Problems to work on

For the reaction of MAGNESIUM (Mg) + HYDROBROMIC ACID (HBr), how many grams of hydrobromic acid are needed when 4.0 grams of magnesium are consumed?

Calculate the number of hydrogen atoms in 0.252 L of sulfuric acid (H_2SO_4). (density 1/83 g/mL)

What is the volume, in liters, of 12.0 moles of bromine (Br_2) ? Bromine is a liquid at room temperature and has a density of 3.12 g/cm^3.

STATES OF MATTER

What makes something the state of matter it is?

liquid	**gas**
solid	**aqueous**

Molarity Problems

1. Determine the chromium ion concentration in a 300. mL solution that contains 5.00 g of chromium (III) sulfate ($Cr_2(SO_4)_3$).

2. How many grams of sodium chloride (NaCl) are needed to prepare 550. mL of a 0.222 M solution?

3. What volume of a 0.345 M barium iodide (BaI_2) solution contains 0.121 moles of iodide ions?

4. How many grams of lithium nitride (Li_3N) are needed to prepare 1.50 mL of a 0.222 M solution.

Limiting reactants

How do you know you have a limiting reactant problem?

1. Pick a product
2. How much of that product do you have from each reactant?
3. The least amount of product is the limiting reactant.

Write and balance the reaction between LITHIUM + ALUMINUM CHLORIDE (Li (s) + $AlCl_3$ (aq))

If you have 4.00 grams of lithium and 350. mL of 0.231 M of aluminum chloride, how much of the solid will you form at the end of the reaction?

THE IDEAL GAS LAW

The Ideal Gas Law interrelates the amount of a gas and its pressure, volume, and temperature. It is used to predict or calculate the changes in any of these quantities due to changes in the others. Understanding and being able to use the Ideal Gas Law is essential whenever you have to work with gases.

Gas? What's a Gas?

Model 2 Pressure – force per unit area
units

Standard Pressure:

Examples of PRESSURE in your life:

$$PV=nRT$$

1. According to the Ideal Gas Law, if the temperature increases while n and V remain unchanged, what must happen to the pressure?

2. According to the Ideal Gas Law, if the volume increases while n and T remain unchanged, what must happen to the pressure?

3. According to the Ideal Gas Law, if the number of molecules in the container increases while T and P remain unchanged, what must happen to the volume?

4. At what temperature does an ideal gas exert no pressure?

5. Why would it be nonsense to use °C versus K?

6. Calculate the volume occupied by 1.00 mole of a gas at 1.00 atm and 273 K. **Remember this number and note that these values of temperature and pressure are called STP (standard temperature pressure). CONVERSION FACTOR ALERT!**

7. **Derive an expression for the gas density (m/V) by using the Ideal Gas Law and the relationship between moles of a gas (n) and its mass (m). You should substitute moles (n) = m/MW, where MW is the molecular weight. Rearrange the equation to obtain an expression for m/V. Pay close attention to units.**

Model 4 Relationships Using the Ideal Gas Law

Boyle's Law

$P_1V_1=P_2V_2$

Charles's and Guy-Lussac's Law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \text{ or } \frac{P_1}{T_1} = \frac{P_2}{T_2}$$

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

1. According to the Ideal Gas Law, which of the following is/are correct for a gas cylinder of fixed volume filled with one mole of oxygen gas? Please explain each one.
   a. When the temperature of the cylinder changes from 15 °C to 30 °C, the pressure inside the cylinder doubles.
   b. When a second mole of oxygen is added to the cylinder, the ratio T/P remains constant.
   c. An identical cylinder filled with the same pressure of hydrogen contains more molecules because hydrogen molecules are smaller than oxygen molecules.
   d. When a second mole of oxygen is added to the cylinder, the ratio T/P decreases by 50%.
2. Suppose we have a sample of ammonia gas with a volume of 3.5 L at a pressure of 1.67 atm. The gas is compressed to a volume of 1.35 L at a constant temperature. Calculate the final pressure.
3. A quantity of gas occupies a volume of 16.5 L at 78 ºC and 4.56 atm. What is the volume at STP?
4. If 15.0 g of hydrogen sulfide gas occupies 10.0 L at STP, what is the molecular weight?
5. Forty miles above the earth's surface the temperature is -23 °C, and the pressure is only 0.20 mm Hg. What is the density of air (molar mass = 29.0 g/mol) at this altitude?

PARTIAL PRESSURE

Why?

The total pressure of a mixture of gases is the sum of the pressures that each component would exert if it were alone in container. The Ideal Gas Law relates the partial pressure caused by one component in a mixture to the amount of that component present. By using partial pressures to mix gases in the amounts that are needed, you can produce gas mixtures with properties tailored to specific requirements.

Information

The pressure of a gas in a container is caused by the molecules hitting the walls of the container. If the different gases in a mixture do not interact with each other, as in the case for an ideal gas, then the collisions of one gas with the walls will not depend on the presence of the other gases. The pressure due to each component in the mixture then will be independent of the other components. The total pressure, P_T, is the sum of the pressures of the different gases in the mixture.

$$\mathbf{P_T = P_A + P_B + P_C + etc......}$$

where P_A, P_B, P_C, etc, are the pressures of the different gases in the container.

$P_A = n_A \frac{RT}{V}$ is the pressure of each gas

The pressure of each component is called the ***partial pressure*** due to that component.

The pressure due to one component of a gas mixture is called the partial pressure due to that component. This is *Dalton's Law of Partial Pressures.*

$$\frac{P_A}{P_T} = \frac{n_A}{n_T}$$

Mole fraction of A

The ratio of the pressures is the same as the ratio of the moles of gas A to the total number of moles. This ratio (n_A/n_T) is called the **mole fraction** of the gas A, and given the symbol X_A. Another equation is:

$$\mathbf{P_A = X_A P_T}$$

The mole fraction of all the gas components must equal to 1.

$$\mathbf{X_T = X_A + X_B + X_C + ... = 1}$$

1. The mole fraction of oxygen in air is 0.209. Assuming nitrogen is the only other constituent, what are the partial pressures of oxygen and nitrogen when the barometer reads 755 torr?

2. Calculate the partial pressure of 2.25 moles of oxygen that have been mixed (no reaction) with 1.75 moles of nitrogen in a 15.0 L container at 298 K.

3. A 25.0 L gas cylinder at 32 °C is filled with 1.33 moles of carbon dioxide and 4.11 moles of nitrogen. Calculate the total pressure and the mole fractions and partial pressure of carbon dioxide and nitrogen in the cylinder.

4. Mixtures of helium and oxygen are used in scuba diving tanks to help prevent "the bends", a condition caused by nitrogen bubbles forming in the bloodstream. If 95 L of oxygen and 25 L of helium at STP are pumped into a scuba tank with a volume of 8.0 L, what is the partial pressure of each gas in the tank and what is the total pressure in the tank at 25 °C?

KINETIC MOLECULAR THEORY

Why?

The Kinetic Molecular Theory is a simple model that serves to explain the origin of the Ideal Gas Law in terms of the properties of individual gas particles, i.e., atoms and molecules. Through understanding this theory, you will be able to see how some macroscopic properties of matter are a consequence of the microscopic properties of atoms and molecules. You also will be able to explain other phenomena like diffusion and effusion and appreciate why and how real gases differ from an ideal gas.

Model 1: Kinetic Molecular Theory (KMT) and the Ideal Gas Law (gas molecules are in constant, rapid, and random motion)

1. A gas is composed of molecules whose size is much smaller than the distances between them. The volume of individual atoms and molecules is negligible.

2. Gas molecules move randomly at various speeds and in every possible direction

3. Atoms and molecules in a gas do not attract or repel each other.

4. The average kinetic energy of an atom or molecule in a gas is proportional to the Kelvin temperature. Any two gases at the same temperature will have the same average kinetic energy.

$$E = 1/2\ mv^2 = 3/2\ RT$$

The pressure exerted by a gas in a container is related to both the frequency of the collisions with the walls and the force with which the particles strike the wall.

1. If the temperature of a gas contained in a fixed volume cylinder is raised, what happens to the pressure. Explain the reason for your prediction using the KMT of gases.

2. If the volume of a container is increased, but the temperature remains constant, what happens to the pressure? Explain the reason for your prediction using the tenants of the KMT of gasses.

3. Use the KMT to rationalize Boyles' Law

4. Use the KMT to rationalize Charles' Law

Distribution of gases based on temperature and molar mass

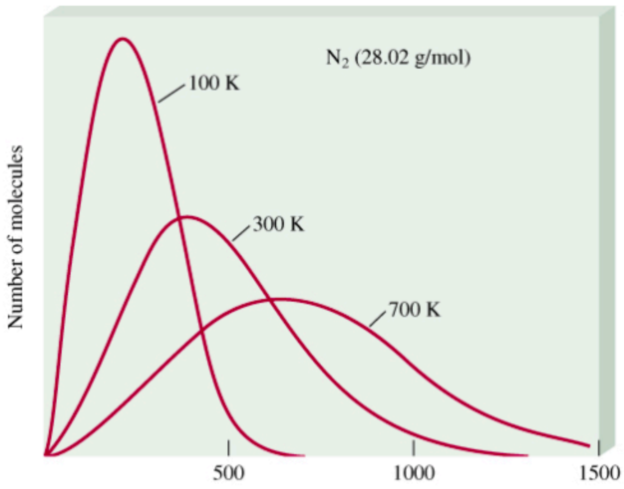

Figure 1: N_2 at 3 different temperatures

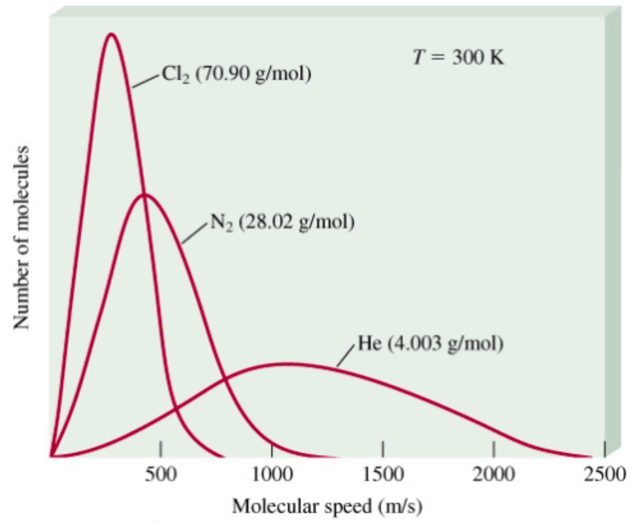

Figure 2: 3 different gases at the same temperature

5. What is happening to speed of gas molecules as the temperature increases in Figure 1 of Model 2? Explain using KMT.

6. According to Model 1 KMT, "Any two gases at the same temperature will have the same average kinetic energy". Will they have the same average molecular speed? How is this accounted for?

8. Describe what is happening in Figure 2 Model 2. How does the molecular weight affect the average kinetic energy? average speed?

9 You have two separate containers. They are the same size (they have the same volume). They have equal numbers of moles of gas and they are at the same temperature. One container contains 1 mole of H_2 gas and the other contains 1 mole of He gas.

a) In which container is the pressure the greatest?
b) In which container is the average kinetic energy of the molecules the least?
c) Which container has more total gas-particle mass?
d) In which container are the particles moving the fastest?
e) In which container is the *total* force of the collision between the molecules and the walls of the container the greatest?
f) In which container is the frequency of collisions with the walls of the container the greatest?
g) Which sample has a greater density?