Ch. 1, part A: Ideal Gases
Genchem Review Problems

**Example 1:**
Argon is an inert gas used in some light bulbs. In one experiment, 452 mL of the gas is heated from 22 °C to 187 °C at constant pressure. What is the final volume of the argon?

Solution…

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad \rightarrow \quad V_2 = \frac{V_1}{T_1} T_2 \qquad V_2 = \frac{452 mL}{295\_K} 460\_K = 705 mL$$

**Example 2:**
If a sample of oxygen has a volume of 425 mL at 70 °C and a pressure of 0.950 atm, what will be its volume at STP?

Solution…

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \quad \rightarrow \quad V_2 = \frac{P_1 V_1}{T_1} \frac{T_2}{P_2} = \frac{(0.950 atm)(425 mL)}{343\_K} \frac{273\_K}{1 atm} = 321 mL$$

**Example 3:**
A flask of volume 0.85 L is filled with carbon dioxide gas at a pressure of 1.44 atm and a temperature of 312 K. A solution of LiOH of negligible volume is introduced into the flask. Eventually the pressure of carbon dioxide is reduced to 0.56 atm due to the reaction:

$CO_2$ (g) + 2 LiOH (aq) → $Li_2CO_3$ (aq) + $H_2O$ (l)

How many grams of lithium carbonate are formed by this process? (Assume that the temperature remains constant.)

Solution…

PV = nRT — We have different amounts of $CO_2$ (g) "before" and "after" this reaction goes to completion.

We need to find the number of moles of $CO_2$ (g) before and after…

$$n_{before\_reaction} = \frac{P_1V_1}{T_1R} = \frac{(1.44atm)(0.85L)}{(312\_K)(0.0821\frac{L*atm}{mol\_K})} = 0.048mol$$

$$n_{after\_reaction} = \frac{P_2V_2}{T_2R} = \frac{(0.56atm)(0.85L)}{(312\_K)(0.0821\frac{L*atm}{mol\_K})} = 0.019mol$$

$$n_{before\_reaction} - n_{after\_reaction} = 0.048mol - 0.019mol = 0.029mol\_consumed\_to\_make\_Li_2CO_3$$

How many grams of $Li_2CO_3$ were made? Use stoichiometry.

$$0.029mol\_CO_2 X \frac{1mol\_Li_2CO_3}{1mol\_CO_2} X \frac{73.89g\_Li_2CO_3}{1mol\_Li_2CO_3} = 2.1g\_Li_2CO_3$$

**Example 4:**
An unknown gas has a density of 20.8 g/L at 3.57 atm and 32 $^{o}$C. What is the molecular weight of this gas?

Solution….

$$MW = \frac{D\_RT}{P} = \frac{(20.8\frac{g}{L})(0.0821\frac{L*atm}{mol\_K})(305\_K)}{3.57atm} = 146\frac{g}{mol}$$

*How could you find the mass or the molecular weight of a gas using the ideal gas law?*

PV = nRT → n = PV/RT

Also… MW = g/mol Thus, mol (or n) = g/MW

Substitute g/MW for n into n = PV/RT….

$$\frac{g}{MW} = \frac{PV}{RT}$$ Rearrange…

$$MW = \frac{gRT}{PV}$$ Thus, you must know how many grams.

*What if you know the density? How can you find the MW?*

D = m/V or g/V Thus, we can substitute in D for g/V….

$$MW = \frac{gRT}{PV} \rightarrow MW = \frac{D\_RT}{P}$$

**Example 5:**
A 2.00 L flask contains 3.0 g of carbon dioxide and 0.10 g of He and has a temperature of 17 ºC. What are the partial pressures of carbon dioxide and He? What is the total pressure exerted by the mixture of gases?

Solution…

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

Thus, we can calculate the partial pressures of both gases…

Need to calculate moles first…

$$3.0g\_CO_2 X \frac{1mol\_CO_2}{44.009g\_CO_2} = 0.068mol\_CO_2$$

$$P_{CO_2} = \frac{nRT}{V} = \frac{(0.068mol)(0.0821\frac{L*atm}{mol\_K})(290\_K)}{2.00L} = 0.81atm\_CO_2$$

Now…He….

$$0.10g\_HeX \frac{1mol\_He}{4.0026g\_He} = 0.025mol\_He$$

$$P_{He} = \frac{nRT}{V} = \frac{(0.025mol)(0.0821\frac{L*atm}{mol\_K})(290\_K)}{2.00L} = 0.30atm\_He$$

The total pressure is the sum of the partial pressures…

$$P_{total} = P_{CO_2} + P_{He} = 0.81atm + 0.30atm = 1.11atm$$

**Example 6:**
Oxygen gas is collected over water at 30 $^{o}$C, and the total pressure is 645 Torr. Given that the vapor pressure of water is 32.8 Torr at 30 K, what is the partial pressure of oxygen? What is the mole fraction of oxygen?

Solution…

$$P_{O_2} = P_{total} - P_{water} = 645 torr - 32.8 torr = 613 torr$$

Using Raoult's law, we can find the mole fraction…

$$P_{some\_substance} = X_{some\_substance} P_{total} \rightarrow X_{some\_substance} = \frac{P_{some\_substance}}{P_{total}}$$

$$X_{O_2} = \frac{P_{O_2}}{P_{total}} = \frac{613 torr}{645 torr} = 0.95$$

We can actually have a naked number!

*What's the mole fraction of the water?* 0.05 *How do you know?*