10 Avogadro's Law

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- **Measure the density and molecular weight of known gas samples**
- **Verify Avogadro's Law**
- **Determine the molecular weight of an unknown gas**

DISCUSSION

In the early 1800's, Amedeo Avogadro put forth a brilliant, intuitive statement: Equal volumes of any gas, measured at the same pressure and temperature, contain the same number of free particles. This statement did not seem logical at the time (the same beaker could hold the same number of marbles or tennis balls?) and was not generally accepted. It was therefore called the Avogadro Hypothesis. Now it is accepted well enough to be called Avogadro's Law.

In this experiment, you will measure the number of moles (*n*), the molar mass (*M*) and density (*d*) of several known gases. With this data you can verify Avogadro's Law. The moles of a gas can be calculated from the ideal gas equation:

$$n = \frac{PV}{RT}$$

You will also measure the molar mass of butane gas and bunsen burner gas. Butane is a lighter fuel. Bunsen burner gas is commonly either natural gas (methane, CH_4) or bottled gas (propane, C_3H_8). From the experimental molar mass you will attempt to identify what the major component of Bunsen burner gas is.

PROCEDURE

1. Obtain a special gas syringe that is equipped with a nail and closed tip. Push the syringe plunger in as far as possible and install the closed tip. Pull the plunger out until a hole in the plunger is exposed. Insert the nail through the hole so that it will keep the plunger from returning to its original position. Determine the mass of the empty syringe in this extended condition. Since all the mass measurements rely on the mass of this empty syringe and since the mass changes are all quite small, be sure that this reading is correct.
2. Record the absolute (Kelvin) temperature of the room.
3. Record the barometric pressure.

Remove the closed tip and the nail. Push the plunger in as far as possible. Attach the hose of the gas container (balloon) to the syringe, and release the clamp on the hose. Fill the syringe with gas sample to a volume larger than the extended condition in Step 1. Place the nail back through the hole in the plunger and push the plunger until the nail contacts the syringe barrel. Place the clamp back on the hose, withdraw the syringe, and quickly replace the closed tip.

4. Measure the volume of the gas using the graduations along the syringe barrel.
5. Measure the mass of the syringe filled with gas.
6. Calculate the mass of each gas sample.
7. Calculate the density of each gas in units of g/L.
8. Using the mass and molecular weight of known gases (from the periodic table), calculate the moles of gas in the syringe. (For air, assume M=29 g/mol.)
9. Using the ideal gas equation, calculate the moles of gas in the syringe.
10. From the measured mass of the gas (Step 6) and calculated number of moles (Step 9), calculate the experimental molar mass of each gas.
11. Calculate the percent error in the experimental molar mass.

Repeat Steps 4 through 11 with each of the available known gases and with air. Determine how closely your data supports Avogadro's law.

12. Fill the syringe with butane gas (lighter fuel) as in Step 4 above.

13. Weigh the filled syringe.

14. Calculate the mass of the gas.

15. From the ideal gas law, calculate the molar mass of the gas.

Rep*eat Steps 12 through 15 with bunsen burner gas.* Determine whether the bunsen burner gas is methane or propane.

10 Avogadro's Law

Name _____
Partner _____
Section _____Locker ____
Instructor _____

Enter the data or answer the questions *according to the corresponding step in the procedure*

1. Mass of empty syringe	
2. Absolute temperature	
3. Barometric pressure	

	Gas:_____	Gas:_____	Gas:_____	Gas:_____	air
4. Volume of gas					
5. Mass syringe					
6. Mass of gas					
7. Density of gas					
8. Moles (mass/*M*)					
9. Moles (=*PV/RT)*					
10. *M* (grams/mol)					
11. Percent error					

How closely do your data support Avogadro's Law?

	Butane	**Bunsen Burner Gas**
12. Volume of gas		
13. Mass of filled syringe		
14. Mass of gas		
15. *M* of gas		

Identify the bunsen burner gas.

APPLICATION OF PRINCIPLES

1. Of the gases used in this experiment, which are "heavier" (more dense) than air, and which are "lighter" (less dense)?

2. Which will have the lower density under room conditions, carbon dioxide or carbon monoxide? Explain.

3. What is the molecular weight of a gas if 600.0 *mL* of it has a mass of 0.890 *g* at a pressure of 625 *torr* and a temperature of $27^{o}C$?