Honors Chemistry -

CONSTANTS/FORMULAS:

- Boyle's law
- Charles' law
- Gay-Lussac's law
- Combined gas law
- Dalton's law
- Ideal gas law
- Molar volume
- Molecular Mass Determination (of a gas)

OBJECTIVES:

- Memorize the values for STP.
- Memorize and be able to apply the gas laws: Boyle's, Charles, Dalton's law of partial pressure, Combined gas law, Gay-Lussac's.
- Be able to use molar volume of a gas at STP in problems.
- Be able to calculate gas density at STP.
- Memorize and be able to apply the ideal gas law.
- Memorize the gas constant R = .0821 L-atm/mol-K.
- Be able to do problems involving gas stoichiometry (at STP and other conditions).

Unit PROBLEM SET – Gases, Gas Laws, and Gas Stoichiometry

- Follow the instructions for the cover page for Problem Sets.
- Show your work on all problems. Credit will not be given without work.
  Include units on your answers.

Review:

1. Draw the dot diagram for Bismuth.

2. Draw the Lewis Structure for the following and identify the VSEPR Shape:
   A. Carbonate ion
   B. silicon disulfide

Current Unit Material

3. A sample of diborane gas (B_2H_6) a substance that bursts into flame when exposed to air, has a pressure of 345 torr at a temperature of -15^0C and a volume of 3.48 L. If conditions are changed so that the temperature is 36^0C and the pressure is 268 torr, what will be the volume of the sample?

4. The density of a gas was measured at 1.30 atm and 47^0C and found to be 1.95 g/L. Calculate the molar mass of the gas.

5. Mixtures of helium and oxygen are used in scuba diving tanks to help prevent "the bend". For a particular dive, 46 L of O_2 at 25^0C and 1.0 atm and 12 L He at 25^0C and 1.0 atm were pumped into a tank with a volume of 5.0 L. Calculate the partial pressure of each gas and the total pressure in the tank at 25^0C. Hint: Label all of the variables and calculate each tank (oxygen and helium) as separate problems!

6. What is one every day application of one or more of the gas laws. Be specific and illustrate your example. (You may draw, cut out a picture, download a graphic, etc.)

7. Calculate the volume of oxygen gas at STP, required for the complete combustion of 45 g of octane (C_8H_{18}).

8. Calculate the volume of oxygen gas at 85 ^{0}C and 789 torr, required for the complete combustion of 45 g of octane (C_8H_{18}).

(extra-credit): A sample of methane gas having a volume of 2.80 L at 25 ^{0}C and 1.65 atm was mixed with a sample of oxygen gas having a volume of 35.0 L at 31^0C and 1.25 atm. The mixture was then ignited to form carbon dioxide and water. Calculate the volume of CO_2 formed at a pressure of 2.50 atm and a temperature of 125^0 C.

Unit 10 - Gas Laws Notes

Gases: 4 measurable quantities:

Volume 1 ml = 1 cm^3 Pressure Temperature # of moles

Variables?

STP?

GAS LAWS – Must be Memorized!!!

Boyle's law - $P_1 V_1 = P_2 V_2$ (V varies inversely with P)
Graph of P vs V? inversely?

Example. If 1.0 L of a gas at 1.2 atm is allowed to expand to 5.0 L, what is the new pressure?

You try: A sample of O_2 gas has a volume of 150 ml when its pressure is 720 mm Hg, what will the volume be if the pressure is increased to 750 mm Hg?

(Answer: 144 ml)

Charles law: $V_1/T_1 = V_2/T_2$ (V varies directly with the Kelvin temperature)
T must be in Kelvin Graph of V vs T? Directly? Why T in K?

Example: A helium filled balloon has a volume of 2.75 L at 20.0 ^{0}C . The volume of the balloon decreases to 2.46 L after it was placed outside on a cold day. What is the outside temperature?

You try: A sample of neon occupies a volume of 752 ml at 25 ^{0} C. What volume will the gas occupy at 50. ^{0}C?

(Answer: 815 ml)

Gay-Lussac's Law: $P_1/T_1 = P_2/T_2$ (P varies directly with Kelvin Temperature)
Like which other law?

You Try: Before a trip from Raleigh to NY, the pressure in a tire is 1.8 atm at 20 ^{0}C. Ath the end of the trip the pressure gauge reads 1444 mm Hg. What is the new temperature in the tire?

(Answer: 309 K (or 36 ^{0}C))

Combined Gas Law: $\underline{P_1V_1} = \underline{P_2V_2}$ $\underline{\text{T must be in K!!!}}$ T_1 T_2

Example: If 282.4 ml of a gas at 25 ^{0}C and 1.3 atm is cooled to 20. ^{0}C and 780 mm Hg. What is the new volume?

You try: a 700. ml gas sample at STP is compressed to a volume of 200. ml, and the temperature is increased to 30.0 ^{0}C. What is the new pressure of the gas in kPa?

(Answer: 394 kPa)

Dalton's law of Partial Pressures: pressure of each gas in a mixture is called the partial pressure of that gas. Total Pressure = sum of partial pressures

$$P_T = P_1 + P_2 + P_3 \ldots \text{etc.}$$

Special case: gases collected by water displacement – see diagram on board!

Use formula $P_T = P_{atm} = P_g + P_{H2O}$

Total atmosphere = gas + water

P_{atm} from lab or is given: P_{H2O} = Table page 899

Example: Oxygen is collected by water displacement. The barometric pressure and temperature are 84.5 kPa and 20.0 ^{0}C. What is the partial pressure of O_2?

You try: A gas is collected over water and the atmospheric pressure is 101.1 kPa at 50 C. What is the partial pressure of the gas?

(Answer: 88.8 kPa)

Ideal Gas Law Notes

PV = nRT

Must use the following units with the ideal gas law!
P = atm V = L T = K n = moles

R = gas constant 0.0821 L-atm/mol- K (memorize)

Example: What is the pressure exerted by a 12.0 g sample of Nitrogen gas (N_2) in a 10.0 L container at 25 ^{0}C?

Practice Ideal Gas Law Worksheet: 1 – 4 (page 12 in packet)

GAS LAW PROBLEMS

Work the following problems and identify the gas law used; be sure your answer includes units!

1. A gas occupies a volume of 35.9 ml at a temperature of 22.0 C. What volume will the same gas occupy at a temperature of 28.0 C?
2. At a pressure of 780 mm Hg and 24.2 C a gas has a volume of 350.0 ml. What will the volume of this gas be under standard conditions?
3. A gas occupies a volume of 24.8 ml at 725 torr. What will the pressure of the gas be at 22.5 ml?
4. A gas occupies a volume of 40.8 ml at a temperature of 33.5 C. At what temperature will the volume of the gas be 39.2 ml?
5. If 45.0 ml of a gas is under 1.3 atm of pressure; at what pressure will the volume be 60.0 ml?
6. Compare the rates of effusion of nitrogen and bromine gas at the same temperature and pressure.
7. A gas at a temperature of 67.5 C and a pressure of 882 torr occupies a volume of 242.2 ml. What will the volume of the gas be at 840 torr and 80.0 C?
8. A gas with a volume of 388.9 ml at a pressure of 1.0045 atm is subjected to a pressure of 1.877 atm. What is its volume at the new pressure?
9. Hydrogen gas is collected over water and the atmospheric pressure in 122kPa at 50 C. What is the partial pressure of hydrogen?

Ideal Gas Law Practice

Remember: PV = nRT and D = PM/RT
Must use atm, L, moles and K R = .0821 L-atm/mol-K

1. How many moles of oxygen will occupy a volume of 2.5 liters at 1.2 atm and 25 ^{0}C ?

2. What volume will 2.0 moles of nitrogen occupy at 720 torr and 20.0 ^{0}C?

3. What pressure will be exerted by 25 g of CO_2 at a temperature of 25 ^{0}C and a volume of 500. ml?

4. At what temperature will 5.00 g of Cl_2 exert a pressure of 900. torr at a volume of 750. ml?

5. What is the density of NH_3 at 800. torr and 25. ^{0} C?

6. If the density of a gas is 1.2 g/L at 745 torr and 20. ^{0}C, what is its molecular mass?

7. How many moles of nitrogen gas will occupy a volume of 347 ml at 6680 torr and 27 ^{0}C?

8. What volume will 454 grams of hydrogen occupy at 1.05 atm and 25 ^{0}C? (remember hydrogen is diatomic!)

9. Find the number of grams of CO_2 that exerts a pressure of 785 torrs at a volume 32.5 L and a temperature of 32 ^{0}C.

10. An elemental gas has a mass of 10.3 g. If the volume is 58.4 L and the pressure is 758 torr at a temperature of 2.5 ^{0}C, what is the gas (Hint find the molar mass!)

Unit – Gases, Gas Laws, & Gas Stoichiometry TEST REVIEW

INFORMATION TO BE MEMORIZED/Used:
As practice; write the formulas without your notes!
Charles' Law
Boyle's Law
Gay-Lussac's Law
Combined gas law
Dalton's law
Graham's law
Ideal gas law
R =
Molar volume at STP
STP =
Density at STP and Density NOT at STP
Molar Mass from the Ideal Gas Law

PRACTICE PROBLEMS: Work without your notes – just your reference packet!

1. If 259 ml of oxygen gas is at 112 kPa, what will the volume be at standard pressure?

2. What is the pressure of helium gas collected over water, if the barometric pressure is 88.3 kPa and the temperature is 30 C?

3. What is the volume of a gas at 273 K, if it had a volume of 22.8 ml at 48 C?

4. If a 25 ml of sulfur dioxide is at 37 C and 90.2 kPa, what will the temperature be if the volume becomes 19.6 ml and the pressure is 760 torr.

5. What is the volume of 156 grams of chlorine gas at STP?

6. What is the pressure exerted by 1.32 moles of gas in an 18 L vessel at 27 C?

7. A 759 ml vessel contains 0.0945 mol of a gas at 98.6 kPa. What is the temperature of the gas?

8. What volume of hydrogen gas at STP will be produced from 16.7 g of magnesium reacting with an excess amount of hydrochloric acid?

9. What volume of fluorine gas is required to react with 2.67 g of calcium bromide to form calcium fluoride and bromine at 41 C and 4.31 atm?

10. Which one of the following will diffuse the fastest at STP: NH_3, CH_4, Ar, HBr?

ANSWERS:

1. 286 ml	2. 84.1 kPa	3. 19.4 ml	4. O C (273 K)
5. 49.2 L	6. 1.81 atm	7. 95.3 K	8. 15.4 L H_2
9. 79.9 ml	10. CH_4		

Flick Your Bic – Molar Mass Determination of Butane

Objective: To use the ideal gas law to determine the molar mass of butane.
Equipment: make an equipment list after reading the procedure
Procedure:

1. Weigh the lighter.
2. Fill a graduated cylinder up with water and invert it into a large beaker/container. Make sure there are NO bubbles in the cylinder!
3. Through water displacement collect about 25-40 ml of butane gas in your cylinder. You will do this by placing the lighter under the water into the mouth of the cylinder. Then press the button to release gas into the cylinder – the gas should displace the water and you should get a graduated cylinder filled with gas – do not light the lighter.
4. Carry your inverted cylinder with to the fume hood and release the butane in the hood – do not inhale.
5. Dry off the lighter and reweigh it. The lighter must be VERY dry or the moisture will interfere with your results.
6. Use a thermometer to get the temperature of the room.
7. Check the whiteboard to get the atmospheric pressure.

Data Table with Results (Shaded Areas are Calculated Results!)

Data Collection (don't forget units!):	
Mass of Butane lighter (before):	
Mass of Butane lighter (after):	
Mass of butane used:	
Volume of water displaced =volume of butane collected from the lighter:	
Temperature of the room:	
Atmospheric pressure:	
Calculations:	
Pressure of the butane:	
Moles of butane:	
Molar mass of butane:	
Empirical Formula/Molecular Formula	
Percent error:	

Calculations: Show all work here!

1. Using Dalton's law of partial pressures – calculate the partial pressure of the butane and enter in your data table beside the pressure of butane.

2. Using the ideal gas law, calculate the moles of butane and enter in your data table.

3. Using your answer for the moles of butane from (2) and your mass of butane used (data table) – calculate the molar mass of butane.

4. The percentage composition of the gas in the lighter is as follows: carbon, 82.63% and hydrogen, 17.37%. Calculate the empirical formula for butane and enter in the data table.

5. Using your molar mass, see if you can get a whole-number multiple of the empirical formula for the molecular formula of the gas and enter your result in the data table.

6. Given that the molar mass of butane is 58 g/mol – calculate your percent error.

Questions:

1. How do you explain the fact that the "gas" is a liquid in the lighter, but a gas when it is collected (think phase diagram……..)?

Complete the following Error Analysis Table – listing at least two possible errors and their effect on the molar mass (would it be higher or lower – and why!)

Error	Analysis

Conclusion: Write a paragraph conclusion – a minimum of three grammatically correct sentences!