Announcements

Wednesday, October 21, 2009

MasteringChemistry due dates (all at 11:59pm)

- Ch 5: this Fri, Oct 23
- Ch 6: Fri, Oct 30

Na: group I

Al: group III

Cl: group VII

H: molar mass 1.008 g/mol

Collecting gases over water

If you collect 19.0 mL of gas over water from a reaction that produces $H_2(g)$, how many moles of hydrogen gas were collected? Atmospheric pressure = 760 mmHg, T = 23 °C.

$P_{tot} = P_{H_2O} + P_{H_2}$

correcting for vapor pressure of H_2O

$P_{tot} = 760$ mmHg

$P_{H_2O(g)} = 21.10$ mmHg

$P_{H_2} = P_{tot} - P_{H_2O}$

$= 0.97223$ atm

corrected

$P_{H_2}V = n_{H_2}RT$

$$n_{H_2} = \frac{P_{H_2}V}{RT}$$

$P_{H_2} = 0.97223$ atm

$V = 0.019$ L

$R = 0.08206 \frac{L \cdot atm}{K \cdot mol}$

$T = 296.15$ K

$n = 7.60 \times 10^{-4}$ mol H_2

at STP and ignoring H_2O vapor...

(22.4 L per 1 mol @ STP)

$$.0190 \text{ L } \cancel{\text{gas}} \times \frac{1 \text{ mol}}{22.4 \text{ L } \cancel{\text{gas}}} = 8.48 \times 10^{-4} \text{ mol } H_2$$

Stoichiometry and gas laws

With known *P, V,* and *T,* you can calculate… n

From a balanced chemical equation you can construct a…
mol ratio from the balancing coefficients

$$P, V, T \rightarrow n_A \xrightarrow[\text{ratio}]{\text{mol}} n_B \longrightarrow P, V, T$$

$CO_2(g) + 2\ LiOH(s) \rightarrow Li_2CO_3(s) + H_2O(l)$ (a CO_2 scrubber)

How many L of CO_2 (at 1 atm and 293 K) can be removed by 10.0 g LiOH?

P T

23.95 g/mol

$$g\ LiOH \longrightarrow mol\ LiOH \longrightarrow mol\ CO_2 \xrightarrow[nRT]{PV=} L\ CO_2$$

$$10.0\,g\ LiOH \times \frac{1\ mol\ LiOH}{23.95\,g\ LiOH} \times \frac{1\ mol\ CO_2}{2\ mol\ LiOH} = 0.20877\ mol\ CO_2$$

$$V = \frac{nRT}{P} = \frac{(.20877\,mol)(.08206\,\frac{L\cdot atm}{mol\cdot K})(293\,K)}{1\ atm} = \boxed{5\ L\ CO_2}$$

On your own, how many kg LiOH are necessary to remove the CO_2 produced by 2 men for 2 days? (Assume 12 breaths per minute, 0.50 L air per breath, 5.0% of exhaled air's volume is CO_2)

Kinetic molecular theory

Simplest model for behavior of gases:

- Gases made of particles (atoms/molecules) with nearly negligible volumes (mostly empty space)
- Average kinetic energy is proportional to absolute temperature $E_k \propto T$ $E_k = \frac{1}{2}mv^2$
- Particles fly in a straight line until they collide with another particle or wall of container
- Collisions are completely elastic (energy is exchanged, not lost) assumption

$PV = nRT$

Boyle's law

$PV = \cancel{nRT}$ $PV = \text{constant}$, $V \propto \frac{1}{P}$ less internal surf. area, more collisions on wall of vessel

Charles's law

$V \propto T$ as $\uparrow T$, $\uparrow V$ because molecules have more kinetic energy

Avogadro's law

$V \propto n$ as $\uparrow n$, $\uparrow V$ more collisions w/ vessel

Dalton's law

$P_{tot} = P_A + P_B + P_C + \ldots$ gases act independently (small particle size)

Temperature and velocity

Average molecular velocity (u_{RMS})
(root mean square is a type of average)

$u_{RMS} = \sqrt{\frac{3RT}{M_m}}$ (given) R = gas const

$\uparrow M_m = \downarrow u_{RMS}$ large molecules move more slowly

What is the root mean square velocity of nitrogen molecules at 298 K?

$N_2 = 28.02\ g/mol$
$= 0.02802\ kg/mol$

<u>Be very careful of units in these calculations!!</u>

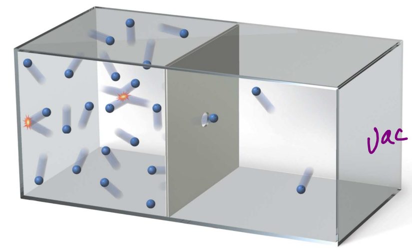
R = 8.314 (kg · m²)/(s² · K · mol) (This is R in SI units)

$$u_{RMS} = \sqrt{\frac{3RT}{M_m}} = \sqrt{\frac{3\left(8.314 \frac{\cancel{kg}\cdot m^2}{s^2\cdot \cancel{K}\cdot \cancel{mol}}\right)(298\ \cancel{K})}{.02802\ \cancel{kg}/\cancel{mol}}}$$

$= 515\ m/s$

Effusion and diffusion

<u>Effusion</u>: escape of gas through a pinhole into a vacuum



<u>Diffusion</u>: gas spreading in a container or mixing with other gases

<u>Both</u> are related to molar mass of gas

Effusion/diffusion rate
relative to 2 gases

$\frac{Rate_A}{Rate_B} = \sqrt{\frac{M_m B}{M_m A}}$ molar masses

Which balloon would shrink faster? One filled with He or N_2? By what ratio?

$$\frac{Rate_{He}}{Rate_{N_2}} = \sqrt{\frac{28.02\ g/mol}{4.003\ g/mol}} = 2.646$$

The helium balloon shrinks 2.646 times faster than N_2.