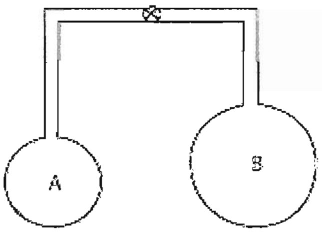
Gas Laws Practice Two

1. Examine the diagram below. Gas A is in a 2.00 L flask under a pressure of .45 atm. Gas B is in a 5.00 L flask under a pressure of 1.36 atm. (These volumes include the volume of the tubing.) When the closed value is open what is going to happen? What will be the final pressure of these two gases when they are mixed? The temperature remains constant. (Dalton's Law of Partial Pressure)

$P_{2A} = \frac{P_1V_1}{V_2} = \frac{(0.45)(2.00)}{(7.00\,L)}$

$P_{2B} = \frac{P_1V_1}{V_2} = \frac{(1.36)(5.00)}{7.00}$



$P_f = \frac{(0.45)(2.00) + (1.36)(5.00)}{7.00}$ (0.9, 6.8)

$P_f = 1.1\,atm$

2. Hydrogen sulfide, H_2S, has a very strong rotten egg odor. Methyl salicylate, $C_8H_8O_3$, has a wintergreen odor and Benzaldehyde, C_7H_6O, has a pleasant almond odor. If the vapors for these three substances were released at the same time from across a room, which odor would you smell first? Show your work and explain your answer. (Graham's Law)

$v = \sqrt{\frac{3RT}{M_m}}$ fastest molecule

Speed is inversly related to Mm

$H_2S = 32.06 + 2.02 = 34.08\,g/mol$

$C_8H_8O_3 = (12.01 \times 8) + (1.01 \times 8) + (16.00 \times 3) = 152.16\,g/mol$ (96.08 + 8.08 + 48)

$C_7H_6O = (12.01 \times 7) + (1.01 \times 6) + 16.00 = 106.13\,g/mol$

3. An unknown gas diffuses 1.62 times slower than does oxygen gas. What is the molecular mass of the unknown gas? (Graham's Law)

$0.617 = \frac{1}{1.62}$ $v_1 = \sqrt{\frac{3RT}{M_{m1}}}$ $v_2 = \sqrt{\frac{3RT}{M_{m2}}}$ $v_1^2 = \frac{3RT}{M_{m1}}$ $v_2^2 = \frac{3RT}{M_{m2}}$

$\frac{O_2}{unk} = 1.62 = \sqrt{\frac{M_{m\,unk}}{32}}$ unk Mm = 84.0 g/mol

$\frac{v_1^2}{v_2^2} = \frac{M_{m2}}{M_{m1}}$ $\frac{v_1}{v_2} = \sqrt{\frac{M_{m2}}{M_{m1}}}$

4. At 137°C and 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? (Ideal Gas Law)

Radon

$n = \frac{PV}{RT} = \frac{(3.11)(13.46)}{(0.0821)(410)} = 1.24$ $\frac{276\,g}{} = 222.58\,g/mol$

5. In the Dumas-bulb technique for determining the molar mass of an unknown liquid, you vaporize the sample of a liquid that boils below 100°C in a boiling-water bath and determine the mass of vapor required to fill the bulb. From the following data, calculate the molar mass of the unknown liquid: mass of unknown vapor, 1.012 g; volume of bulb, 354 cm³; pressure, 742 torr; temperature, 99°C. (Ideal Gas Law)

$n = \frac{PV}{RT} = \frac{\left(\frac{742}{760}\right)(0.354\,L)}{(0.0821)(372)} = 0.011316$

$\frac{1.012\,g}{0.011316\,mol} =$

$M_m = 89.4\,g/mol$

6. A lighter-than-air balloon is designed to rise to a height of 6 miles at which point it will be fully inflated. At that altitude the atmospheric pressure is 210 mm Hg and the temperature is -40 °C. If the full volume of the balloon is 100,000.0 L, how many kilograms of helium will be needed to inflate the balloon? (~~Combined~~ Ideal Gas Law)

5.8 Kg

$n = \frac{PV}{RT} = \frac{\left(\frac{210}{760}\right)(100{,}000)}{(0.0821)(233K)} = 1444.46\text{mol} \times \frac{4.0026g}{\text{mol}} = 5781.6g$

7. A quantity of potassium chlorate is selected to yield, through heating, 75.0 mL of O_2 when measured at STP. If the actual temperature is 28 °C and the actual pressure is 0.894 atm, what volume of oxygen will result? What is the quantity of potassium chlorate that is used? (Ideal Gas Law and Stoichiometry)

$2KClO_{3(s)} \xrightarrow{\Delta} 2KCl + 3O_{2(g)}$

48.00
35.45
39.10
122.55g

$0.075 L \times \frac{1 mol}{22.4 L} = 0.0033482 \text{ mol } O_2$ — 75.0 mL O_2 @ STP

$V_2 = \frac{P_1 V_1 T_2}{T_1 P_2} = \frac{(1.00)(75.0)(301)}{273 \cdot 0.894} = 92.5 mL$

$0.0033482 \text{ mol } O_2 \times \frac{2KClO_3}{3O_2} \times 122.55g/mol = 0.2748 \, KClO_3$ (assumes 100% yield)

8. The human body needs at least 1.03 x 10^{-2} mol O_2 every minute. If all of this oxygen is used for the cellular respiration reaction that breaks down glucose, how many grams of glucose does the human body consume each minute? (Stoichiometry)

$$C_6H_{12}O_6(s) + 6\,O_2(g) \rightarrow 6\,CO_2(g) + 6\,H_2O(l)$$

12.01 × 6
1.01 × 12
16 × 6
180.18

$0.0103 \text{ mol } O_2 \times \frac{1\, C_6H_{12}O_6}{6\, O_2} \times \frac{180.18g}{mol} = 0.309g$

309mg $C_6H_{12}O_6$

9. In the space shuttle, the CO_2 that the crew exhales is removed from the air by a reaction within canisters of lithium hydroxide. On average, each astronaut exhales about 20.0 mol of CO_2 daily. What volume of water will be produced when this amount of CO_2 reacts with an excess of LiOH? The density of water is about 1.00 g/mL. (Stoichiometry)

$$CO_2(g) + 2\,LiOH(s) \rightarrow Li_2CO_3(aq) + H_2O(l)$$

$20.0 \text{ mol } CO_2 \times \frac{1\, H_2O}{1\, CO_2} \times \frac{18.02g}{mol} \times \frac{1mL}{1g} = 360.4mL$

360mL

10. Carbon monoxide can be combined with hydrogen to produce methanol, CH_3OH. Methanol is used as an industrial solvent, as a reactant in synthesis, and as a clean-burning fuel for some racing cars. If you had 152.5 kg CO and 24.50 kg H_2, how many kilograms of CH_3OH could be produced? (Stoichiometry)

28.01 2.02 32.05 g/mol

$$CO + 2H_2 \rightarrow CH_3OH$$

152.5 Kg 24.50 Kg

$$152.5\,Kg \times \frac{1\,Kmol}{28.01\,Kg} \times \frac{1\,CH_3OH}{1\,CO} \times \frac{32.05\,Kg}{Kmol} = 174.5\,Kg$$

CO is limiting

$$24.50\,Kg \times \frac{1\,Kmol}{2.02\,Kg} \times \frac{1\,CH_3OH}{2H_2} \times \frac{32.05\,Kg}{Kmol} = 194.4\,Kg$$

11. Air-bag design depends on stoichiometric precision:

$$3(2\,NaN_3(s) \longrightarrow 2\,Na(s) + 3\,N_2(g))$$

$$6\,Na(s) + Fe_2O_3(s) \longrightarrow 3\,Na_2O(s) + 2\,Fe$$

$$6NaN_3 + 6Na + Fe_2O_3 \longrightarrow 6Na + 9N_2 + 3Na_2O + 2Fe$$

Assume that 65.1 L of N_2 gas are needed to inflate an air bag to the proper size. How many grams of sodium azide, NaN_3, must be included in the gas generant to generate this amount of N_2? The density of N_2 gas is about 0.916 g/L under these conditions. (Stoichiometry)

$$65.1\,L \times 0.916\,g/L \times \frac{1\,mol}{28.02\,g} \times \frac{2\,NaN_3}{3\,N_2} \times \frac{65.02\,g}{mol} = 92.2\,g\ NaN_3$$

How much Fe_2O_3 must be added to the gas generant for this amount of NaN_3?

$$92.2\,g\ NaN_3 \times \frac{1\,mol}{65.02\,g} \times \frac{1\,Fe_2O_3}{6\,NaN_3} \times \frac{159.68\,g}{1\,mol} = 37.7\,g\ Fe_2O_3$$

12. Engine efficiency depends on the reactant proportions:

gasoline + air ----> carbon dioxide + water + energy

$2\,C_8H_{18(g)}$ + $25\,O_{2(g)}$ ----> $16\,CO_{2(g)}$ + $18\,H_2O_{(g)}$ energy released: 10,900 kJ

How many liters of air must react with 1.000 L of isooctane in order for combustion to occur completely? At 20° C, the density of isooctane is 0.6916 g/mL, and the density of oxygen is 1.331 g/L. (Hint: remember to use the percentage of oxygen in air.) (Stoichiometry)

$$1000\,mL\ C_8H_{18} \times 0.6916\,g/mL \times \frac{1\,mol}{114.26\,g} \times \frac{25\,O_2}{2\,C_8H_{18}} \times \frac{32.00\,g}{1\,mol} \times \frac{1\,L}{1.331\,g} = 1820\,L\ O_2 / .21 = 8667\,L \text{ of Air}$$