Mole Conversions, Types of Reactions, and Stoichiometry Test Review

Students should be able to:

1. Identify the type of reaction – synthesis, decomposition, single replacement, double replacement, combustion of a hydrocarbon.
2. Predict the products of reactions – all types.
3. Balance equations.
4. Write net ionic equations for single and double replacement reactions.
5. Identify spectator ions in single and double replacement reactions.
6. Convert moles to grams and to particles.
7. Convert grams and particles to moles.
8. Convert moles to liters and liters to moles (gases only).
9. Convert moles of one compound to moles of another compound in the same reaction.
10. Explain the difference between a limiting reactant and an excess reactant.
11. Explain why it is advantageous to use an excess reactant.
12. Determine which reactant is the limiting and which is the excess.
13. Calculate the amount of each product formed.
14. Calculate the amount of excess reactant that remains.
15. Calculate the amount of one reactant that is needed to react completely with another reactant.
16. Calculate the amount one reactant that is necessary to produce a given amount of product (assuming 100% yield).
17. Calculate the percent yield.
18. Use laboratory data to find the actual yield of a reaction, the theoretical yield and the percent yield.

Practice Problems – *Remember to always start with a balanced chemical equation.*

1. In a single displacement reaction, 9.23 g of aluminum react with excess hydrochloric acid. How many grams of hydrogen will be produced? How many liters of hydrogen would this be at STP?

2. The actual amount of product made in a reaction is 39.7 g although a mass-mass calculation predicted 65.6 g. What is the percentage yield of the product?

3. In the laboratory, a student reacts 5.50 grams of hydrogen gas with an excess of nitrogen gas and makes 20.4 grams of ammonia (NH_3). What was the percent yield of the reaction?

4. If 61.8 g of calcium hydroxide are gently heated, how many grams of water vapor are produced?

5. A. If 100.0 grams of copper metal is added to a solution containing 100.0 grams of silver nitrate, how many grams of silver metal are produced?
   B. What is the limiting reactant? The excess reactant?
   C. How many grams of the limiting reactant will remain at the end of the reaction?
   D. What type of reaction is this?

6. Calcium oxide, or lime, is produced from the thermal decomposition of limestone ($CaCO_3$). The only other product of the decomposition is carbon dioxide. What mass of limestone will be needed to produce 255 grams of calcium oxide? Assume 78.9% yield.

7. Nitrogen gas can be prepared by passing gaseous ammonia (NH_3) over solid copper oxide at high temperatures. The other products of the reaction are solid copper and water vapor. When 18.1 grams of NH_3 is reacted with an excess CuO, 12.5 grams of nitrogen gas are produced. What is the percent yield of N_2?

8. If 1.85 g of Al reacts with excess copper (II) sulfate and the percent yield of copper is 56.6%, what mass of copper is produced?

9. How many grams of carbon dioxide will be produced when 5.0 liters of C_3H_8 (propane) is combusted?

10. Identify the limiting reactant when 7.81 grams of HCl reacts with 5.24 grams of NaOH to produce NaCl and H_20. How many grams of sodium chloride will be produced? How many grams of the excess reactant will remain?

11. Solid lithium hydroxide is used in space vehicles to remove exhaled carbon dioxide from the living environment to form solid lithium carbonate and liquid water. What mass of gaseous carbon dioxide can be absorbed by 1000.0 grams of lithium hydroxide? What volume of CO_2 is this at STP?

$$LiOH(s) + CO_2(g) \rightarrow Li_2CO_3(s) + H_2O(l)$$

12. Over the years the thermite reaction has been used for welding railroad rails, in incendiary bombs, and to ignite solid fueled rocket motors. The reaction is:

$$Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(l) + Al_2O_3(s)$$

What masses of Fe_2O_3 and aluminum must be used to produce 15.0 grams of iron? What masses of aluminum oxide would be produced?

STOICHIOMETRY
PRACTICE PROBLEMS

①

$$\underset{9.23\text{g Al}}{2Al} + 6HCl \rightarrow \underset{\substack{?\text{g} \\ ?\text{L}}}{3H_2} + 2AlCl_3$$

$$\frac{9.23\text{g Al}}{1}\Bigg|\frac{1\text{ mole Al}}{26.98\text{g Al}}\Bigg|\frac{3\text{ mole }H_2}{2\text{ mole Al}}\Bigg|\frac{2.02\text{g }H_2}{1\text{ mole }H_2} = \boxed{1.04\text{g }H_2}$$

$$\frac{1.04\text{g }H_2}{1}\Bigg|\frac{1\text{ mole }H_2}{2.02\text{g }H_2}\Bigg|\frac{22.4\text{ L }H_2}{1\text{ mole }H_2} = \boxed{11.5\text{ L }H_2}$$

②

$$\%\text{ yield} = \left(\frac{\text{Actual Yield}}{\text{Theoretical Yield}}\right)(100)$$

$$= \left(\frac{39.7\text{g}}{65.6\text{g}}\right)(100) = \boxed{60.5\%}$$

③

$$\underset{5.50\text{g}}{3H_2} + N_2 \rightarrow \underset{\substack{?\text{ Theor.} \\ \text{yield in grams}}}{2NH_3} \rightarrow \text{Actual yield} = 20.4\text{g }NH_3$$

$$\frac{5.50\text{g }H_2}{1}\Bigg|\frac{1\text{ mole }H_2}{2.02\text{g }H_2}\Bigg|\frac{2\text{ moles }NH_3}{3\text{ moles }H_2}\Bigg|\frac{17.04\text{g }NH_3}{1\text{ mole }NH_3} = 30.9\text{g }NH_3$$

= Theoretical

$$\%\text{ yield} = \frac{20.4\text{g}}{30.9\text{g}} \times 100 = \boxed{66.0\%}$$

④

$$\underset{61.8\text{g}}{Ca(OH)_2} \xrightarrow{\Delta} CaO + \underset{?\text{g }H_2O}{H_2O}$$

$$\frac{61.8\text{g }Ca(OH)_2}{1}\Bigg|\frac{1\text{ mole }Ca(OH)_2}{74.10\text{g }Ca(OH)_2}\Bigg|\frac{1\text{ mole }H_2O}{1\text{ mole }Ca(OH)_2}\Bigg|\frac{18.02\text{g}}{1\text{ mole }H_2O} = \boxed{15.0\text{g }H_2O}$$

Test Review

7.) $2NH_3 + 3CuO \rightarrow N_2 + 3Cu + 3H_2O$

18.1g excess

$\boxed{\underline{\quad}\,g \text{ theoretical yield}}$

$$\frac{18.1\,g\,NH_3}{1}\Bigg|\frac{1\,mol\,NH_3}{17.04\,g\,NH_3}\Bigg|\frac{1\,mol\,N_2}{2\,mol\,NH_3}\Bigg|\frac{28.02\,g\,N_2}{1\,mol\,N_2} = 14.9\,g\,N_2$$

$$\%\,Yield = \frac{12.5\,g}{14.9\,g} \times 100 = \boxed{83.9\,\%}$$

---

8) $2Al + 3CuSO_4 \rightarrow 3Cu + Al_2(SO_4)_3$

1.85g

$\boxed{\underline{\quad}\,g \text{ theoretical yield}}$

$$\frac{1.85\,g\,Al}{1}\Bigg|\frac{1\,mol\,Al}{26.98\,g\,Al}\Bigg|\frac{3\,mol\,Cu}{2\,mol\,Al}\Bigg|\frac{63.55\,g\,Cu}{1\,mol\,Cu} = \boxed{6.54\,g\,Cu}$$

$$\%\,Yield = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100$$

$$56.6 = \frac{x}{6.54} \times 100$$

$$.566 = \frac{x}{6.54}$$

$$x = \boxed{3.70\,g\,Cu} \rightarrow \text{actual yield}$$

---

9) $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

5.0L

$\underline{\quad}\,g$

$$\frac{5.0\,L\,C_3H_8}{1}\Bigg|\frac{1\,mol\,C_3H_8}{22.4\,L\,C_3H_8}\Bigg|\frac{3\,mol\,CO_2}{1\,mol\,C_3H_8}\Bigg|\frac{44.01\,g\,CO_2}{1\,mol\,CO_2} = \boxed{\begin{matrix}\cancel{29\,g\,CO_2}\\ 29.5\,g\,CO_2\\ 29.48\end{matrix}}$$

TEST REVIEW

10) $$\underset{7.81\text{g}}{HCl} + \underset{5.24\text{g}}{NaOH} \rightarrow NaCl + H_2O$$

$$\frac{7.81\text{g HCl}}{1}\Big|\frac{1\text{mol HCl}}{36.46\text{g HCl}}\Big|\frac{1\text{mol NaCl}}{1\text{mol HCl}}\Big|\frac{58.44\text{g NaCl}}{1\text{mol NaCl}} = 12.5\text{g NaCl}$$

$$\frac{5.24\text{g NaOH}}{1}\Big|\frac{1\text{mol NaOH}}{40.00\text{g NaOH}}\Big|\frac{1\text{mol NaCl}}{1\text{mol NaOH}}\Big|\frac{58.44\text{g NaCl}}{1\text{mol NaCl}} = \boxed{\begin{array}{c}7.66\text{g NaCl}\\ \text{theoretical yield}\end{array}}$$

LR → NaOH

ER → HCl

$$\frac{5.24\text{g NaOH}}{1}\Big|\frac{1\text{mol NaOH}}{40.00\text{g NaOH}}\Big|\frac{1\text{mol HCl}}{1\text{mol NaOH}}\Big|\frac{36.46\text{g HCl}}{1\text{mol HCl}} = 4.78\text{g HCl } \underline{\underline{\text{used}}}$$

$$7.81\text{g} - 4.78\text{g} = \boxed{\begin{array}{c}3.03\text{g}\\ \text{excess HCl}\end{array}}$$

---

11) $$\underset{1000.0\text{g}}{2LiOH} + \underset{-\text{g}}{CO_2} \rightarrow Li_2CO_{3(s)} + H_2O_{(g)}$$

$$\frac{1000.0\text{g LiOH}}{1}\Big|\frac{1\text{mol LiOH}}{23.95\text{g LiOH}}\Big|\frac{1\text{mol CO}_2}{2\text{mol LiOH}}\Big|\frac{44.01\text{g CO}_2}{1\text{mol CO}_2} = \boxed{\begin{array}{c}918.8\text{ g}\\ CO_2\\ \text{absorbed}\end{array}}$$

$$\frac{918.8\text{g CO}_2}{1}\Big|\frac{1\text{mol CO}_2}{44.01\text{g CO}_2}\Big|\frac{22.4\text{L CO}_2}{1\text{mol CO}_2} = \boxed{468\text{L CO}_2}$$

TEST REVIEW

12) $Fe_2O_3 + 2Al \rightarrow \underset{15.0g}{2Fe} + Al_2O_3$

$$\frac{15.0\,g\,Fe}{1}\left|\frac{1\,mol\,Fe}{55.85\,g\,Fe}\right|\frac{2\,mol\,Al}{2\,mol\,Fe}\left|\frac{26.98\,g\,Al}{1\,mol\,Al}\right. = 7.25\,g\,Al$$

needed

$$\frac{15.0\,g\,Fe}{1}\left|\frac{1\,mol\,Fe}{55.85\,g\,Fe}\right|\frac{1\,mol\,Fe_2O_3}{2\,mol\,Fe}\left|\frac{159.7\,g\,Fe_2O_3}{1\,mol\,Fe_2O_3}\right. = 21.4\,g\,Fe_2O_3$$

needed

$$\underbrace{21.4g + 7.25g}_{28.65g} = \underbrace{15.0g + \underline{13.65}g}_{28.65g}$$

~~close enough!~~ close enough!

OR

$$\frac{15.0\,g\,Fe}{1}\left|\frac{1\,mol\,Fe}{55.85\,g\,Fe}\right|\frac{1\,mol\,Al_2O_3}{2\,mol\,Fe}\left|\frac{101.96\,g\,Al_2O_3}{1\,mol\,Al_2O_3}\right. = \boxed{13.69\,g\,Al_2O_3}$$