

Stoichiometry

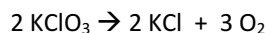
Name _____

Period _____

Unit 6 – Worksheet 1 (Goal 1 - 2)

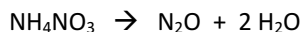
1. For each of the following reactions, solve the problem:

- a. How many moles of $KClO_3$ are needed to produce 0.366 moles of O_2 ?



$$0.366 \text{ mol } O_2 \left(\frac{2 \text{ mol } KClO_3}{3 \text{ mol } O_2} \right) = 0.244 \text{ mol } KClO_3$$

- b. How many moles of H_2O are produced from 9.45 moles of NH_4NO_3 ?



$$9.45 \text{ mol } NH_4NO_3 \left(\frac{2 \text{ mol } H_2O}{1 \text{ mol } NH_4NO_3} \right) = 18.9 \text{ mol } H_2O$$

2. Aluminum sulfate, $Al_2(SO_4)_3$ is used in fireproofing fabrics and the manufacture of antiperspirants.



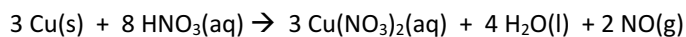
- a. How many moles of $Al_2(SO_4)_3$ would be produced if 6 mol of H_2SO_4 reacted with excess Al_2O_3 ?

$$6 \text{ mol } H_2SO_4 \left(\frac{1 \text{ mol } Al_2(SO_4)_3}{3 \text{ mol } H_2SO_4} \right) = 2 \text{ mol } Al_2(SO_4)_3$$

- b. How many moles of Al_2O_3 are required to make 2 mol of H_2O ?

$$2 \text{ mol } H_2O \left(\frac{1 \text{ mol } Al_2O_3}{3 \text{ mol } H_2O} \right) = 0.7 \text{ mol } Al_2O_3$$

3. Copper (II) nitrate, $\text{Cu}(\text{NO}_3)_2$, is used to give a dark finish to items made of copper metal, making them appear antique. Using the balanced equation, complete the following table:



Equation	Cu	HNO_3	$\text{Cu}(\text{NO}_3)_2$	H_2O	NO
# of moles	3	8	3	4	2
Molar Mass	63.6 g/mol	63.0 g/mol	187.6 g/mol	18.0 g/mol	30.0 g/mol
Total Mass	3 x molar mass 191 g	8 x molar mass 504 g	3 x molar mass 563 g	4 x molar mass 72 g	2 x molar mass 60 g
State of Matter	Solid	Aqueous	Aqueous	Liquid	Gas

What is the total mass of the reactants? 695 g

What is the total mass of the products? 695 g

What law does the comparison of the mass of the reactants and products follow?

Conservation of Mass

Make sure each equation is BALANCED before working on the Stoichiometry problem!

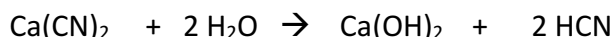
1. "Baking Powder" consists of a mixture of "Baking Soda" (sodium bicarbonate, NaHCO_3) and some solid acid so that the moistened mixture will react to form CO_2 gas. When sodium dihydrogen phosphate, NaH_2PO_4 , is used in this reaction, the following reaction occurs,



What mass of sodium dihydrogen phosphate (NaH_2PO_4) must be used to completely react with 0.65 mole of "baking soda."

$$0.65 \text{ mol NaHCO}_3 \left(\frac{1 \text{ mol NaH}_2\text{PO}_4}{1 \text{ mol NaHCO}_3} \right) \left(\frac{120.0 \text{ g NaH}_2\text{PO}_4}{1 \text{ mol NaH}_2\text{PO}_4} \right) = 78 \text{ g NaH}_2\text{PO}_4$$

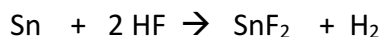
2. Calcium cyanide powder is used by beekeepers to destroy a colony of diseased bees. This powder must be stored in a closed container, since moist air decomposes it, according to the equation:



Determine the number of moles of water needed to liberate 94.5g of HCN gas.

$$94.5 \text{ g HCN} \left(\frac{1 \text{ mol HCN}}{27.0 \text{ g HCN}} \right) \left(\frac{2 \text{ mol H}_2\text{O}}{2 \text{ mol HCN}} \right) = 3.50 \text{ mol H}_2\text{O}$$

3. Stannous flouride is a common toothpaste additive as a source of flourideion for retarding tooth decay. It may be manufactured from tin and dry hydrogen flouride gas:



If 31.4g of SnF_2 are to be produced what mass of hydrogen gas will be liberated?

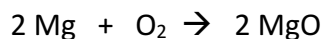
$$31.4 \text{ g SnF}_2 \left(\frac{1 \text{ mol SnF}_2}{156.7 \text{ g SnF}_2} \right) \left(\frac{1 \text{ mol H}_2}{1 \text{ mol SnF}_2} \right) \left(\frac{2.0 \text{ g H}_2}{1 \text{ mol H}_2} \right) = 0.401 \text{ g H}_2$$

4. "Fools gold" is pyrite ore, and it contains beautiful crystals of FeS_2 . This is also a source of iron metal, and so is somewhat valuable although it isn't gold. How many grams of this ore must be used to obtain 255 kg of pure iron?



$$255 \text{ kg Fe} \left(\frac{1,000 \text{ g Fe}}{1 \text{ kg Fe}} \right) \left(\frac{1 \text{ mol Fe}}{55.9 \text{ g Fe}} \right) \left(\frac{4 \text{ mol FeS}_2}{4 \text{ mol Fe}} \right) \left(\frac{120.0 \text{ g FeS}_2}{1 \text{ mol FeS}_2} \right) = 5.48 \times 10^5 \text{ g FeS}_2$$

5. How many moles of oxygen are required to produce 242 grams of MgO, magnesium oxide?



$$242 \text{ g MgO} \left(\frac{1 \text{ mol MgO}}{40.3 \text{ g MgO}} \right) \left(\frac{1 \text{ mol O}_2}{2 \text{ mol MgO}} \right) = 3.00 \text{ mol O}_2$$

6. Welders use the reaction of Acetylene (C₂H₂) and Oxygen (O₂) to provide energy for their welds. The equation for the reaction is:



What volume of Oxygen (O₂) will be required to burn 52 grams of Acetylene (C₂H₂)?

$$52 \text{ g C}_2\text{H}_2 \left(\frac{1 \text{ mol C}_2\text{H}_2}{26.0 \text{ g C}_2\text{H}_2} \right) \left(\frac{5 \text{ mol O}_2}{2 \text{ mol C}_2\text{H}_2} \right) \left(\frac{22.4 \text{ L O}_2}{1 \text{ mol O}_2} \right) = 110 \text{ L O}_2$$

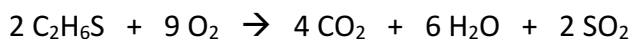
7. Silicon Carbide is one of the hardest substances known to man. It is used extensively in sharpening stones and other tools. Silicon Carbide (SiC) is made by the following reaction.



What mass of carbon C is required to produce 5.0 grams of Silicon Carbide?

$$5.0 \text{ g SiC} \left(\frac{1 \text{ mol SiC}}{40.1 \text{ g SiC}} \right) \left(\frac{3 \text{ mol C}}{1 \text{ mol SiC}} \right) \left(\frac{12.0 \text{ g C}}{1 \text{ mol C}} \right) = 4.5 \text{ g C}$$

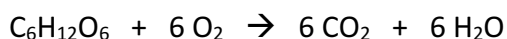
8. The odorous compound Dimethyl Mercaptan (C₂H₆S) is burned to Sulfur Dioxide (SO₂).



What volume of Sulfur Dioxide (SO₂) is produced by each 1.000 kg of Dimethyl Mercaptan (C₂H₆S) burned?

$$1.000 \text{ kg C}_2\text{H}_6\text{S} \left(\frac{1,000 \text{ g C}_2\text{H}_6\text{S}}{1 \text{ kg C}_2\text{H}_6\text{S}} \right) \left(\frac{1 \text{ mol C}_2\text{H}_6\text{S}}{62.1 \text{ g C}_2\text{H}_6\text{S}} \right) \left(\frac{2 \text{ mol SO}_2}{2 \text{ mol C}_2\text{H}_6\text{S}} \right) \left(\frac{22.4 \text{ L SO}_2}{1 \text{ mol SO}_2} \right) = 360.7 \text{ L SO}_2$$

9. An astronaut on the moon missions consumes 1.000 kg units of carbohydrates (C₆H₁₂O₆) per day. These react in his body as follows:



How many grams of Oxygen are required to sustain the astronaut each day?

$$1.000 \text{ kg } C_6H_{12}O_6 \left(\frac{1,000g \text{ } C_6H_{12}O_6}{1 \text{ kg } C_6H_{12}O_6} \right) \left(\frac{1 \text{ mol } C_6H_{12}O_6}{180.2 \text{ g } C_6H_{12}O_6} \right) \left(\frac{6 \text{ mol } O_2}{1 \text{ mol } C_6H_{12}O_6} \right) \left(\frac{32.0 \text{ g } O_2}{1 \text{ mol } O_2} \right) = 1,067 \text{ g } O_2$$

Use the following equation solve the next three stoichiometry problems:



10. What mass of water is needed to react with 7.30×10^{24} formula units of Li_3N ?

$$7.30 \times 10^{24} \text{ } Li_3N \text{ formula units} \left(\frac{1 \text{ mol } Li_3N}{6.02 \times 10^{23} \text{ } Li_3N \text{ formula units}} \right) \left(\frac{3 \text{ mol } H_2O}{1 \text{ mol } Li_3N} \right) \left(\frac{18.0 \text{ g } H_2O}{1 \text{ mol } H_2O} \right) = 655 \text{ g } H_2O$$

11. When 13.3 ml of NH_3 are produced how many formula units of $LiOH$ are also produced?

$$13.3 \text{ ml } NH_3 \left(\frac{1 \text{ L } NH_3}{1000 \text{ ml } NH_3} \right) \left(\frac{1 \text{ mol } NH_3}{22.4 \text{ L } NH_3} \right) \left(\frac{3 \text{ mol } LiOH}{1 \text{ mol } NH_3} \right) \left(\frac{6.02 \times 10^{23} \text{ } LiOH \text{ formula units}}{1 \text{ mol } LiOH} \right) \\ = 1.07 \times 10^{21} \text{ } LiOH \text{ formula units}$$

12. When 4.0×10^{12} molecules of water are used, how many grams of NH_3 are produced?

$$4.0 \times 10^{12} \text{ } H_2O \text{ molecules} \left(\frac{1 \text{ mol } H_2O}{6.02 \times 10^{23} \text{ } H_2O \text{ molecules}} \right) \left(\frac{1 \text{ mol } NH_3}{3 \text{ mol } H_2O} \right) \left(\frac{17.0 \text{ g } NH_3}{1 \text{ mol } NH_3} \right) = 3.8 \times 10^{-11} \text{ g } NH_3$$

Limiting Reagent and Percent Yield

Name _____

Period _____

Unit 6 – Worksheet 2 (Goals 3 – 6)

1. What is a Limiting Reagent?

The limiting reagent (or reactant) is the reactant that is consumed first in a chemical reaction. This reactant limits how much product can be formed.

2. What is an Excess Reagent?

The excess reagent (or reactant) is the reactant that remains after all of the limiting reagent has reacted.

3. When solving for an amount of a product formed by stoichiometry, which reagent should be used?

The limiting reagent must be used to perform stoichiometry because the limiting reagent limits how much product can be produced.

4. Actual Yield –

The actual yield is the amount of product produced and collected experimentally in a chemical reaction.

5. Theoretical Yield –

The theoretical yield is the maximum amount of product predicted by stoichiometric calculations.

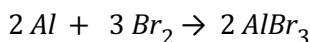
6. Percent Yield –

The percent yield calculated using the following relationship: $\frac{(\text{actual yield})}{(\text{theoretical yield})} \times 100\%$

Identify and use the limiting reagent in a reaction to calculate the maximum amount of product(s) produced and the amount of excess reagent.

7. Aluminum (Al) reacts with bromine (Br₂) in a combination reaction to form Aluminum bromide (AlBr₃).

a. Write the balanced equation for this reaction.



b. Identify the limiting reagent and calculate how many grams of product can be made from 2.2×10^{24} atoms of aluminum reacting with 500 grams of bromine?

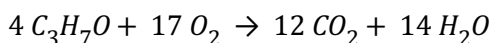
$$2.2 \times 10^{24} \text{ atoms Al} \left(\frac{1 \text{ mol Al}}{6.02 \times 10^{23} \text{ atoms Al}} \right) \left(\frac{3 \text{ mol Br}_2}{2 \text{ mol Al}} \right) \left(\frac{159.8 \text{ g Br}_2}{1 \text{ mol Br}_2} \right) = 876 \text{ g Br}_2$$

876 g Br₂ is GREATER than the actual 500 g of Br₂, so Br₂ is the LIMITING REAGENT

$$500 \text{ g Br}_2 \left(\frac{1 \text{ mol Br}_2}{159.8 \text{ g Br}_2} \right) \left(\frac{2 \text{ mol AlBr}_3}{3 \text{ mol Br}_2} \right) \left(\frac{266.68 \text{ g AlBr}_3}{1 \text{ mol AlBr}_3} \right) = 556 \text{ g AlBr}_3 \sim 600 \text{ g AlBr}_3$$

8. C₃H₇O completely combusts. (remember: H₂O and CO₂?)

a. Write the balanced equation for this reaction.



b. If 87 Liters of oxygen reacts with 87 grams of C₃H₇O find the limiting reagent. Then calculate the volume of carbon dioxide that can be produced (assume STP)?

$$87 \text{ L O}_2 \left(\frac{1 \text{ mol O}_2}{22.4 \text{ L O}_2} \right) \left(\frac{4 \text{ mol C}_3\text{H}_7\text{O}}{17 \text{ mol O}_2} \right) \left(\frac{59.10 \text{ g C}_3\text{H}_7\text{O}}{1 \text{ mol C}_3\text{H}_7\text{O}} \right) = 54 \text{ g C}_3\text{H}_7\text{O} < 87 \text{ g C}_3\text{H}_7\text{O}; \text{ O}_2 \text{ LIMITING}$$

$$87 \text{ L O}_2 \left(\frac{1 \text{ mol O}_2}{22.4 \text{ L O}_2} \right) \left(\frac{12 \text{ mol CO}_2}{17 \text{ mol O}_2} \right) \left(\frac{22.4 \text{ L CO}_2}{1 \text{ mol CO}_2} \right) = 61 \text{ L CO}_2$$

c. How many moles of excess reagent are left over, unused?

$$87 \text{ L O}_2 \left(\frac{1 \text{ mol O}_2}{22.4 \text{ L O}_2} \right) \left(\frac{4 \text{ mol C}_3\text{H}_7\text{O}}{17 \text{ mol O}_2} \right) = 0.91 \text{ mol C}_3\text{H}_7\text{O}$$

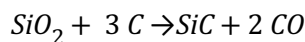
$$87 \text{ g C}_3\text{H}_7\text{O} \left(\frac{1 \text{ mol C}_3\text{H}_7\text{O}}{59.10 \text{ g C}_3\text{H}_7\text{O}} \right) = 1.5 \text{ mol C}_3\text{H}_7\text{O}$$

$$1.5 \text{ mol C}_3\text{H}_7\text{O} - 0.91 \text{ mol C}_3\text{H}_7\text{O} = 0.6 \text{ mol C}_3\text{H}_7\text{O}$$

Calculate the theoretical yield, actual yield, or percent yield given appropriate information.

9. Silicon dioxide reacts with carbon to produce silicon carbide (SiC) and carbon monoxide.

a. Write the balanced equation for this reaction.



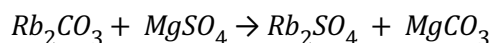
b. If 75 grams of silicon dioxide is heated with excess of carbon, 31.9 grams of silicon carbide is produced. What is the percent yield of this reaction?

$$75 \text{ g SiO}_2 \left(\frac{1 \text{ mol SiO}_2}{60.09 \text{ g SiO}_2} \right) \left(\frac{1 \text{ mol SiC}}{1 \text{ mol SiO}_2} \right) \left(\frac{40.10 \text{ g SiC}}{1 \text{ mol SiC}} \right) = 50 \text{ g SiC}$$

$$\% \text{ Yield} = \frac{31.9 \text{ g SiC}}{50 \text{ g SiC}} \times 100 \% = 64 \%$$

10. A solution of rubidium carbonate reacts with aqueous magnesium sulfate in a double replacement reaction. Magnesium carbonate is not soluble.

a. Write the balanced equation for this reaction.



b. If the reaction proceeds with an 87% yield, how many grams of precipitate are collected when 12 grams of magnesium sulfate reacts with excess rubidium carbonate?

$$12 \text{ g MgSO}_4 \left(\frac{1 \text{ mol MgSO}_4}{120.38 \text{ g MgSO}_4} \right) \left(\frac{1 \text{ mol MgCO}_3}{1 \text{ mol MgSO}_4} \right) \left(\frac{84.32 \text{ g MgCO}_3}{1 \text{ mol MgCO}_3} \right) = 8.4 \text{ g MgCO}_3$$

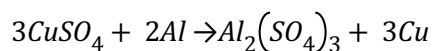
$$\left(\frac{87}{100} \right) \times 8.4 \text{ g MgCO}_3 = 7.3 \text{ g MgCO}_3$$

c. How many formula units of rubidium carbonate are consumed when the reaction from part b proceeds?

$$12 \text{ g MgSO}_4 \left(\frac{1 \text{ mol MgSO}_4}{120.38 \text{ g MgSO}_4} \right) \left(\frac{1 \text{ mol Rb}_2\text{CO}_3}{1 \text{ mol MgSO}_4} \right) \left(\frac{6.02 \times 10^{23} \text{ formula units Rb}_2\text{CO}_3}{1 \text{ mol Rb}_2\text{CO}_3} \right) = 6.0 \times 10^{22} \text{ Formula units Rb}_2\text{CO}_3$$

Calculate the % yield of experimental data after identifying the limiting reagent.

11. Write the complete balanced equation for the single replacement reaction between a solution of copper (II) sulfate, CuSO_4 and the element aluminum, Al.



You dissolve 25.0 grams of copper (II) sulfate, then react it with 5.0 grams of aluminum. Upon collecting the copper produced, you dry it and determine the collected copper's mass to be 9.0 grams.

- a. Show your work, and also explain how you know which reactant was the limiting reagent and which was in excess.

$$25.0 \text{ g CuSO}_4 \left(\frac{1 \text{ mol CuSO}_4}{159.62 \text{ g CuSO}_4} \right) \left(\frac{2 \text{ mol Al}}{3 \text{ mol CuSO}_4} \right) \left(\frac{26.98 \text{ g Al}}{1 \text{ mol Al}} \right) = 2.82 \text{ g Al}$$

$< 5.0 \text{ g Al}$; CuSO_4 LIMITING; Al Excess

- b. Show your work for calculating the % yield of this experiment.

$$25.0 \text{ g CuSO}_4 \left| \frac{1 \text{ mol CuSO}_4}{159.62 \text{ g CuSO}_4} \right| \left| \frac{3 \text{ mol Cu}}{3 \text{ mol CuSO}_4} \right| \left| \frac{63.55 \text{ g Cu}}{1 \text{ mol Cu}} \right| = 9.95 \text{ g Cu}$$

$$\% \text{ Yield} = \left(\frac{9.0 \text{ g Cu}}{9.95 \text{ g Cu}} \right) \times 100 \% = 90. \%$$

- c. How many grams of copper (II) sulfate went unreacted?

Trick Question: NONE – Copper (II) sulfate was the LIMITING reagent. All of it reacted!