Exercise 13 **Gas Stoichiometry I**

A sample of nitrogen gas has a volume of 1.75 L at STP. How many moles of N_2 are present?

n

V

Standard T & P

0°C 1 atm

273K

$PV = nRT$

$(1\ atm)(1.75\ L) = n\left(0.0821\ \frac{L \cdot atm}{mol \cdot K}\right)(273\ K)$

$n = 0.0781\ mol\ N_2$

$\frac{1\ mol\ N_2}{22.4\ L\ N_2} = \frac{x\ mol\ N_2}{1.75\ L\ N_2}$

$x\ mol\ N_2 = 0.078\ mol\ N_2$

Exercise 14 **Gas Stoichiometry II**

Quicklime (CaO) is produced by the thermal decomposition of calcium carbonate ($CaCO_3$). Calculate the volume of CO_2 at STP produced from the decomposition of 152 g $CaCO_3$ by the reaction

V = ? L

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

152g ?L

$$\frac{152\ g\ CaCO_3}{} \left| \frac{1\ mol\ CaCO_3}{100.09\ g\ CaCO_3} \right| \frac{1\ mol\ CO_2}{1\ mol\ CaCO_3} \left| \frac{22.4\ L\ CO_2}{1\ mol\ CO_2} \right.$$

$= 34.0\ L\ CO_2$

Exercise 15 **Gas Stoichiometry III** CH_4

A sample of methane gas having a volume of 2.80 L at 25°C and 1.65 atm was mixed with a sample of oxygen (O_2) gas having a volume of 35.0 L at 31°C 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°C.

? L CO_2 CO_2

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

CH_4	O_2	CO_2
V = 2.80 L	V = 35.0 L	P = 2.50 atm
T = 25°C	T = 31°C	T = 125°C
P = 1.65 atm	P = 1.25 atm	V = ? L

CH_4

PV = nRT

$$(1.65\ atm)(2.80\ L) = n\left(0.0821\ \frac{L \cdot atm}{mol \cdot K}\right)(298\ K)$$

$$n_{CH_4} = 0.189\ mol\ CH_4 \times \frac{1\ mol\ CO_2}{1\ mol\ CH_4} = 0.189\ mol\ CO_2$$

O_2

$$(1.25\ atm)(35.0\ L) = n\left(0.0821\ \frac{L \cdot atm}{mol \cdot K}\right)(304\ K)$$

$$n = 1.75\ mol\ O_2 \times \frac{1\ mol\ CO_2}{2\ mol\ O_2} = .876\ mol\ CO_2$$

n = 0.189 mol CO_2

PV = nRT

$$V = \frac{nRT}{P}$$

$$V = \frac{(0.189\ mol)\left(0.0821\ \frac{L \cdot atm}{mol \cdot K}\right)(398\ K)}{2.50\ atm}$$

V = 2.47 L CO_2

Exercise 16 **Gas Density/Molar Mass**

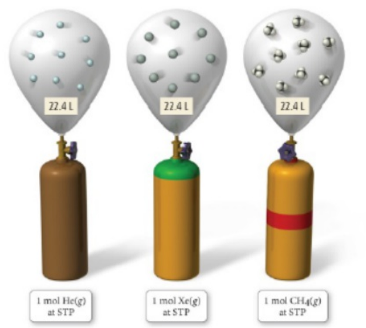
The density of a gas was measured at 1.50 atm and 27ºC and found to be 1.95 g/L. Calculate the molar mass of the gas.

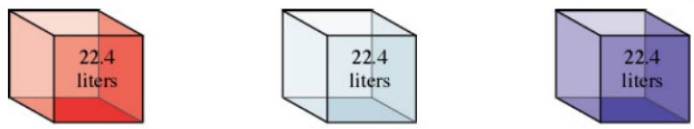
P T d MM?

$MM = \frac{dRT}{P}$

$MM = \frac{(1.95\ g/L)(0.0821\ \frac{L\cdot atm}{mol\cdot K})(300\ K)}{1.50\ atm} = 32.0\ g/mol$

THE DENSITY OF GASES





32 g of O_2 (1 mole) 2 g of H_2 (1 mole) 17 g of NH_3 (1 mole)

$d = \frac{m}{V} = \frac{P(MM)}{RT}$ {for ONE mole of gas}= $\frac{MM}{22.4\ L}$ AND Molar Mass = $MM = \frac{dRT}{P}$

$PV = nRT$

$PV = \left(\frac{g}{MM}\right)RT$

$(MM)PV = gRT$

$MM = \frac{gRT}{PV}$

$MM = \frac{dRT}{P}$

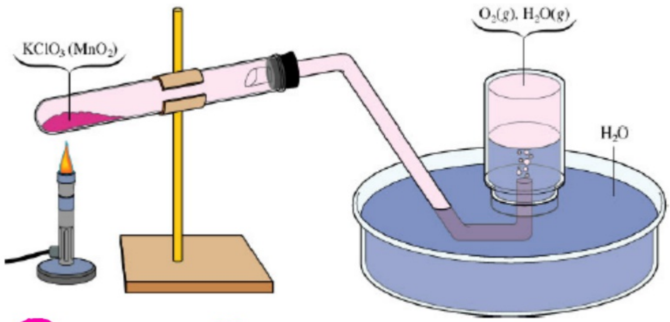
$\therefore d = \frac{MM\,P}{RT}$

$g \mid \frac{mol}{g} = mol$

Exercise 20 **Gas Collection over Water**

A sample of solid potassium chlorate ($KClO_3$) was heated in a test tube (see the figure above) and decomposed by the following reaction:

$$2\ KClO_3(s) \rightarrow 2\ KCl(s) + 3\ O_2(g)$$



The oxygen produced was collected by displacement of water at 22ºC at a total pressure of 754 torr. The volume of the gas collected was 0.650 L, and the vapor pressure of water at 22ºC is 21 torr. Calculate the partial pressure of O_2 in the gas collected and the mass of $KClO_3$ in the sample that was decomposed.

$P_T = 754$ torr

$V_{O_2} = 0.650$ L

$P_{H_2O} = 21$ torr

$P_{O_2} = ?$ torr

$m_{KClO_3} = ?$ g

$P_T = P_{H_2O} + P_{O_2}$

$P_{O_2} = P_T - P_{H_2O}$

$P_{O_2} = 754\ \text{torr} - 21\ \text{torr}$

$P_{O_2} = 733$ torr

$PV = nRT$

$(.964\ \text{atm})(0.650\ \text{L}) = n\left(0.0821\ \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}\right)(295\ \text{K})$

$n = 0.0259$ mol O_2

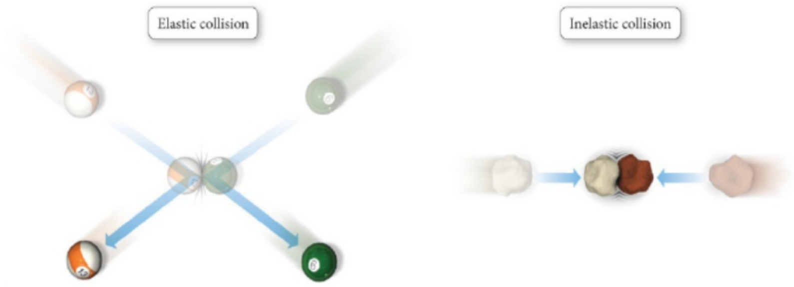
$\frac{0.0259\ \text{mol}\ O_2}{} \left|\ \frac{2\ \text{mol}\ KClO_3}{3\ \text{mol}\ O_2}\ \right|\ \frac{122.55\ \text{g}\ KClO_3}{1\ \text{mol}\ KClO_3}$

$= 2.12$ g $KClO_3$

KINETIC MOLECULAR THEORY OF GASES

Assumptions of the MODEL:

1. All particles are in constant, random, motion.
2. All collisions between particles are perfectly elastic. E is conserved
3. The volume of the particles in a gas is negligible
4. The average kinetic energy of the molecules is its Kelvin temperature.

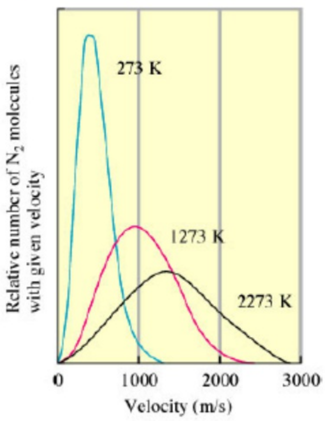


This theory neglects any intermolecular forces as well. And it is important to note that gases expand to fill their container, solids/liquids do not. And that gases are compressible; solids/liquids are not appreciably compressible.

No IMF's

Examine the effect of temperature on the numbers of molecules with a given velocity as it relates to temperature.

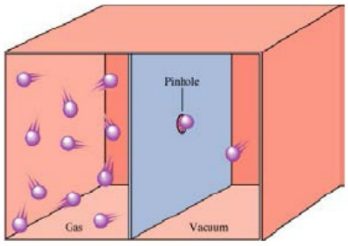
HEAT 'EM UP, SPEED 'EM UP!!



Drop a vertical line from the peak of each of the three bell shaped curves—that point on the *x*-axis represents the AVERAGE velocity of the sample at that temperature. Note how the bells are "squashed" as the temperature increases. You may see graphs like this on the AP exam where you have to identify the highest temperature based on the shape of the graph!

GRAHAM'S LAW OF DIFFUSION AND EFFUSION

Effusion is closely related to diffusion. **Diffusion** is the term used to describe the mixing of gases. The ***rate*** of diffusion is the ***rate*** of the mixing.



Effusion is the term used to describe the passage of a gas through a tiny orifice into an evacuated chamber as shown on the right.
The rate of effusion measures the speed at which the gas is transferred into the chamber.

The rates of effusion of two gases are inversely proportional to the square roots of their molar masses at the same temperature and pressure.

$$\frac{\text{Rate of effusion of gas 1}}{\text{Rate of effusion of gas 2}} = \sqrt{\frac{MM_2}{MM_1}}$$

REMEMBER ***rate*** is a change in a quantity over time, NOT just the time!

Exercise 22 Effusion Rates
Calculate the ratio of the effusion rates of hydrogen gas (H_2) and uranium hexafluoride (UF_6), a gas used in the enrichment process to produce fuel for nuclear reactors.

Exercise 23
A pure sample of methane is found to effuse through a porous barrier in 1.50 minutes. Under the same conditions, an equal number of molecules of an unknown gas effuses through the barrier in 4.73 minutes. What is the molar mass of the unknown gas?