Announcements

Monday, October 19, 2009

Quiz 2 is this Wed, Oct 21 (ch 4 and most of 5)

MasteringChemistry due dates (all at 11:59pm)

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

Density of a gas

$d = \frac{\text{mass}}{\text{volume}} = \frac{\text{molar mass}}{\text{molar volume}}$ periodic tbl (g/mol) / 22.4 L/mol at STP

(g/L) for gases

What is the density of oxygen gas at STP? $O_2(g)$

M_m O_2 = 32.00 g/mol

molar volume of any gas at STP = 22.4 L/mol

$d = \frac{32.00 \text{ g/mol}}{22.4 \text{ L/mol}} = 1.43 \text{ g/L}$ at STP

SF_6 sulfur hexafluoride d at STP = $\frac{146.07 \text{ g/mol}}{22.4 \text{ L/mol}} = 6.52 \text{ g/L}$

At other pressures or temperatures... $PV = nRT$

$n = m(g) \times \frac{1 \text{ mol}}{m(g)}$ (M_m) $n = \frac{m}{M_m}$

$PV = \frac{m}{M_m}RT \longrightarrow PM_m = \frac{m}{V}RT \longrightarrow PM_m = dRT$

What is the density of $O_2(g)$ at 125 °C and 740 mmHg?

$d = \frac{PM_m}{RT} = \frac{(.97368 \text{ atm})(32.00 \text{ g/mol})}{(.08206 \frac{L\cdot atm}{K\cdot mol})(398.15 K)} = 0.954 \text{ g/L}$

$P = 740 \text{ mmHg} \times \frac{1 \text{ atm}}{760 \text{ mmHg}} = .97368 \text{ atm}$

$M_m = 32.00 \text{ g/mol}$

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

$T = 125°C + 273.15 = 398.15 K$

Molar mass of a gas

Given: mass, volume, pressure, temperature
Calculate: molar mass (g/mol) $d = m/V$

$PM_m = dRT$ $M_m = \frac{dRT}{P} = \frac{mRT}{VP}$

Calculate the molar mass of a gas sample with mass of 0.582 g, volume of 213 mL, pressure of 754 mmHg, and temperature of 100.0 °C.

$M_m = \frac{mRT}{VP} = \frac{(.582\,g)(.08206\,\frac{L\cdot atm}{K\cdot mol})(373.15\,K)}{(.213\,L)(.9921\,atm)} = 84.3\ g/mol$

$m = 0.582\,g$

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

$T = 100.0\,°C + 273.15 = 373.15\,K$

$V = 213\,mL \times \frac{1\,L}{1000\,mL} = 0.213\,L$

$P = 754\,mmHg \times \frac{1\,atm}{760\,mmHg} = 0.99211\,atm$

Mixtures of gases

Gas molecules act independently!

For any mixture of gases, the total pressure is the sum of the pressures that each gas exerts (partial pressures)

$P_{total} = P_a + P_b + P_c + \ldots$ (Dalton's law of partial pressures)

Mole fraction $= \frac{n_a}{n_{total}} = \chi_a$ greek chi χ (for 1 substance)

In one container with constant V and T,

$\chi = \frac{n_a}{n_{total}} = \frac{P_a}{P_{total}} = \chi_a$

$P_a = \chi_a P_{total}$ (χ_a: mole fraction of "a"; P_a: partial pressure of "a")

Air is 78% nitrogen by volume. What is the partial pressure of nitrogen if the atmospheric pressure is 755 mmHg that day?

$\chi_{N_2} = 0.78$ (78% by volume)

$P_{N_2} = (\chi_{N_2})(P_{tot}) = (0.78)(755\,mmHg)$

(partial pressure of N_2) $= 590\ mmHg$

Mole fraction and partial pressure

A mixture of 5 g H_2, 8 g N_2, and 10 g O_2 has a total pressure of 7 atm. What is P_{H2}, P_{N2}, and P_{O2}?

$5\,g\,H_2 \times \frac{1\,mol\,H_2}{2.016\,g\,H_2} = 2.480\,mol\,H_2$

$8\,g\,N_2 \times \frac{1\,mol\,N_2}{28.02\,g\,N_2} = 0.2855\,mol\,N_2$

$10\,g\,O_2 \times \frac{1\,mol\,O_2}{32.00\,g\,O_2} = 0.3125\,mol\,O_2$

$\Sigma : 3.078\,mol\,total$

$\chi_{H_2} = \frac{2.480\,mol\,H_2}{3.078\,mol\,tot} = 0.8057$

$\chi_{N_2} = \frac{.2855\,mol\,N_2}{3.078\,mol\,tot} = 0.09276$

$\chi_{O_2} = \frac{.3125\,mol\,O_2}{3.078\,mol\,tot} = 0.1013$

$P_{H_2} = (.8057)(7\,atm) = 6\,atm$

$P_{N_2} = (.09276)(7\,atm) = 0.6\,atm$

$P_{O_2} = (.1013)(7\,atm) = 0.7\,atm$

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what is the volume of this container if $T = 298\,K$?

$PV = nRT \quad V = \frac{nRT}{P}$ use total for n and P

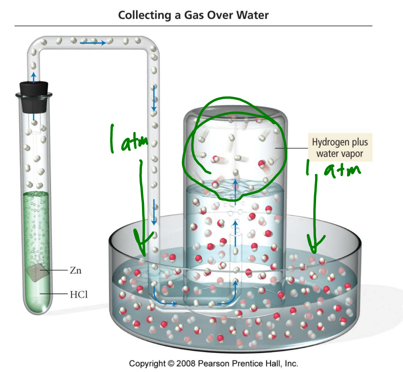
$V = \frac{(3.078\,mol)(.08206\,\frac{L\cdot atm}{mol\cdot K})(298\,K)}{(7\,atm)} = 10.75\,L \rightarrow 10\,L$

Collecting a gas over water

Partial pressures work in the ideal gas law too...

$P_aV = n_aRT$ for one gas (a) in a mixture of gases

Collection of a gas over water



When H_2 is produced by the reaction, the gas collected is a mixture of H_2 and water vapor.

Vapor pressure of water:

max P_{H2O} when a gas is saturated with water vapor

T	***P_{H2O}* (mmHg)**
20 °C	17.55
23 °C	21.10
25 °C	23.78

$P_{total} = P_{H2O} + P_{H2}$

P_{total}: atmospheric pressure (barometer)

P_{H2O}: vapor pressure of H_2O

P_{H2}: use in $PV = nRT$ to calc mol $H_2(g)$

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

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

$=$

corrected

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

$n_{H_2} = \_\_\_\_\_\_$

$P_{H_2} =$

$V =$

$R =$

$T =$

at STP and ignoring H_2O vapor ...