

## Stoichiometry Worksheet

### I. ONE REACTANT IN EXCESS – COMBUSTION

You burn an excess of butane (C<sub>4</sub>H<sub>10</sub>) in a limited amount of oxygen (O<sub>2</sub>). If 67.2 L of CO<sub>2</sub> gas is formed, what volume of oxygen gas was present at the start of the reaction?

STEP 1: Balance the reaction:



STEP 2: Use a molar conversion to convert quantity of product given to moles:

$$67.2 \text{ L CO}_2 * \frac{(1 \text{ mol CO}_2)}{(22.4 \text{ L CO}_2)} = 3 \text{ mol CO}_2$$

STEP 3: Use a molar ratio to calculate the moles of reactant that I'm asking about:

$$3 \text{ mol CO}_2 * \frac{(13 \text{ mol O}_2)}{(8 \text{ mol CO}_2)} = 4.875 \text{ mol O}_2$$

STEP 4: Use a molar conversion to convert moles of reactant to the units I ask for:

$$4.875 \text{ mol O}_2 \frac{(22.4 \text{ L O}_2)}{(1 \text{ mol O}_2)} = 109.2 \text{ L O}_2 = \boxed{109 \text{ L O}_2}$$

### II. ONE REACTANT IN EXCESS – SINGLE DISPLACEMENT

14 g of lithium is combined with excess K<sub>2</sub>SO<sub>4</sub>. What is the mass of the new ionic compound that is formed? How do you know that this reaction will take place?

STEP I: Balance the reaction:



Reaction occurs because Li is higher up than K on the activity series.

STEP 2: Use a molar conversion to convert quantity of reactant given to moles:

$$14 \text{ g Li} * \frac{(1 \text{ mol Li})}{(7 \text{ g Li})} = 2 \text{ mol Li}$$

STEP 3: Use a molar ratio to calculate moles of product that I'm asking about:

$$2 \text{ mol Li} * \frac{(1 \text{ mol Li}_2\text{SO}_4)}{(2 \text{ mol Li})} = 1 \text{ mol Li}_2\text{SO}_4$$

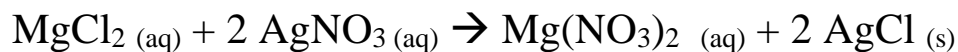
STEP 4: Use a molar conversion to convert moles of product to units that I ask for:

$$1 \text{ mol Li}_2\text{SO}_4 * \frac{(110 \text{ g Li}_2\text{SO}_4)}{(1 \text{ mol Li}_2\text{SO}_4)} = \boxed{110 \text{ Li}_2\text{SO}_4}$$

### III. ONE REACTANT IN EXCESS – DOUBLE DISPLACEMENT

You combine 50.0 mL of a 20.0 M solution of  $\text{MgCl}_2$  with excess  $\text{AgNO}_3$  solution. What is the mass of solid precipitate that is formed? How do you know that this reaction will happen?

STEP 1: Balance the reaction. Show which compounds are (aq) and which are (s).



STEP 2: Use a molar conversion to convert the quantity of reactant given to moles:

$$50 \text{ mL of } 20\text{M MgCl}_2 = 0.05 \text{ L of } 20\text{M MgCl}_2$$

$$0.05 \text{ L} * \frac{(20 \text{ mol MgCl}_2)}{(1 \text{ L})} = 1 \text{ mol MgCl}_2$$

STEP 3: Use a molar ratio to convert moles of reactant to moles of product I'm asking about:

$$1 \text{ mol MgCl}_2 * \frac{(2 \text{ mol AgCl})}{(1 \text{ mol MgCl}_2)} = 2 \text{ mol AgCl}$$

STEP 4: Use a molar conversion to convert moles of product to the units that I ask for:

$$2 \text{ mol AgCl} \frac{(143 \text{ g AgCl})}{(1 \text{ mol AgCl})} = \boxed{248 \text{ g AgCl}}$$

#### IV. FIND LIMITING REACTANT – COMBUSTION

You burn 35.2 g pentanol (C<sub>5</sub>H<sub>12</sub>O) in 44.8 L of oxygen gas (O<sub>2</sub>) at STP. What is the volume of water vapor formed?

STEP 1: Balance the reaction:



STEP 2a & 2b: Use molar conversions to convert the quantities of reactants given to moles of reactants:

$$\mathbf{2a:} \quad 35.2 \text{ g C}_5\text{H}_{12}\text{O} \left( \frac{1 \text{ mol C}_5\text{H}_{12}\text{O}}{88 \text{ g C}_5\text{H}_{12}\text{O}} \right) = 0.4 \text{ mol C}_5\text{H}_{12}\text{O}$$

$$\mathbf{2b:} \quad 44.8 \text{ L O}_2 \left( \frac{1 \text{ mol O}_2}{22.4 \text{ L O}_2} \right) = \boxed{2 \text{ mol O}_2} \leftarrow \text{limiting reactant}$$

STEP 3a: Use your first molar ratio to determine which reactant is limiting. Once you have figured this out, go back and circle the limiting reactant in step 2.

$$\text{Pick } 0.4 \text{ mol C}_5\text{H}_{12}\text{O} \left( \frac{15 \text{ mol O}_2}{2 \text{ mol C}_5\text{H}_{12}\text{O}} \right) = 3 \text{ mol O}_2 \text{ are needed to react fully with } 0.4 \text{ mol C}_5\text{H}_{12}\text{O}$$

$$\text{or pick } 2 \text{ mol O}_2 \left( \frac{2 \text{ mol C}_5\text{H}_{12}\text{O}}{15 \text{ mol O}_2} \right) = 0.267 \text{ mol C}_5\text{H}_{12}\text{O} \text{ are needed to react fully with } 2 \text{ mol O}_2$$

STEP 3b: Now that you know which is limiting reactant, use your second molar ratio to determine how much of the product that I'm asking about will form.

$$2 \text{ mol O}_2 \left( \frac{12 \text{ mol H}_2\text{O}}{15 \text{ mol O}_2} \right) = 1.6 \text{ mol H}_2\text{O}$$

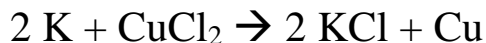
STEP 4: Use a molar conversion to convert moles of product to the units that I ask for:

$$1.6 \text{ mol H}_2\text{O} \left( \frac{22.4 \text{ L H}_2\text{O}}{1 \text{ mol H}_2\text{O}} \right) = 35.84 \text{ L H}_2\text{O gas} = \boxed{35.8 \text{ L H}_2\text{O gas}}$$

## V. FIND LIMITING REACTANT – SINGLE DISPLACEMENT

You heat 54.6 g of Potassium (K) with 107.2 g copper (II) chloride (CuCl<sub>2</sub>). What is the mass of the new ionic compound that will form? How do you know this reaction will happen?

STEP 1: Balance the reaction:



Reaction will occur because K is higher up than Cu on the activity series.

STEP 2a & 2b: Use molar conversions to convert the quantities of reactants given to moles of reactants:

$$\mathbf{2a:} \quad 54.6 \text{ g K} \quad \left( \frac{1 \text{ mol K}}{39 \text{ g K}} \right) = \boxed{1.4 \text{ mol K}} \leftarrow \text{limiting reactant}$$

$$\mathbf{2b:} \quad 107.2 \text{ g CuCl}_2 \quad \left( \frac{1 \text{ mol CuCl}_2}{134 \text{ g CuCl}_2} \right) = 0.8 \text{ mol CuCl}_2$$

STEP 3a: Use your first molar ratio to determine which is the limiting reactant. Once you figure this out, go back and circle the amount of limiting reactant that you have from step 2.

$$\text{Pick } 1.4 \text{ mol K} \quad \left( \frac{1 \text{ mol CuCl}_2}{2 \text{ mol K}} \right) = 0.7 \text{ mol CuCl}_2 \text{ needed to react fully with } 1.4 \text{ mol K}$$

$$\text{Or pick } 0.8 \text{ mol CuCl}_2 \quad \left( \frac{2 \text{ mol K}}{1 \text{ mol CuCl}_2} \right) = 1.6 \text{ mol K needed to react fully with } 0.8 \text{ mol CuCl}_2$$

STEP 3b: Now that you know which is limiting reactant, use your second molar ratio to determine how much of the product that I'm asking about will form.

$$1.4 \text{ mol K} \quad \left( \frac{2 \text{ mol KCl}}{1 \text{ mol K}} \right) = 2.8 \text{ mol KCl}$$

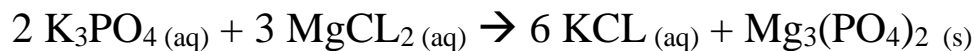
STEP 4: Use a molar conversion to convert moles of product to the units that I ask for:

$$2.8 \text{ mol KCl} \quad \left( \frac{75 \text{ g KCl}}{1 \text{ mol KCl}} \right) = 210 \text{ g KCl} = \boxed{2.10 \times 10^2 \text{ g KCl}}$$

## V. FIND LIMITING REACTANT – DOUBLE DISPLACEMENT

You combine 250 mL of a 4.00 M solution of  $K_3PO_4$  with 50.0 mL of a solution of 10.0 M  $MgCl_2$ . What is the mass of precipitate that is formed? How do you know that a reaction has occurred?

STEP 1: Balance the reaction:



Reaction will occur because ionic compounds of  $Mg^{2+}$  and  $PO_4^{3-}$  are insoluble. Therefore a phase change has occurred from when these ions were in soluble compounds ( $Mg^{2+}$  with  $Cl^-$  and  $PO_4^{3-}$  with  $K^+$ ). Find this information on your solubility chart.

STEP 2a & 2b: Use molar conversions to convert the quantities of reactants given to moles of reactants:

$$\mathbf{2a:} \quad 250 \text{ mL } K_3PO_4 (aq) \quad \frac{(1 \text{ L})}{(10^3 \text{ mL})} * \frac{(4 \text{ moles})}{(1 \text{ L})} = 1 \text{ mol } K_3PO_4$$

$$\mathbf{2b:} \quad 50 \text{ mL } MgCl_2 (aq) \quad \frac{(1 \text{ L})}{(10^3 \text{ mL})} * \frac{(10 \text{ moles})}{(1 \text{ L})} = \boxed{0.5 \text{ mol } MgCl_2} \leftarrow \text{limiting reactant}$$

STEP 3a: Use your first molar ratio to determine which is the limiting reactant. Once you figure this out, go back and circle the amount of limiting reactant that you have from step 2.

$$\text{Pick } 0.5 \text{ mol } MgCl_2 \quad \frac{(2 \text{ mol } K_3PO_4)}{(3 \text{ mol } MgCl_2)} = 0.333 \text{ mol } K_3PO_4 \text{ needed to react fully with } 0.5 \text{ mol } MgCl_2$$

$$\text{Or pick } 1 \text{ mol } K_3PO_4 \quad \frac{(3 \text{ mol } MgCl_2)}{(2 \text{ mol } K_3PO_4)} = 1.5 \text{ mol } MgCl_2 \text{ needed to react fully with } 1 \text{ mol } K_3PO_4$$

STEP 3b: Now that you know which is limiting reactant, use your second molar ratio to determine how much of the product that I'm asking about will form.

$$0.5 \text{ mol } MgCl_2 \quad \frac{(1 \text{ mol } Mg_3(PO_4)_2)}{(3 \text{ mol } MgCl_2)} = 0.167 \text{ mol } Mg_3(PO_4)_2$$

STEP 4: Use a molar conversion to convert moles of product to the units that I ask for:

$$0.167 \text{ mol } Mg_3(PO_4)_2 \quad \frac{(265 \text{ g } Mg_3(PO_4)_2)}{(1 \text{ mol } Mg_3(PO_4)_2)} = 44.24 \text{ g } Mg_3(PO_4)_2 = \boxed{44 \text{ g } Mg_3(PO_4)_2}$$