EXTRA PRACTICE: Limiting Reactant and Percent Yield Worksheet

1. Chlorine can replace bromine in bromide compounds forming a chloride compound and elemental bromine. The following equation is an example of the reaction:

   $2KBr(aq) + Cl_2(aq) \rightarrow 2KCl(aq) + Br_2(l)$

   (a) When 0.855g of Cl_2 and 3.205g of KBr are mixed in solution, which is the limiting reactant?

$$\frac{0.855\,\cancel{g\,Cl_2}}{} \cdot \frac{1\,\cancel{mol\,Cl_2}}{71\,\cancel{g\,Cl_2}} \cdot \frac{2\,\cancel{mol\,KCl}}{1\,\cancel{mol\,Cl_2}} \cdot \frac{74.6\,g\,KCl}{1\,\cancel{mol\,KCl}} = 1.80\,g\,KCl$$

LR

$$\frac{3.205\,\cancel{g\,KBr}}{} \cdot \frac{1\,\cancel{mol\,KBr}}{119\,\cancel{g\,KBr}} \cdot \frac{2\,\cancel{mol\,KCl}}{2\,mol\,KBr} \cdot \frac{74.6\,g\,KCl}{1\,\cancel{mol\,KCl}} = 2.01\,g\,KCl$$

ER

Limiting Reactant = Cl_2

   (b) How many grams of each product are formed?

(Use Limiting Reactant now that we know it is Cl_2)

$$\frac{0.855\,\cancel{g\,Cl_2}}{} \cdot \frac{1\,\cancel{mol\,Cl_2}}{71\,\cancel{g\,Cl_2}} \cdot \frac{1\,\cancel{mol\,Br_2}}{1\,\cancel{mol\,Cl_2}} \cdot \frac{159.8\,g\,Br_2}{1\,\cancel{mol\,Br_2}} = 1.92\,g\,Br_2$$

Masses of each product based on the limiting reactant: 1.80 g KCl & 1.92 g Br_2

Excess Reactant = KBr

   (c) How many grams of the excess reactant remain after the reaction is complete?

g LR used → g ER used

$$\frac{0.855\,\cancel{g\,Cl_2}}{} \cdot \frac{1\,\cancel{mol\,Cl_2}}{71\,\cancel{g\,Cl_2}} \cdot \frac{2\,\cancel{mol\,KBr}}{1\,mol\,Cl_2} \cdot \frac{119\,g\,KBr}{1\,\cancel{mol\,KBr}}$$

= 2.87 g KBr used

HAD − USED:

3.205 g − 2.87 g = 0.335 g KBr left over

2. A process by which zirconium metal can be produced from the mineral zirconium (IV) orthosilicate, $ZrSiO_4$, starts by reacting it with chlorine gas to form zirconium (IV) chloride.

   $ZrSiO_4 + 2Cl_2 \rightarrow ZrCl_4 + SiO_2 + O_2$

   What mass of $ZrCl_4$ can be produced if 862g of $ZrSiO_4$ and 950.g of Cl_2 are available? (You must first determine limiting reactant).

$$\frac{862\,\cancel{g\,ZrSiO_4}}{} \cdot \frac{1\,\cancel{mol\,ZrSiO_4}}{183.3\,\cancel{g\,ZrSiO_4}} \cdot \frac{1\,\cancel{mol\,ZrCl_4}}{1\,\cancel{mol\,ZrSiO_4}} \cdot \frac{233.2\,g\,ZrCl_4}{1\,\cancel{mol\,ZrCl_4}}$$

LR

= 1096.67 g $ZrCl_4$

$$\frac{950\,\cancel{g\,Cl_2}}{} \cdot \frac{1\,\cancel{mol\,Cl_2}}{71\,\cancel{g\,Cl_2}} \cdot \frac{1\,\cancel{mol\,ZrCl_4}}{2\,\cancel{mol\,Cl_2}} \cdot \frac{233.2\,g\,ZrCl_4}{1\,\cancel{mol\,ZrCl_4}}$$

ER

= 1560.14 g $ZrCl_4$

3. In the reaction $BaCO_3 + 2HNO_3 \rightarrow Ba(NO_3)_2 + CO_2 + H_2O$, what mass of $Ba(NO_3)_2$ can be formed by combining 55g $BaCO_3$ and 26g HNO_3?

$$\frac{55\ \cancel{g\ BaCO_3}}{} \times \frac{1\ \cancel{mol\ BaCO_3}}{197.3\ \cancel{g\ BaCO_3}} \times \frac{1\ \cancel{mol\ Ba(NO_3)_2}}{1\ \cancel{mol\ BaCO_3}} \times \frac{261.3\ g\ Ba(NO_3)_2}{1\ \cancel{mol\ Ba(NO_3)_2}}$$

ER

$$= 72.84\ g\ Ba(NO_3)_2$$

$$\frac{26\ \cancel{g\ HNO_3}}{} \times \frac{1\ \cancel{mol\ HNO_3}}{63\ \cancel{g\ HNO_3}} \times \frac{1\ \cancel{mol\ Ba(NO_3)_2}}{2\ \cancel{mol\ HNO_3}} \times \frac{261.3\ g\ Ba(NO_3)_2}{1\ \cancel{mol\ Ba(NO_3)_2}}$$

LR

$$= 53.92\ g\ Ba(NO_3)_2$$

4. Huge quantities of sulfur dioxide are produced from zinc sulfide by means of the following reaction.

$$2ZnS(s) + 3O_2(g) \rightarrow 2ZnO(s) + 2SO_2(g)$$

If the typical yield is 86.78%, how much SO_2 should be expected if 4897g of ZnS are used?

↳ solve for actual yield = X

$$\frac{4897\ \cancel{g\ ZnS}}{} \times \frac{1\ \cancel{mol\ ZnS}}{97.5\ \cancel{g\ ZnS}} \times \frac{2\ \cancel{mol\ SO_2}}{2\ \cancel{mol\ ZnS}} \times \frac{64.1\ g\ ZnS}{1\ \cancel{mol\ ZnS}} = 3219.46\ g\ SO_2$$

(theoretical yield)

$$86.78\% = \left(\frac{X}{3219.46\ g\ SO_2}\right) \times 100$$

$$(0.8678)(3219.46\ g\ SO_2) = X$$

$$2793.85\ g\ SO_2 = X = \text{actual yield.}$$

5. Aspirin, $C_9H_8O_4$, is synthesized by the reaction of salicylic acid, $C_7H_6O_3$, with acetic anhydride, $C_4H_6O_3$.

$$2C_7H_6O_3 + C_4H_6O_3 \rightarrow 2\ C_9H_8O_4 + H_2O$$

a. When 20.0 g of $C_7H_6O_3$ and 20.0g of $C_4H_6O_3$ react, What mass, in grams, of aspirin are formed, and which is the limiting reagent?

$$\frac{20.0\ \cancel{g\ C_7H_6O_3}}{} \times \frac{1\ \cancel{mol\ C_7H_6O_3}}{138\ \cancel{g\ C_7H_6O_3}} \times \frac{2\ \cancel{mol\ C_9H_8O_4}}{2\ \cancel{mol\ C_7H_6O_3}} \times \frac{180\ g\ C_9H_8O_4}{1\ \cancel{mol\ C_9H_8O_4}}$$

LR

$$= 26.09\ g\ C_9H_8O_4$$

$$\frac{20.0\ \cancel{g\ C_4H_6O_3}}{} \times \frac{1\ \cancel{mol\ C_4H_6O_3}}{102\ \cancel{g\ C_4H_6O_3}} \times \frac{2\ \cancel{mol\ C_9H_8O_4}}{1\ mol\ C_4H_6O_3} \times \frac{180\ g\ C_9H_8O_4}{1\ \cancel{mol\ C_9H_8O_4}}$$

ER

$$= 70.59\ g\ C_9H_8O_4$$

Limiting Reactant = $C_7H_6O_3$

6. Dichlorine monoxide, Cl_2O is sometimes used as a powerful chlorinating agent in research. It can be produced by passing chlorine gas over heated mercury (II) oxide according to the following equation:

$HgO + Cl_2 \rightarrow HgCl_2 + Cl_2O$

What is the percent yield, if the quantity of the reactants is sufficient to produce 0.86g of Cl_2O but only 0.71 g is obtained?

theoretical yield ← ↳ actual yield

$$\% \text{ yield} = \left(\frac{0.71 \text{ g } Cl_2O}{0.86 \text{ g } Cl_2O}\right) \times 100$$

$$82.56\%$$

7. In the commercial production of the element arsenic, arsenic(III) oxide is heated with carbon, which reduces the oxide to the metal according to the following equation:

$2As_2O_3 + 3C \rightarrow 3CO_2 + 4As$

a. If 8.87g of As_2O_3 is used in the reaction and 5.33 g of As is produced, what is the percent yield?

↳ actual yield

$$8.87 \text{ g } As_2O_3 \times \frac{1 \text{ mol } As_2O_3}{197.8 \text{ g } As_2O_3} \times \frac{4 \text{ mol } As}{2 \text{ mol } As_2O_3} \times \frac{74.9 \text{ g } As}{1 \text{ mol } As} = 6.72 \text{ g } As$$

(theoretical yield)

$$\% \text{ yield} = \left(\frac{5.33 \text{ g } As}{6.72 \text{ g } As}\right) \times 100$$

$$= 79.31\%$$

b. If 67 g of carbon is used up in a different reaction and 425g of As is produced, calculate the percent yield of this reaction.

$$67 \text{ g } C \times \frac{1 \text{ mol } C}{12 \text{ g } C} \times \frac{4 \text{ mol } As}{3 \text{ mol } C} \times \frac{74.9 \text{ g } As}{1 \text{ mol } As} = 557.59 \text{ g } As$$

(theoretical yield)

$$\% \text{ yield} = \left(\frac{425 \text{ g } As}{557.59 \text{ g } As}\right) \times 100$$

$$= 76.22\%$$

8. Assume that the following hypothetical reaction takes place.

$2A + 7B \rightarrow 4C + 3D$

Calculate the percent yield in each of the following cases:

a. The reaction of 0.0251 mol of A produces 0.0349 mol of C.

↳ actual yield

$$\frac{0.0251 \cancel{\text{mol A}} \mid 4 \text{ mol C}}{\mid 2 \cancel{\text{mol A}}} = 0.0502 \text{ mol C}$$

(theoretical yield)

$$\% \text{ yield} = \left(\frac{0.0349 \text{ mol}}{0.0502 \text{ mol}}\right) \times 100 = 69.52\%$$

b. The reaction of 1.19 mol of A produces 1.41 mol of D.

↳ actual yield

$$\frac{1.19 \cancel{\text{mol A}} \mid 3 \text{ mol D}}{\mid 2 \cancel{\text{mol A}}} = 1.785 \text{ mol D}$$

(theoretical yield)

$$\% \text{ yield} = \left(\frac{1.41 \text{ mol D}}{1.785 \text{ mol D}}\right) \times 100 = 78.99\%$$

c. The reaction of 189 mol of B produces 39 mol of D.

↳ actual yield

$$\frac{189 \cancel{\text{mol B}} \mid 3 \text{ mol D}}{\mid 7 \cancel{\text{mol B}}} = 81 \text{ mol D}$$

(theoretical yield)

$$\% \text{ yield} = \left(\frac{39 \text{ mol D}}{81 \text{ mol D}}\right) \times 100 = 48.15\%$$

d. The reaction of 3500 mol of B produces 1700 mol of C.

↳ actual yield

$$\frac{3500 \cancel{\text{mol B}} \mid 4 \text{ mol C}}{\mid 7 \cancel{\text{mol B}}} = 2000 \text{ mol C}$$

(theoretical yield)

$$\% \text{ yield} = \left(\frac{1700 \text{ mol C}}{2000 \text{ mol C}}\right) \times 100 = 85\%$$