Name: KEY! per___

Gas Stoichiometry

Practice Sheet #32

1. Hydrogen is combined with oxygen to form water.
   a. Write a balanced chemical equation for this reaction.

$$2\,H_2 + 1\,O_2 \rightarrow 2\,H_2O$$

   b. What volume and mass of hydrogen and oxygen (at STP) would be required to produce 27.0 g of water?

$$27.0\text{ g } H_2O \times \frac{1\text{ mol } H_2O}{18.02\text{ g } H_2O} \times \frac{2\text{ mol } H_2}{2\text{ mol } H_2O} \times \frac{2.016\text{ g } H_2}{1\text{ mol } H_2} = 3.02\text{ g } H_2 \times \frac{1\text{ mol}}{2.016\text{ g}} \times \frac{22.4\text{ L}}{1\text{ mol}} = 33.6\text{ L } H_2$$

$$27.0\text{ g } H_2O \text{ " " } \times \frac{1\text{ mol } O_2}{2\text{ mol } H_2O} \times \frac{32\text{ g } O_2}{1\text{ mol } O_2} = 24.0\text{ g } O_2 \times \frac{1\text{ mol}}{32\text{ g}} \times \frac{22.4\text{ L}}{1\text{ mol}} = 16.8\text{ L } O_2$$

2. Nitrogen monoxide reacts with oxygen to produce nitrogen dioxide.
   a. Write a balanced chemical equation for this reaction.

$$2\,NO + 1\,O_2 \rightarrow 2\,NO_2$$

   b. If 140 L of oxygen react at STP, what volume of and mass of nitrogen monoxide is required? What volume and mass of nitrogen dioxide (at STP) would be produced?

$$140\text{ L } O_2 \times \frac{1\text{ mol } O_2}{22.4\text{ L}} \times \frac{2\text{ mol } NO_2}{1\text{ mol } O_2} = 12.5\text{ mol } NO_2 \times \frac{46\text{ g } NO_2}{1\text{ mol}} = \boxed{575\text{ g } NO_2}$$

$$\text{" " } \times \frac{22.4\text{ L}}{1\text{ mol}} = \boxed{280\text{ L } NO_2}$$

$$140\text{ L } O_2 \times \frac{1\text{ mol } O_2}{22.4\text{ L}} \times \frac{2\text{ mol } NO}{1\text{ mol } O_2} = 12.5\text{ mol } NO \times \frac{30\text{ g } NO}{1\text{ mol}} = \boxed{375\text{ g } NO}$$

$$\text{" " } \times \frac{22.4\text{ L}}{1\text{ mol}} = \boxed{280\text{ L } NO}$$

   c. If 15.0 g of nitrogen monoxide react, what volume of and mass of oxygen (at STP) is required? What volume and mass of nitrogen dioxide (at STP) would be produced?

$$15.0\text{ g } NO \times \frac{1\text{ mol } NO}{30\text{ g } NO} \times \frac{2\text{ mol } NO_2}{2\text{ mol } NO} = 0.500\text{ mol } NO_2 \times \frac{46\text{ g } NO_2}{1\text{ mol}} = \boxed{23.0\text{ g } NO_2}$$

$$\text{" " } \times \frac{22.4\text{ L}}{1\text{ mol}} = \boxed{11.2\text{ L } NO_2}$$

$$15.0\text{ g } NO \times \frac{1\text{ mol } NO}{30\text{ g } NO} \times \frac{1\text{ mol } O_2}{2\text{ mol } NO} = 0.250\text{ mol } O_2 \times \frac{32\text{ g } O_2}{1\text{ mol}} = \boxed{8.00\text{ g } O_2}$$

$$\text{" " } \times \frac{22.4\text{ L}}{1\text{ mol}} = \boxed{5.60\text{ L } O_2}$$

3. Nitrogen monoxide reacts with chlorine to form nitrosyl chloride (NOCl) at STP.
   a. Write a balanced chemical equation for this reaction.

$$2\,NO + 1\,Cl_2 \rightarrow 2\,NOCl$$

   b. If 448 mL of nitrogen monoxide react with 336 mL of chlorine, which reactant is limiting and which is in excess?

$$0.448\text{ L} \times \frac{1\text{ mol } NO}{22.4\text{ L}} \times \frac{2\text{ mol } NOCl}{2\text{ mol } NO} = 0.0200\text{ mol } NOCl$$

$$0.336\text{ L} \times \frac{1\text{ mol } Cl_2}{22.4\text{ L}} \times \frac{2\text{ mol } NOCl}{1\text{ mol } Cl_2} = .0300\text{ mol } NOCl$$

$\boxed{\text{LR} = NO \qquad \text{Excess} = Cl_2}$

   c. What volume and mass of nitrosyl chloride will be produced (at STP)?

$$0.0200\text{ mol } NOCl \times \frac{22.4\text{ L}}{1\text{ mol}} = \boxed{0.448\text{ L } NOCl}$$

$$0.0200\text{ mol } NOCl \times \frac{65.45\text{ g } NOCl}{1\text{ mol}} = \boxed{1.31\text{ g } NOCl}$$

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4. Propyne (C_3H_4) undergoes combustion with oxygen to produce carbon dioxide and water.
   a. Write a balanced chemical equation for this reaction.

$$\_C_3H_4 + \underline{4}\,O_2 \longrightarrow \underline{3}\,CO_2 + \underline{2}\,H_2O$$

   b. If 52.0 L of propyne at 1.24 atm and 2870 °C, what volume and mass of oxygen is required?

$PV=nRT$, $n=\frac{PV}{RT}$

$n=\frac{(1.24\,atm)(52.0L)}{(0.0821\,\frac{L\,atm}{mol\,K})(3143K)}$

$n = 0.250\,mol\,C_3H_4 \times \frac{4\,mol\,O_2}{1\,mol\,C_3H_4} = 1.00\,mol\,O_2$

$1\,mol\,O_2 \times \frac{32g}{1\,mol\,O_2} = \boxed{32.0\,g\,O_2}$

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

$V=\frac{(1.00\,mol)(0.0821)(3143K)}{(1.24\,atm)}$

$\boxed{V=208\,L}$

   c. What volume and mass of carbon dioxide water will be produced?

$0.250\,mol\,C_3H_4 \times \frac{3\,mol\,CO_2}{1\,mol\,C_3H_4} = 0.750\,mol\,CO_2$

$0.750\,mol\,CO_2 \times \frac{44.04g\,CO_2}{1\,mol\,CO_2} = \boxed{33.0\,g\,CO_2}$

$V=\frac{(0.750mol)(0.0821)(3143K)}{(1.24\,atm)}$

$\boxed{V=156\,L\,CO_2}$

5. Carbon monoxide is combined with hydrogen to produce methanol (CH_3OH) at 5.25×10^6 Pa and 250 °C.
   a. Write a balanced chemical equation for this reaction.

$$\_CO + \underline{2}\,H_2 \longrightarrow \_CH_3OH$$

   b. If 450 mL of carbon monoxide react with 800 mL of hydrogen, which reactant is limiting and which is excess?

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

$n_{CO}=\frac{(5.25\times10^6\,Pa)(0.450L)}{(8314\,\frac{L\,Pa}{mol\,K})(523K)} = 0.543\,mol$

$n_{H_2}=\frac{(5.25\times10^6\,Pa)(0.800L)}{(8314\,\frac{L\,Pa}{mol\,K})(523K)} = 0.966\,mol$

$0.543\,mol\,CO \times \frac{1\,mol\,CH_3OH}{1\,mol\,CO} = 0.543\,mol\,CH_3OH$

$0.966\,mol\,H_2 \times \frac{1\,mol\,CH_3OH}{2\,mol\,H_2} = 0.483\,mol\,CH_3OH$

$\boxed{H_2 = L.R \quad CO = excess}$

   c. What volume and mass of methanol will be produced? If the percent yield for the reaction is 90.0 %, what mass of methanol will actually be produced?

$0.483\,mol\,CH_3OH \times \frac{32g\,CH_3OH}{1\,mol\,CO} = \boxed{15.5\,g\,CO}$ theoretical

$0.90 = \frac{x}{15.5}$ actual $= \boxed{14.0\,g\,CO}$ actual

$V=\frac{nRT}{P} = \frac{(0.483\,mol)(8314\,\frac{L\,Pa}{mol\,K})(523K)}{(5.25\times10^6\,Pa)}$

$\boxed{V=0.400\,L}$

6. Automobile air bags inflate following a serious impact. The impact triggers the chemical reactions:

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

   a. If an automobile air bag has a volume of 11.8 L, how much NaN_3 in grams is required to fully inflate the air bag upon impact? Assume STP conditions.

$$11.8\,L\,N_2 \times \frac{1\,mol\,N_2}{22.4\,L\,N_2} \times \frac{2\,mol\,NaN_3}{3\,mol\,N_2} \times \frac{64.99g\,NaN_3}{1\,mol\,NaN_3} = \boxed{22.8\,g\,NaN_3}$$