are inversely proportional; temperature is constant	volume & Kelvin temp of a gas are directly proportional; P is constant	pressure & Kelvin temp of a gas are directly proportional; V is constant
when to use it	given 2 difft pressures & 1 volume or given 2 difft volumes & 1 pressure	given 2 difft volumes & 1 temperature or given 2 difft temperatures & 1 volume	given 2 difft pressures & 1 temperature or given 2 difft temperatures & 1 pressure
specific units req'd?	any - but must be the same on both sides of equation	any unit for volume (same on both sides), Kelvin temperature	any unit for pressure (same on both sides), Kelvin temperature

1. Convert the following temperatures.
   (A) 104 °C to K (B) -3 °C to K (C) 67 K to °C (D) 1671 K to °C
2. Convert the following pressures.
   (A) 635 torr to atm (B) 104.2 kPa to mm Hg (C) 1.45 atm to Pa
3. A gas that effuses 1.19 times slower than nitrogen is added to light bulbs. What is the molecular mass of this unknown gas?
4. (A) What is the molecular mass of a 0.2500 g sample of a gas at 99.8°C and 0.9131 atm in a 100.0 cm^3 container? (B) What is the gas in the container?
5. A small 2.00 L fire extinguisher has an internal pressure of 506.6 kPa at 25°C. What volume of methyl bromide, the fire extinguisher's main ingredient , is needed to fill an empty fire extinguisher at standard pressure if the temperature remains constant?
6. If 45.0 g of propane gas burns completely in the following reaction:
   $C_3H_{8(g)} + 5\ O_{2(g)} \rightarrow 3\ CO_{2(g)} + 4\ H_2O_{(g)}$
   then how many liters of carbon dioxide gas will be released if the system is at STP?
7. Air in a closed cylinder is heated from 25°C to 36°C. If the initial pressure is 3.80 atm, what is the final pressure?
8. At what temperature Celsius will 19.4 g of molecular oxygen, O_2, exert a pressure of 1820 mm Hg in a 5.12 L cylinder?

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9. To what temperature must 32.0 ft^3 of a gas at 2.0 °C be heated for it to occupy 1.00 x 10^2 ft^3 at the same pressure? (ft^3 is a unit of volume)
10. Determine the molar mass of a gas that has a density of 2.18 g/L at 66°C and 720 mm Hg.
11. A 3.10 mL bubble of methane gas forms at the bottom of a bog where the temperature is 12°C and the pressure is 8.5 atm. The bubble rises to the surface where the temperature is 35°C and the pressure is 1.18 atm. What is the new volume of the methane bubble?
12. A mixture of 2.00 moles of H_2, 2.00 moles of NH_3, 4.00 moles of CO_2 and 5.00 moles of N_2 exerts a total pressure of 800. torr. What is the partial pressure of each gas?
13. For the reaction $2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(g)}$, how many liters of water can be made from 5.0 L of oxygen gas and an excess of hydrogen?

UNIT 10 - GASES

DETERMINING MOLAR MASS USING THE IDEAL GAS EQUATION LAB

DISCUSSION & OBJECTIVE

Gases are one of the major products and/or reactants in many chemical reactions. Of all the states of matter, gases are the most affected by changes in temperature and pressure. The method of collecting the gas also affects the pressure of the gas. The relationship between the density of a gas and the pressure and temperature at which it is collected can be used to determine the molecular weight of the gas.

This lab activity will use the Ideal Gas Equation to experimentally determine the molar mass of a common gas - butane. Since real gases do not behave ideally at room temperature, the results will be expected to vary from the calculated molar mass. The idea of a dry gas versus one collected over water will also be involved.

MATERIALS

- butane lighter, large container, large graduated cylinder, thermometer, balance

SAFETY PRECAUTIONS

- basic safety precautions apply; **Do not try to ignite the gas after collecting it!**

PROCEDURE

1. Immerse the lighter completely in water. Then use a paper towel to dry the lighter as best as possible. Then weigh the butane lighter to the nearest hundredth of a gram. Record this value in the data table.
2. Fill the container about two-thirds to three-fourths full with water.
3. Place the graduated cylinder in the container and fill it with water also. Invert the cylinder and keep the opening of the cylinder under the surface of the water to prevent any water from leaving the cylinder. (You should not have any air bubbles at the top of the graduated cylinder.)
4. Check the lighter to be certain it is open as much as possible to allow gas to escape rapidly.
5. Place the top of the lighter up into the opening of the cylinder and depress the striker to allow the gas to bubble up into the cylinder. (Butane is not very flammable under water!)
6. Allow the gas to escape until about 250 mL of gas are collected. Quickly read the volume of the gas because butane is more soluble in water than most hydrocarbons. Record this volume.
7. Dry the lighter **completely** and weigh it again. Record this value.
8. Read the temperature of the water to the nearest tenth of a degree. Record this temperature.
9. Your instructor will provide you with the barometric pressure reading.

* Click here to go to the water vapor pressure table online. Or, make sure that you note this measurement for the temperature of your lab before you leave class.

DATA TABLE

Mass of the lighter before collecting gas	_____ g
Mass of the lighter after collecting gas	_____ g
Mass of gas collected	_____ **g**
Volume of gas collected	_____ mL
Volume measurement in Liters	_____ **L**
Temperature of the water (and gas)	_____ ^{o}C
Temperature measurement in Kelvins	_____ **K**
Barometric pressure	_____ inches Hg
Barometric pressure conversion (1 inch = 25.4 mm)	_____ mm Hg
Vapor pressure of water at certain temperature *	_____ mm Hg
Pressure of the "dry" gas	_____ mm Hg
Dry gas pressure measurement in atm	_____ **atm**

UNIT 10 - GASES

CALCULATIONS

The ideal gas equation is $P V = n R T$

where P = pressure, V = volume, n = moles, R = ideal gas constant, and T = temperature.

Make sure that your calculations are clearly shown in #3 below! (Please note that clearly implies not only legibility, but also a logical progression of calculations. Numbers written haphazardly all over your paper is not a logical progression.)

Experimental molar mass = _____g/mole

The formula for butane is C_4H_{10}. Calculate the theoretical molar mass based on this formula.

Theoretical molar mass = _____ g/mole

Calculate the % error: $\frac{|\text{theoretical value} - \text{experimental value}|}{\text{theoretical value}} \times 100$

LAB QUESTIONS

1.) Identify at least three (3) possible sources of experimental error. (The errors you include should stem from either an assumption that was made about the gas or lab conditions or something that you did or did not do during the lab. Remember, I know that you're intelligent young adults. "We read the insert name of measuring device here wrong." is not an acceptable source of experimental error. Think about your answers!)

2.) Read Step 6 in the PROCEDURE. What effect would leaving the gas in contact with the water for an excessive amount of time have on the experimental molar mass? (Would the experimental molar mass be higher or lower if you did this? Why? Think about your calculations.)

3.) Show **in detail** how you determined the experimental molar mass of butane, the theoretical molar mass of butane, and your percent error.