# NS J4 (pg 1 of 1) Stoichiometry with Gases

Name____________________________ Per_____

Many reactions involve gases, and as you know in the lab measuring volume of a gas is sometimes easier than measuring the mass of a gas. Because of this, having a tool to convert volumes of gases into moles is very useful. We have that tool, a variation of the Combined Gas Law, called the Ideal Gas Law, shown here.

$$P\,V = n\,R\,T$$

*P* is pressure, *V* is volume, *n* is moles, *T* is temperature, and *R* is the gas constant.

Because of Avogadro's Law that states that at constant temperature and pressure, the number of molecules (moles) is proportional to the volume of any gas, R is a constant based on know measurements of *P*, *V*, *n*, and *T*. The value of R depends on the units of the *P*, *V*, *n*, and *T* that are used to calculate the value as shown below. Generally two values are used based on whether pressure is measured in mmHg of atm. You will not have to memorize these values, they will be given to you in the problem, just as you have been given density values, or specific heat capacity values.

$$\frac{760\,mmHg \bullet 22.4\,L}{1\,mol \bullet 273\,K} = 62.4\,\frac{mmHg \bullet L}{mol \bullet K} \qquad \frac{1atm \bullet 22.4\,L}{1\,mol \bullet 273\,K} = 0.0821\,\frac{atm \bullet L}{mol \bullet K}$$

When working a stoichiometry problem, you may solve for the moles of some substance yet have been asked to provide an answer in volume, you can use the Ideal Gas Law to convert from moles to volume as in sample problem #1. Or if you are given a volume of a gas as a reactant and you need moles to solve the problem, you can use the Ideal Gas Law as in sample problem #2.

## Consider the following sample problems

1. Suppose you decomposed 1.71 g of potassium chlorate, what volume of oxygen could be produced if the oxygen were collected at 25ºC at 740 mmHg pressure?

| Molar Mass g/mol | |
|---|---|
| $KClO_3$ | 122.55 |
| KCl | 74.55 |
| $O_2$ | 32.00 |

First, write a balanced equation.

$2KClO_3 \rightarrow 2KCl + 3O_2$

$$1.71\,g\,KClO_3 \times \frac{1\,mol\,KClO_3}{122.55\,g\,KClO_3} \times \frac{3\,mol\,O_2}{2\,mol\,KClO_3} = 0.209\,mol\,O_2$$

$PV = nRT$

25°C + 273 — temp must be in Kelvin

$$V_{O_2} = \frac{nRT}{P} \qquad \frac{0.209\,mol \cdot 62.4\,\frac{L\,mmHg}{mol\,K} \cdot 298\,K}{740\,mmHg} = 0.526\,L\ of\ O_2 = 526\,ml\ of\ O_2$$

How do I know which gas constant to use? The pressure units must match.

2. A 1,550 ml flask of chlorine gas at a temperature of 65ºC and a pressure of 0.78 atm is reacted with an excess of aluminum metal. Calculate the percent yield of aluminum chloride if 3.00 g of aluminum chloride was collected in the flask after the reaction.

| Molar Mass g/mol | |
|---|---|
| Al | 26.98 |
| $Cl_2$ | 70.90 |
| $AlCl_3$ | 133.33 |

Again – write a balanced equation.

$3Cl_2 + 2Al \rightarrow 2AlCl_3$

$$\%\,yield = \frac{Exp}{Theor}$$

This must be calculated from the info in the problem

$PV = nRT$

$$n_{Cl_2} = \frac{PV}{RT} \qquad \frac{0.78\,atm \cdot 1.55\,L}{0.0821\,\frac{atm\,L}{mol\,K} \cdot 338\,K} = 0.0436\,mol\,Cl_2$$

R = 0.0821 was used so that the atm pressure units would match

temp must be in Kelvin 65°C + 273

$$0.0436\,mol\,Cl_2 \times \frac{2\,mol\,AlCl_3}{3\,mol\,Cl_2} \times \frac{133.33\,g\,AlCl_3}{1\,mol\,AlCl_3} = 3.87\,g\,AlCl_3\ theor$$

$$\frac{3.00\,g\,AlCl_3\ exp}{3.87\,g\,AlCl_3\ theor} \times 100 = 77.5\%\ yield$$