Stoichiometry Worksheet #1

1. Aluminum chloride, $AlCl_3$, is used as a catalyst in various industrial reactions. It is prepared from hydrogen chloride gas and aluminum metal shavings.

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

1A. How many moles of $AlCl_3$ can be prepared from 3.5 moles of hydrogen chloride gas with an excess of aluminum?

$$3.5 \text{ mol HCl} \times \frac{2 \text{ mol AlCl}_3}{6 \text{ mol HCl}} = 1.2 \text{ mol AlCl}_3$$

Ans: **1.2 mol AlCl₃**

1B. How many moles of hydrogen gas would be produced from the use of 8.5 moles of aluminum with an excess of hydrogen chloride?

Ans: **13 mol H₂**

$$8.5 \text{ mol Al} \times \frac{3 \text{ mol H}_2}{2 \text{ mol Al}} = 13 \text{ mol H}_2$$

2. When dinitrogen pentoxide, N_2O_5, a white solid, is heated, it decomposes to nitrogen dioxide and oxygen.

$$2N_2O_5(s) \xrightarrow{\Delta} 4NO_2(g) + O_2(g)$$

2A. How many moles of nitrogen dioxide can be formed from the decomposition of 1.25 g of N_2O_5?

$$1.25 \text{ g N}_2O_5 \times \frac{1 \text{ mol N}_2O_5}{108.02 \text{ g N}_2O_5} \times \frac{4 \text{ mol NO}_2}{2 \text{ mol N}_2O_5} = 0.0231 \text{ mol NO}_2$$

Ans: **0.0231 mol NO₂**

2B. How many grams of oxygen can be formed from the decomposition of 2.3 g of N_2O_5?

$$2.3 \text{ g N}_2O_5 \times \frac{1 \text{ mol N}_2O_5}{108.02 \text{ g N}_2O_5} \times \frac{1 \text{ mol O}_2}{2 \text{ mol N}_2O_5} \times \frac{32.00 \text{ g O}_2}{1 \text{ mol O}_2} = 0.34 \text{ g O}_2$$

Ans: **0.34 g O₂**

3. Chlorine is prepared from sodium chloride by electrochemical decomposition. Formerly chlorine was produced by heating hydrochloric acid with pyrolusite [manganese dioxide or manganese(IV) oxide, MnO_2], a common manganese ore. Small amounts of chlorine may be prepared in the laboratory by the same reaction.

$$4HCl(aq) + MnO_2(s) \rightarrow 2H_2O(l) + MnCl_2(aq) + Cl_2(g)$$

3A. How many grams of HCl react with 5.00 g of MnO_2, according to the equation?

$$5.00 \text{ g MnO}_2 \times \frac{1 \text{ mol MnO}_2}{86.94 \text{ g MnO}_2} \times \frac{4 \text{ mol HCl}}{1 \text{ mol MnO}_2} \times \frac{36.46 \text{ g HCl}}{1 \text{ mol HCl}} = 8.39 \text{ g HCl}$$

Ans: **8.39 g HCl**

3B. If a chemist wanted to prepare 100. g of chlorine, how many grams of MnO_2 are needed, assuming there is more than enough hydrochloric acid?

Ans: **123 g MnO₂**

$$100. \text{ g Cl}_2 \times \frac{1 \text{ mol Cl}_2}{70.90 \text{ g Cl}_2} \times \frac{1 \text{ mol MnO}_2}{1 \text{ mol Cl}_2} \times \frac{86.94 \text{ g MnO}_2}{1 \text{ mol MnO}_2} = 123 \text{ g MnO}_2$$

3C. How many molecules of water are produced from the reaction of 5.0 g of HCl?

Ans: **4.1 x 10²² molec. H₂O**

$$5.0 \text{ g HCl} \times \frac{1 \text{ mol HCl}}{36.46 \text{ g HCl}} \times \frac{2 \text{ mol H}_2O}{4 \text{ mol HCl}} \times \frac{6.02 \times 10^{23} \text{ molecules H}_2O}{1 \text{ mol H}_2O} = 4.1 \times 10^{22} \text{ molecules H}_2O$$

4. Sodium is a soft, reactive metal that instantly reacts with water to give hydrogen gas and a solution of sodium hydroxide, NaOH.

$$2Na(s) + 2H_2O(l) \rightarrow H_2(g) + 2NaOH(aq)$$

4A. How many grams of sodium metal are needed to give 7.81 g of hydrogen by this reaction?

Ans: **178 g Na**

$$7.81 \text{ g H}_2 \times \frac{1 \text{ mol H}_2}{2.02 \text{ g H}_2} \times \frac{2 \text{ mol Na}}{1 \text{ mol H}_2} \times \frac{22.99 \text{ g Na}}{1 \text{ mol Na}} = 178 \text{ g Na}$$

4B. How many sodium atoms are needed to react with 1.25×10^{24} molecules of water?

Ans: **1.25 x 10²⁴ atoms Na**

$$1.25 \times 10^{24} \text{ molecules H}_2O \times \frac{1 \text{ mol H}_2O}{6.02 \times 10^{23} \text{ molecules H}_2O} \times \frac{2 \text{ mol Na}}{2 \text{ mol H}_2O} \times \frac{6.02 \times 10^{23} \text{ atoms Na}}{1 \text{ mol Na}} =$$

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