Name ___________________________ **Chemistry** **___/___/___**

Gas Stoichiometry Problems

1. Solid iron reacts with oxygen gas to form solid iron(III) oxide. What volume of oxygen gas is needed to produce 84.0 grams of solid iron(III) oxide if the pressure of the gas is 2.77 atm and the temperature is 35°C?

$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

$$\frac{84.0 \text{ g } Fe_2O_3}{1} \times \frac{1 \text{ mole } Fe_2O_3}{159.6 \text{ g } Fe_2O_3} \times \frac{3 \text{ mole } O_2}{2 \text{ moles } Fe_2O_3} \quad 0.789 \text{ moles } O_2$$

$$V = \frac{(0.789)(0.08206)(308)}{2.77} = \mathbf{7.20\ L}$$

2. Hydrogen gas reacts with oxygen gas to form water vapor. What volume of hydrogen gas is needed to produce 30.0 grams of water if the pressure is 1.80 atm and the temperature is 400. K?

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

$$\frac{30.0 \text{ grams } H_2O}{1} \times \frac{1 \text{ mole } H_2O}{18.0 \text{ grams } H_2O} \times \frac{2 \text{ moles } H_2}{2 \text{ moles } H_2O} = 1.67 \text{ moles } H_2$$

$$V = \frac{(1.67)(0.08206)(400)}{1.80} = \mathbf{30.4\ L}$$

3. Solid calcium carbide, CaC_2, reacts with liquid water to produce acetylene, C_2H_2, gas and aqueous calcium hydroxide in a solid metal vessel. What is the final pressure if 38.0 grams of calcium carbide react with excess water if the volume of the vessel is 3.00 L and the temperature is held constant at 250. K? Assume the volume of calcium hydroxide is negligible.

$CaC_2(s) + 2H_2O(l) \rightarrow C_2H_2(g) + Ca(OH)_2(aq)$

$$\frac{38.0 \text{ grams } CaC_2}{1} \times \frac{1 \text{ mole } CaC_2}{64.1 \text{ grams } CaC_2} \times \frac{1 \text{ mole } C_2H_2}{1 \text{ mole } CaC_2} = 0.593 \text{ moles } C_2H_2$$

$$P = \frac{(0.593)(0.08206)(250.)}{3.00} = \mathbf{4.05\ atm\ (410.\ kPa)}$$

4. Solid sodium reacts with chlorine gas to produce solid sodium chloride. What mass of sodium chloride will be produced if 25.0 liters of chlorine gas at a pressure of 2.55 atm and a temperature of 300. K react with excess sodium.

$2Na(s) + Cl_2(g) \rightarrow 2\ NaCl(s)$

$$n = \frac{(2.55)(25.0)}{(0.08206)(300.)} = 2.59 \text{ moles } Cl_2$$

$$\frac{2.59 \text{ moles } Cl_2}{1} \times \frac{2 \text{ moles NaCl}}{1 \text{ mole } Cl_2} \times \frac{58.5 \text{ grams NaCl}}{1 \text{ mole NaCl}} = \mathbf{303\ grams\ NaCl}$$

5. Solid calcium carbonate decomposes to form solid calcium oxide and carbon dioxide, CO_2, gas. What is the total pressure if 90.0 grams of calcium carbonate decompose in a 20.0 liter vessel where the temperature is kept constant of 1000. °C?

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

$$\frac{90.0 \text{ grams } CaCO_3}{1} \times \frac{1 \text{ mole } CaCO_3}{100.1 \text{ grams } CaCO_3} \times \frac{1 \text{ mole } CO_2}{1 \text{ mole } CaCO_3} = 0.899 \text{ moles } CO_2$$

$$P = \frac{(0.899)(0.08206)(1273)}{20.0} = \mathbf{4.70 \text{ atm (or 476 kPa)}}$$

6. $2\ H_2O_2(aq) \rightarrow 2\ H_2O(l) + O_2(g)$

The H_2O_2 in the solution decomposes completely according to the reaction represented above. The $O_2(g)$ produced is collected in an inverted graduated tube over water at 23.4°C and has a volume of 182.4 mL when the water levels inside and outside of the tube are the same. The atmospheric pressure in the lab is 762.6 torr, and the equilibrium vapor pressure of water at 23.4°C is 21.6 torr.

(a) Calculate the partial pressure, in torr, of $O_2(g)$ in the gas-collection tube.
(b) Calculate the mass of water produced.

762.6 – 21.6 = 741.0 torr

741.0 ÷ 760.0 = 0.975 atm

$$n = \frac{(0.975)(0.1824)}{(0.08206)(296.4)} = 0.00731 \text{ moles } O_2$$

$$\frac{0.00731 \text{ moles } O_2}{1} \times \frac{2 \text{ moles } H_2O}{1 \text{ mole } O_2} \times \frac{18.0 \text{ grams } H_2O}{1 \text{ mole } H_2O} = \mathbf{0.263 \text{ grams } H_2O}$$

7. $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$

In a hydrogen-oxygen fuel cell, energy is produced by the overall reaction represented above.
When the fuel cell operates at 25°C and 1.00 atm, 0.0746 mol of $O_2(g)$ is consumed. Calculate the volume of $H_2(g)$ consumed during the same time period. Express your answer in liters measured at 25°C and 1.00 atm.

$$\frac{0.0746 \text{ mol } O_2}{1} \times \frac{2 \text{ mole } H_2}{1 \text{ mol } O_2} = 0.1492 \text{ mol } H_2$$

$$V = \frac{(0.1492)(0.08206)(298)}{1.00} = \mathbf{3.65 \text{ L } H_2}$$

8. $AsF_5(g) \rightarrow AsF_3(g) + F_2(g)$

Answer the following questions regarding the decomposition of arsenic pentafluoride, $AsF_5(g)$. A 55.8 g sample of $AsF_5(g)$ is introduced into an evacuated 10.5 L container at 105°C.

(a) What is the initial pressure, in atmospheres, of the $AsF_5(g)$ in the container?
(b) What is the final pressure when all of the arsenic pentafluoride decomposes?

55.8 ÷ 169.9 = 0.328 moles AsF_5

$$P = \frac{(0.328)(0.08206)(378)}{10.5} = \mathbf{0.969 \text{ atm}}$$

0.969 atm x 2 = **1.94 atm (final pressure)**