Name: KEY

Chemistry WS- Avogadro's Law and Standard Molar Volume

1. Calcium carbonate decomposes to form carbon dioxide and calcium oxide at STP.
   a. Write the balanced chemical equation for the reaction.

$$CaCO_3 \rightarrow CO_2 + CaO$$

   b. How many grams of calcium carbonate will be needed to form 4.5 liters of carbon dioxide?

$$4.5\,L\ CO_2 \times \frac{1\,L\,CaCO_3}{1\,L\,CO_3} \times \frac{1\,mol\,CaCO_3}{22.4\,L\,CaCO_3} \times \frac{100.09\,g\,CaCO_3}{1\,mol\,CaCO_3} = 20.11\,g\,CaCO_3$$

   c. If 4.5 liters of carbon dioxide are formed in the reaction, how many grams of calcium oxide are produced?

$$4.5\,L\ CO_2 \times \frac{1\,L\,CaO}{1\,L\,CO_2} \times \frac{1\,mol\,CaO}{22.4\,L\,CaO} \times \frac{56.08\,g\,CaO}{1\,mol\,CaO} = 11.27\,g\,CaO$$

2. Find the mass of each of the following at STP.
   a. 10.9 L H_2

$$10.9\,L\ H_2 \times \frac{1\,mol\,H_2}{22.4\,L\,H_2} \times \frac{2.02\,g\,H_2}{1\,mol\,H_2} = 0.98\,g\,H_2$$

   b. 5.4 mL NH_4

$$5.4\,mL\ NH_4 \times \frac{1\,L\,NH_4}{1000\,mL\,NH_4} \times \frac{1\,mol\,NH_4}{22.4\,L\,NH_4} \times \frac{18.05\,g\,NH_4}{1\,mol\,NH_4} = 0.0044\,g\,NH_4$$

   c. 3.45 L CO_2

$$3.45\,L\ CO_2 \times \frac{1\,mol\,CO_2}{22.4\,L\,CO_2} \times \frac{44.01\,g\,CO_2}{1\,mol\,CO_2} = 6.78\,g\,CO_2$$

   d. 54.5 mL SO_2

$$54.5\,mL\ SO_2 \times \frac{1\,L\,SO_2}{1000\,mL\,SO_2} \times \frac{1\,mol\,SO_2}{22.4\,L\,SO_2} \times \frac{64.06\,g\,SO_2}{1\,mol\,SO_2} = 0.16\,g\,SO_2$$

3. Ethylene (C_2H_4) undergoes a combustion reaction at STP.
   a. Write the balanced chemical equation for the reaction.

$$1\,C_2H_4 + 3\,O_2 \rightarrow 2\,CO_2 + 2\,H_2O$$

   b. How many liters of water can be formed if 2.5 L of ethylene are consumed in the reaction?

$$2.5\,L\ C_2H_4 \times \frac{2\,L\,H_2O}{1\,L\,C_2H_4} = 5.0\,L\,H_2O$$

   c. How many moles of oxygen are consumed in the reaction?

$$2.5\,L\ C_2H_4 \times \frac{3\,L\,O_2}{1\,L\,C_2H_4} \times \frac{1\,mol\,O_2}{22.4\,L\,O_2} = 0.33\,mol\,O_2$$

   d. How many grams of carbon dioxide are produced in the reaction?

$$2.5\,L\ C_2H_4 \times \frac{2\,L\,CO_2}{1\,L\,C_2H_2} \times \frac{1\,mol\,CO_2}{22.4\,L\,CO_2} \times \frac{44.01\,g\,CO_2}{1\,mol\,CO_2} = 9.82\,g\,CO_2$$

4. At STP, what is the volume of 7.08 mol of nitrogen gas?

$$7.08\,mol\ N_2 \times \frac{22.4\,L\,N_2}{1\,mol\,N_2} = 158.59\,L\,N_2$$

5. What volume, in milliliters, at STP will be occupied by 0.0035 mol of methane, CH_4?

$$0.0035 \text{ mol } CH_4 \times \frac{22.4 \text{ L } CH_4}{1 \text{ mol } CH_4} \times \frac{1000 \text{ mL } CH_4}{1 \text{ L } CH_4} = 78.4 \text{ mL } CH_4$$

6. Assume that 5.60 L of hydrogen gas at STP reacts with excess copper (II) oxide in a single displacement reaction.
   a. Write the balanced chemical equation for the reaction.

$$H_2 + CuO \rightarrow H_2O + Cu$$

   b. How many moles of hydrogen gas react?

$$5.60 \text{ L } H_2 \times \frac{1 \text{ mol } H_2}{22.4 \text{ L } H_2} = 0.25 \text{ mol } H_2$$

   c. How many grams of copper are produced?

$$5.60 \text{ L } H_2 \times \frac{1 \text{ mol } H_2}{22.4 \text{ L } H_2} \times \frac{1 \text{ mol Cu}}{1 \text{ mol } H_2} \times \frac{63.55 \text{ g Cu}}{1 \text{ mol Cu}} = 15.89 \text{ g Cu}$$

7. Combining carbon monoxide and hydrogen gases at STP makes methanol, CH3OH. If 4.50×10^2 mL of carbon monoxide and 8.25×10^2 mL of hydrogen gas are mixed,
   a. Write the balanced chemical equation for the reaction.

$$CO + 2H_2 \rightarrow CH_3OH$$

   b. Which reactant is present in excess?

$$450 \text{ mL CO} \times \frac{1 \text{ L CO}}{1000 \text{ mL CO}} \times \frac{1 \text{ mol CO}}{22.4 \text{ L CO}} \times \frac{1 \text{ mol } CH_3OH}{1 \text{ mol CO}} = 0.020 \text{ mol } CH_3OH$$

CO is excess

$$825 \text{ mL } H_2 \times \frac{1 \text{ L } H_2}{1000 \text{ mL } H_2} \times \frac{1 \text{ mol } H_2}{22.4 \text{ L } H_2} \times \frac{1 \text{ mol } CH_3OH}{2 \text{ mol } H_2} = 0.018 \text{ mol } CH_3OH$$

   c. How many grams of that reactant remains after the reaction?

$$825 \text{ mL } H_2 \times \frac{1 \text{ L } H_2}{1000 \text{ mL } H_2} \times \frac{1 \text{ mol } H_2}{22.4 \text{ L } H_2} \times \frac{1 \text{ mol CO}}{2 \text{ mol } H_2} \times \frac{28.01 \text{ g CO}}{1 \text{ mol CO}} = 0.52 \text{ g CO} - \text{USED}$$

$$450 \text{ mL CO} \times \frac{1 \text{ L CO}}{1000 \text{ mL CO}} \times \frac{1 \text{ mol CO}}{22.4 \text{ L CO}} \times \frac{28.01 \text{ g CO}}{1 \text{ mol CO}} = 0.56 \text{ g CO}_{\text{START}} - 0.52 \text{ g CO}_{\text{USED}} = \boxed{0.04 \text{ g CO remain}}$$

   d. What volume of methanol is produced?

$$825 \text{ mL } H_2 \times \frac{1 \text{ L } H_2}{1000 \text{ mL } H_2} \times \frac{1 \text{ L } CH_3OH}{2 \text{ L } H_2} = 0.411 \text{ L } CH_3OH \text{ or } 412.5 \text{ mL } CH_3OH$$

8. 5.0 L dinitrogen pentoxide decomposes at STP into nitrogen dioxide and oxygen.
   a. Write the balanced chemical equation for the reaction.

$$2N_2O_5 \rightarrow 4NO_2 + O_2$$

   b. How many milliliters of nitrogen dioxide are produced in the reaction?

$$5.0 \text{ L } N_2O_5 \times \frac{4 \text{ L } NO_2}{2 \text{ L } N_2O_5} \times \frac{1000 \text{ mL } NO_2}{1 \text{ L } NO_2} = 10{,}000 \text{ mL } NO_2$$

   c. How many molecules of oxygen are produced in the reaction?

$$5.0 \text{ L } N_2O_5 \times \frac{1 \text{ L } O_2}{2 \text{ L } N_2O_5} \times \frac{1 \text{ mol } O_2}{22.4 \text{ L } O_2} \times \frac{6.022 \times 10^{23} \text{ molecules } O_2}{1 \text{ mol } O_2} = 6.72 \times 10^{22} \text{ molecules } O_2$$