Name: ______________________________

Unit 4

Advanced Topics in Particle Behavior of Matter:
Phases & Attractions

- Apply Avogadro's Law to calculate reacting volumes of gases.
- Apply the concept of molar volume at standard temperature and pressure in calculations.
- Solve problems involving the relationship between temperature, pressure and volume for a fixed mass of an ideal gas.
- Solve problems using the ideal gas equation, $PV = nRT$
- Analyse graphs relating to the ideal gas equation.
- Describe the kinetic molecular theory in terms of the movement of particles whose average energy is proportional to temperature in Kelvin.
- Describe the collision theory (more next unit).

Name: ________________________________

Applying Avogadro's Law

Avogadro's Law says that under the same conditions of temperature and pressure, equal volumes of gases contain the same number of moles of particles. In other words, a balloon that is twice as big as another balloon contains twice as much air.

$$V = kn$$ *(where V = volume, k = constant, n = number of moles)*

This has useful consequences. The volume of 1 mole of gas at STP (standard temperature and pressure) is always the same. It doesn't matter what the gas is. The volume of a mole is the same. At STP, the molar volume of a gas is always 22.7 L. Using the standard molar volume, it is possible to solve several types of problems.

1. What is the volume of 7.15 mol of propane at STP?

2. What is the mass of 3.00 L of hydrogen gas at STP?

3. What is the volume of 7.10 kg of chlorine at STP?

4. How many moles of neon occupy 3.36 L at STP?

Name: ______________________________

Gas Stoichiometry

The gas laws make it clear that there is a relationship between the volume, the number of moles and the mass of a gas. When any of the reagents is a gas, a relationship exists between the volume and the number of moles as well, which is defined by the ideal gas law (PV=nRT).

At constant temperature and pressure, volume-volume problems can be handled simply by using Avogadro's Law ($V \propto n$) because all the other variables in the gas laws cancel out. Since the number of moles and the volumes are proportional, and the coefficients of the balanced equation are mole ratios, the problems can be solved by mole-mole ratio dimensional analysis.

Problems at STP can be simplified even when mass-volume problems are done because at STP the molar volume (GMV) of a gas is always **22.7 L**. Since **22.7 L = 1 mol at STP**, mole-mole ratios can again be used to solved these types of problems.

Answer the following questions using the procedures described on the previous page.
Note: the equations provided may <u>not</u> be balanced.

1. If 35.0 L of propane burns, how many liters of carbon dioxide will form at the same temperature and pressure? [$C_3H_8(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$]

2. If 250. mL of oxygen at STP are consumed when magnesium burns, how many grams of magnesium oxide form? [$Mg(s) + O_2(g) \rightarrow MgO(s)$]

3. Hydrogen peroxide decomposes to release oxygen. How much space does the oxygen occupy if 40.8 g of hydrogen peroxide decomposes at -13˚C and 2.40 atm? [$H_2O_2(aq) \rightarrow H_2O(l) + O_2(g)$]

4. Most of the carbon dioxide in the blood is carried as carbonic acid (H_2CO_3). It decomposes in the alveoli to release carbon dioxide. How many grams of carbonic acid would have to decompose to release 15.0 mL of carbon dioxide into the lungs at 37˚C and 1 atm? [$H_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g)$]

Name: ________________________________

Ideal Gas Law Practice

Solve the following problems. Be sure to write the equation used and show how numbers were put into the equation. All answers must have the correct units.

1. If 4.27 moles of propane are at a temperature of 33.79˚C and are under 167.98 kPa of pressure, what volume does the sample occupy?

2. A sample of carbon monoxide at 55.68˚C and under 0.2 atm of pressure takes up 67.12 L of space. What mass of carbon monoxide is present in the sample?

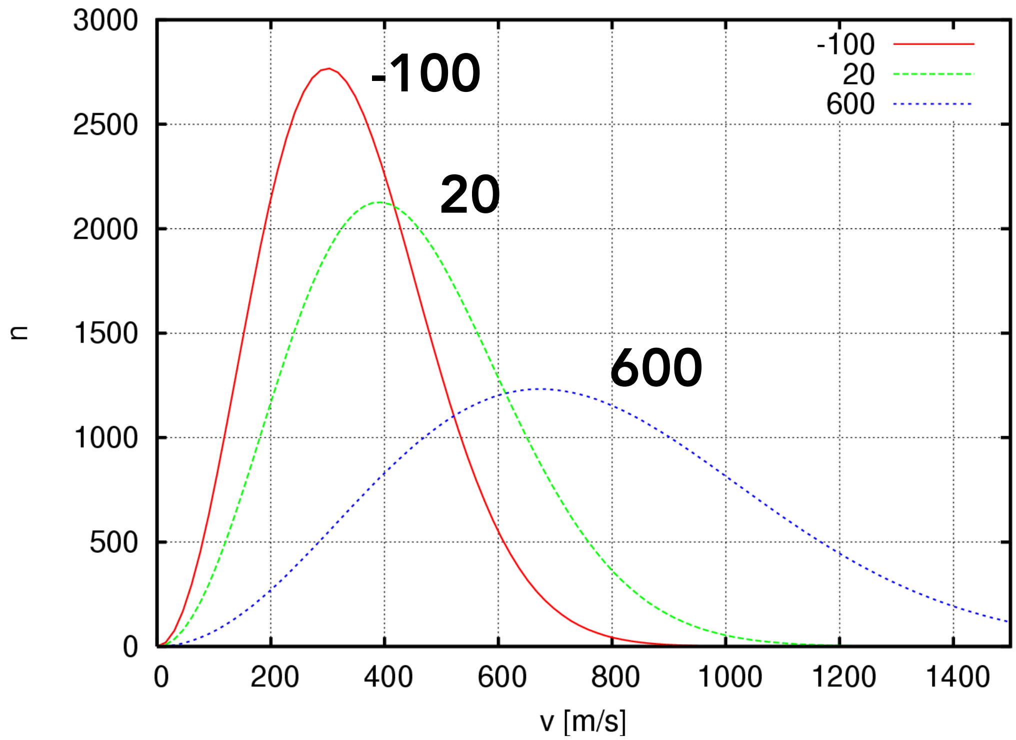
3. At -41.3˚C, 42.06 g of fluorine gas take up 2,788.91 mL of space. What is the pressure of the gas in kPa?

4. At 758.85 mm Hg, 238.96 g of carbon dioxide have a volume of 65.45 dm^3. What is the temperature of the sample in ˚C?

5. At 137˚C and under a pressure of 3.11 atm, a 276 g sample of an unknown noble gas occupies 13.46 L of space. What is the gas?

Name: ______________________

Maxwell-Boltzmann Distribution



The three curves on the graph are the same gas (both type and amount) for different temperatures. The Y-axis is the number of molecules that have a given speed.

1. Why is speed equivalent to temperature? ______________________

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2. Do all molecules at the same temperature…

    1. have the same speed? (Yes or No)

    2. have the same average speed? (Yes or No)

3. State three differences in the size/shape of the curve for higher temperatures.

    1. ______________________

    2. ______________________

    3. ______________________

Name: ______________________________

4. How many molecules have the following speeds:

Speed (m/s)	Number of gas particles (-100˚C)	Number of gas particles (20˚C)	Number of gas particles (600˚C)
200			
400			
600			

5. Will the area under the solid line equal the area under the 20˚C line? Will either equal the area under the 600˚C line?

6. Draw slanted lines in the area that corresponds to all the molecules that have speeds of 600 m/s or greater for the solid line.

7. Using a different kind of shading (slanted lines in the other direction), show all the molecules that have speeds of 600 m/s or greater for the dashed lines and dotted lines.

8. Which temperature has the most molecules with speeds above 600 m/s?