GAS STOICHIOMETRY! Name Key

Fav. Flavor lock

## STP CONDITIONS

1) Solid iron (III) hydroxide decomposes to produce iron (III) oxide and water vapor. If 0.75 L of water vapor are produced at **STP**, how many grams of iron (III) hydroxide were used?

EQ) $2Fe(OH)_{3\,(s)} \rightarrow Fe_2O_{3\,(s)} + 3H_2O_{(g)}$

Stoich) $0.75\,L\,H_2O\left(\frac{1\,mol\,H_2O}{22.4\,L}\right)\left(\frac{2\,mol\,Fe(OH)_3}{3\,mol\,H_2O}\right)\left(\frac{106.88\,g}{1\,mol\,Fe(OH)_3}\right) = \boxed{2.4\,g\,Fe(OH)_3}$

2) Assume that 13.5 grams of solid aluminum react with HCl according to the following balanced equation at **STP**:

EQ) $2\,Al_{(s)} + 6\,HCl_{(aq)} \rightarrow 2\,AlCl_{3\,(aq)} + 3\,H_{2\,(g)}$

How many **liters of $H_2$ gas** could you ideally produce?

$13.5\,g\,Al\left(\frac{1\,mol\,Al}{26.98\,g}\right)\left(\frac{3\,mol\,H_2}{2\,mol\,Al}\right)\left(\frac{22.4\,L}{1\,mol\,H_2}\right) = \boxed{16.8\,L\,H_2}$

## NON-STP CONDITIONS (use PV=nRT either before or after stoichiometry)

3) Ammonium sulfate, an important fertilizer, can be prepared by the reaction of ammonia with sulfuric acid according to the following balanced equation:

EQ) $2\,NH_{3\,(g)} + H_2SO_{4\,(aq)} \rightarrow (NH_4)_2SO_{4\,(aq)}$

**Calculate the volume of $NH_3$** (in liters) needed at 20°C and 25.0 atm to react with 150. g of $H_2SO_4$.
**(hint: find moles of $NH_3$ needed then put in PV=nRT)**

$150.\,g\,H_2SO_4\left(\frac{1\,mol\,H_2SO_4}{98.08\,g}\right)\left(\frac{2\,mol\,NH_3}{1\,mol\,H_2SO_4}\right) = \boxed{3.06\,mol\,NH_3}$

$V = \frac{nRT}{P} = \frac{(3.06\,mol)\left(0.0821\,\frac{L\cdot atm}{mol\cdot K}\right)(293\,K)}{(25.0\,atm)}$

$\boxed{V = 2.94\,L\,NH_3}$

4) If 45.0 L of natural gas, which is essentially methane ($CH_4$), undergoes complete combustion at 0.961 atm and 20.°C, **how many grams of $CO_2$ product is formed?**

EQ: $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$

Math: $n = \frac{PV}{RT}$

$$n = \frac{(0.961\ atm)(45.0\ L)}{(0.0821\ \frac{L \cdot atm}{mol \cdot K})(293\ K)}$$

$$n = 1.80\ mol\ CH_4 \left(\frac{1\ mol\ CO_2}{1\ mol\ CH_4}\right)\left(\frac{44.01\ g}{1\ mol\ CO_2}\right) = \boxed{79.1\ g\ CO_2}$$

5) Fritz Haber, a German chemist, discovered a way to synthesize ammonia gas ($NH_3$) by combining hydrogen ($H_2$) and nitrogen gases ($N_2$) at extremely high temperatures and pressures.

a. Write the balanced equation for this reaction.

$3H_{2(g)} + N_{2(g)} \rightarrow 2NH_{3(g)}$

b. If 100. g of nitrogen combines with excess hydrogen at 550.°C and 250. atm, **what volume (Liters)** of ammonia gas is produced?

$$100.\ g\ N_2 \left(\frac{1\ mol\ N_2}{28.02\ g}\right)\left(\frac{2\ mol\ NH_3}{1\ mol\ N_2}\right) = \boxed{7.14\ mol\ NH_3}$$

$$V = \frac{nRT}{P} = \frac{(7.14\ mol)(0.0821\ \frac{L \cdot atm}{mol \cdot K})(823\ K)}{250.\ atm}$$

$$\boxed{V = 1.93\ L\ NH_3}$$

6) A 3.25 gram sample of solid calcium carbide ($CaC_2$) reacts with water to produce acetylene gas ($C_2H_2$) and aqueous calcium hydroxide. If the acetylene was collected at 17°C and 0.9737 atm, how many **Liters** of $C_2H_2$ were produced?

EQ: $CaC_{2\,(g)} + 2H_2O_{(l)} \rightarrow C_2H_{2\,(g)} + Ca(OH)_{2\,(aq)}$

Math: $3.25\ g\ CaC_2 \left(\frac{1\ mol\ CaC_2}{64.10\ g}\right)\left(\frac{1\ mol\ C_2H_2}{1\ mol\ CaC_2}\right) = 0.0507\ mol\ C_2H_2$

$$V = \frac{nRT}{P} = \frac{(0.0507\ mol)(0.0821\ \frac{L \cdot atm}{mol \cdot K})(290.\ K)}{0.9737\ atm} = \boxed{1.24\ L}$$