Worksheet 21 Gas law and reaction stoichiometry

1. How many grams of phosphorus react with 35.5 L of O_2 at STP to form tetraphosphorus decoxide?

   $$P_4(s) + O_2(g) \rightarrow P_4O_{10}(s) \quad \textit{(unbalanced)}$$

2. The industrial synthesis of nitric acid involves the reaction of nitrogen dioxide gas with water:

   $$NO_2(g) + H_2O(l) \rightarrow HNO_3(aq) + NO(g) \quad \textit{(unbalanced)}$$

   How many moles of nitric acid can be prepared using 450 L of NO_2 at a pressure of 5.00 atm and a temperature of 295 K?

3. In the first step in the industrial process of making nitric acid, ammonia reacts with oxygen at 850°C and 5.00 atm in the presence of a suitable catalyst. The following reaction occurs:

   $$NH_3(g) + O_2(g) \rightarrow NO(g) + H_2O(g) \quad \textit{(unbalanced)}$$

   How many litres of $NH_3(g)$ at 850°C and 5.00 atm are required to react with 1.00 mol of $O_2(g)$ in this reaction?

4. Air bags are activated when a severe impact causes a steel ball to compress a spring and electrically ignite a detonator cap. This causes sodium azide (NaN_3) to decompose explosively according to the following reaction:

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

   What mass of $NaN_3(s)$ must be reacted to inflate an air bag to 70.0 L at STP?

5. Hydrogen gas is produced when zinc reacts with sulfuric acid:

   $$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

   If 159 mL of wet H_2 is collected over water at 25°C and a barometric pressure of 738 torr, how many grams of Zn have been consumed?

6. Small quantities of oxygen gas are sometimes generated in the laboratory by heating $KClO_3$ in the presence of MnO_2 as a catalyst:

   $$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

   What volume of O_2 is collected over water at 20°C by reaction of 0.3570 g of $KClO_3$ if the barometric pressure is 742 torr?

7. How many grams of phosphine (PH_3) can form when 37.5 g of phosphorus and 83.0 L of hydrogen gas react at STP?

   $$P_4(s) + H_2(g) \rightarrow PH_3(g)$$ *(unbalanced)*

8. Consider the reaction between 60.0 mL of liquid methyl alcohol, CH_3OH (density = 0.850 g/mL), and 22.8 L of O_2 at 27°C and a pressure of 2.00 atm. The products of the reaction are CO_2 (g) and H_2O(g). Calculate the number of moles of H_2O formed if the reaction goes to completion.

9. The alkali metals react with the halogens to form ionic metal halides. What mass of potassium chloride forms when 5.25 L of chlorine gas at 0.950 atm and 293 K reacts with 17.0 g of potassium?

   $$2K(s) + Cl_2(g) \rightarrow 2KCl(s)$$

10. Hydrogen gas is produced when aluminum reacts with hydrochloric acid:

    $$2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$$

    What volume of hydrogen gas is collected over water at 35°C by reaction of 0.6470 g of aluminum if the atmospheric pressure is 742 torr?

11. Consider the reaction between 75.0 mL of liquid ethanol, C_2H_5OH (density = 0.789 g/mL), and 32.5 L of O_2 at 27°C and a pressure of 2.50 atm. The products of the reaction are CO_2 (g) and H_2O (g). If the reaction produces 45.0 g of H_2O(g), what is the percent yield?

12. Hydrogen gas (a potential future fuel) can be formed by the reaction of methane with water according to the following equation:

    $$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$$

    In a particular reaction, 25.5 L of methane gas (measured at a pressure of 732 torr and a temperature of 25°C) is mixed with 22.8 L of water vapor (measured at a pressure of 702 torr and a temperature of 12.5 °C). The reaction produces 26.2 L of hydrogen gas measured at STP. What is the percent yield of the reaction?

13. Consider the following reaction:

$$2NH_3(g) + 3Cl_2(g) \rightarrow N_2(g) + 6HCl(g)$$

19.8 L of NH_3 gas (measured at STP) is mixed with 26.8 L of wet Cl_2 (measured at a pressure of 722 torr and a temperature of 35.0 °C). The reaction produces 6.81g of N_2. What is the percent yield of the reaction?

14. Consider the following reaction:

$$2C_5H_6(g) + 13O_2(g) \rightarrow 10CO_2(g) + 6H_2O(g)$$

10.8 L of C_5H_6 gas (measured at STP) is mixed with 26.8 L of <u>wet O_2</u> (measured at a pressure of 0.968 atm and a temperature of 45.0 °C). The reaction produces 5.00 g of $H_2O(g)$. What is the *percent yield* of the reaction?