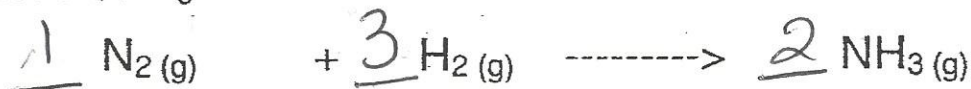


Stoichiometry (Mole Relationships)

Chemical reactions are like recipes - two of these, one of those make 4 servings - and so on. If you want the recipe to come out right you need start with the right ratio of ingredients. You can make a bigger or smaller recipe, but you have to keep the ratios the same. Otherwise, you'll get a gloppy cake or a sour cookie. As you work through the following questions, keep the idea of a recipe in mind.

Balance the following reaction:



Using conversions, fill in the following table:

Situation	N ₂	H ₂	NH ₃	Ratio of all three
For a single "recipe" how many molecules would you need or make?	1	3	2	1:3:2
If you made the "recipe" one hundred times, how many molecules would you need or make?	100	300	200	1:3:2
If you made the "recipe" 538 times, how many molecules would you need or make?	538	1614	1076	1:3:2
If you made the "recipe" a mole number of times, how many molecules would you need or make?	6.02×10^{23}	1.8×10^{24}	1.204×10^{23}	1:3:2
Since its hard to count molecules, how many moles of each would you need or make for the previous situation?	1	3	2	1:3:2
Since these are all gases, it may be easier to use volumes to measure out ingredients?	22.4	67.2	44.8	1:3:2
Or, maybe we could use masses to find how much we need or will make?	28	6	34	14:3:17

1 (N₂) → 28

x 2

x 17

What did you find to be true about the mole ratios in your table? Do they always hold true? Explain mathematically why or why not. Compare them to the coefficients in your equation.

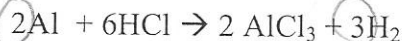
As you saw in the previous exercise, we can use the mole ratios of a balanced equation to predict how much reactant we will need (like making a grocery list for a party), or how much product we can make (when you can't go to the store, what is the maximum amount you can cook).

STOICHIOMETRY WORKSHEET #1

MOLE-MOLE CALCULATIONS

Name: _____

Sample Problems:

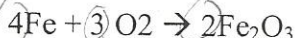


1. In the reaction above, if 0.5 moles of Al reacts,

- a. How many moles of H_2 are produced? b. How many moles of HCl are needed?

$$\frac{.5 \text{ mol Al} \quad 3 \text{ mol H}_2}{2 \text{ mol Al}} = .75 \text{ mole H}_2$$

$$\frac{.5 \text{ mol Al} \quad 6 \text{ mol HCl}}{2 \text{ mol Al}} = 1.5 \text{ mol HCl}$$



2. In the above reaction, if 0.75 moles of Fe reacts,

- a. How many moles of O_2 are needed? b. How many moles of Fe_2O_3 are produced?

$$\frac{.75 \text{ mol Fe} \quad 3 \text{ mol Fe}}{4 \text{ mol Fe}} = 0.5625 \text{ mol Fe}$$

$$\frac{.75 \text{ mol Fe} \quad 2 \text{ mol Fe}_2\text{O}_3}{4 \text{ mol Fe}} = .375 \text{ mol Fe}_2\text{O}_3$$

c. How many grams of Fe_2O_3 is this?

$$\frac{.75 \text{ mol Fe} \quad 2 \text{ mol Fe}_2\text{O}_3 \quad 159.6 \text{ g Fe}_2\text{O}_3}{4 \text{ mol Fe} \quad 1 \text{ mol Fe}_2\text{O}_3} = 59.85 \text{ g Fe}_2\text{O}_3$$

*Fe 2(55.8) = 111.6
O 3(16) = 48
159.6*

d. If 10.0 grams of Fe react, how many moles of O_2 will be needed?

$$\frac{10 \text{ g Fe} \quad 1 \text{ mole Fe} \quad 3 \text{ mol O}_2}{55.8 \text{ g Fe} \quad 4 \text{ mole Fe}} = .134 \text{ mol O}_2$$

Homework Problems:



3. In the above reaction, if 0.75 moles of C_2H_4 reacts,

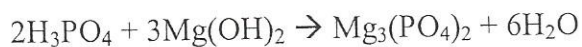
- a. How many moles of CO_2 are produced? b. How many moles of O_2 are also needed?

$$\frac{.75 \text{ mole C}_2\text{H}_4 \quad 2 \text{ mol CO}_2}{1 \text{ mol C}_2\text{H}_4} = 1.5 \text{ mol CO}_2$$

$$\frac{.75 \text{ mol C}_2\text{H}_4 \quad 3 \text{ mol O}_2}{1 \text{ mol C}_2\text{H}_4} = 2.25 \text{ mol O}_2$$

2.25 mol O_2

See pg. N-1 and N-2 for help



4. In the above reaction, if 0.42 moles of $\text{Mg}(\text{OH})_2$ reacts,

a. How many moles of H_3PO_4 react?

$$\frac{0.42 \text{ mol Mg}(\text{OH})_2}{3 \text{ mol Mg}(\text{OH})_2} \times \frac{2 \text{ mol H}_3\text{PO}_4}{1 \text{ mol Mg}(\text{OH})_2} = 0.28 \text{ mol H}_3\text{PO}_4$$

b. How many moles of water are formed?

$$\frac{0.42 \text{ moles Mg}(\text{OH})_2}{3 \text{ moles Mg}(\text{OH})_2} \times \frac{6 \text{ moles H}_2\text{O}}{1 \text{ mol Mg}(\text{OH})_2} = 0.84 \text{ mol H}_2\text{O}$$

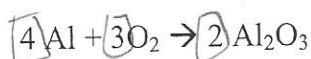
c. How many moles of $\text{Mg}_3(\text{PO}_4)_2$ are made?

$$\frac{0.42 \text{ mole Mg}(\text{OH})_2}{3 \text{ mol Mg}(\text{OH})_2} \times \frac{1 \text{ mol Mg}_3(\text{PO}_4)_2}{1 \text{ mol Mg}(\text{OH})_2} = 0.14 \text{ mol Mg}_3(\text{PO}_4)_2$$

d. How many grams of $\text{Mg}_3(\text{PO}_4)_2$ is this?

$$\frac{0.42 \text{ mol Mg}(\text{OH})_2}{3 \text{ mol Mg}(\text{OH})_2} \times \frac{1 \text{ mol Mg}_3(\text{PO}_4)_2}{1 \text{ mol Mg}(\text{OH})_2} \times \frac{262.9 \text{ g Mg}_3(\text{PO}_4)_2}{1 \text{ mol Mg}_3(\text{PO}_4)_2} = 36.80 \text{ g Mg}_3(\text{PO}_4)_2$$

$\text{Mg } 3(24.3) =$
 $\text{P } 2(31) =$
 $\text{O } 8(16) =$
 262.9



5. In the above reaction, if 2.3 moles of Al_2O_3 are produced,

a. How many moles of O_2 are needed?

$$\frac{2.3 \text{ mole Al}_2\text{O}_3}{2 \text{ mol Al}_2\text{O}_3} \times \frac{3 \text{ mol O}_2}{1 \text{ mol Al}_2\text{O}_3} = 3.45 \text{ mol O}_2$$

b. How many moles of Al are needed?

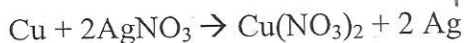
$$\frac{2.3 \text{ mol Al}_2\text{O}_3}{2 \text{ mol Al}_2\text{O}_3} \times \frac{4 \text{ mol Al}}{1 \text{ mol Al}_2\text{O}_3} = 4.6 \text{ mol Al}$$

c. How many grams of Al is this?

$$\frac{2.3 \text{ mol Al}_2\text{O}_3}{2 \text{ mol Al}_2\text{O}_3} \times \frac{4 \text{ mol Al}}{1 \text{ mol Al}_2\text{O}_3} \times \frac{27 \text{ g Al}}{1 \text{ mol Al}} = 124.2 \text{ g Al}$$

d. if 5.0 g grams of Al react, how many moles of O_2 are needed?

$$\frac{5 \text{ g Al}}{27 \text{ g Al}} \times \frac{1 \text{ mol Al}}{1 \text{ mol Al}} \times \frac{3 \text{ mol O}_2}{4 \text{ mol Al}} = 0.138 \text{ mol O}_2$$



6. In the above reaction, if 0.15 moles of AgNO_3 reacts,

a. How many moles of copper will react?

$$\frac{0.15 \text{ mol AgNO}_3}{2 \text{ mol AgNO}_3} \times \frac{1 \text{ mol Cu}}{1 \text{ mol AgNO}_3} = 0.075 \text{ mol Cu}$$

b. How many moles of silver will there be?

$$\frac{0.15 \text{ mol AgNO}_3}{2 \text{ mol AgNO}_3} \times \frac{2 \text{ mol Ag}}{1 \text{ mol AgNO}_3} = 0.15 \text{ mol Ag}$$

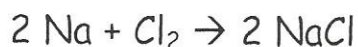
c. How many grams of silver is this?

$$\frac{0.15 \text{ mol AgNO}_3}{2 \text{ mol AgNO}_3} \times \frac{2 \text{ mol Ag}}{1 \text{ mol AgNO}_3} \times \frac{107.9 \text{ g Ag}}{1 \text{ mol Ag}} = 16.185 \text{ g Ag}$$

d. if 15.0 grams of copper reacts, how many moles of silver will be produced?

$$\frac{15 \text{ g Cu}}{63.5 \text{ g Cu}} \times \frac{1 \text{ mol Cu}}{1 \text{ mol Cu}} \times \frac{2 \text{ mol Ag}}{1 \text{ mol Cu}} = 0.472 \text{ mol Ag}$$

Stoichiometry: Moles to Grams



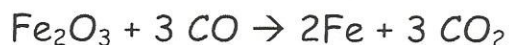
1. How many moles of NaCl are produced from 36 g of Cl_2 ?

$\text{Cl}_2 (35.5) \times 2 = 71$

$$\frac{36 \text{ g Cl}_2}{71 \text{ g Cl}_2} \times \frac{1 \text{ mol Cl}_2}{1 \text{ mol Cl}_2} \times \frac{2 \text{ mol NaCl}}{1 \text{ mol Cl}_2} = \boxed{1.01 \text{ mol NaCl}}$$

2. How many grams of Na are needed to produce 2.6 mol of NaCl?

$$\frac{2.6 \text{ mol NaCl}}{2 \text{ mol NaCl}} \times \frac{2 \text{ mol Na}}{1 \text{ mol Na}} \times \frac{23.0 \text{ g Na}}{1 \text{ mol Na}} = \boxed{59.8 \text{ g Na}}$$



3. How many grams of iron are produced from 1.5 mol of Fe_2O_3 ?

$$\frac{1.5 \text{ mol Fe}_2\text{O}_3}{1 \text{ mol Fe}_2\text{O}_3} \times \frac{2 \text{ mol Fe}}{1 \text{ mol Fe}_2\text{O}_3} \times \frac{55.8 \text{ g Fe}}{1 \text{ mol Fe}} = \boxed{167.4 \text{ g Fe}}$$

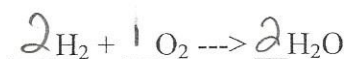
4. How many moles of CO are needed to produce 4.5 g of CO_2 ?

$$\frac{4.5 \text{ g CO}_2}{44 \text{ g CO}_2} \times \frac{1 \text{ mol CO}_2}{1 \text{ mol CO}_2} \times \frac{3 \text{ mol CO}}{3 \text{ mol CO}_2} = \boxed{0.102 \text{ mol CO}}$$

P-4

See pg. N-2 & N-3 for help

STOICHIOMETRY PRACTICE- Balance Equations First!



$$\begin{array}{r} \text{H } 2(1) = 2 \\ \text{O } 1(16) = 16 \\ \hline 18 \end{array}$$

How many grams of H_2O are produced when 2.50 moles of oxygen are used?

$$\frac{2.5 \text{ moles O}_2}{1 \text{ mol O}_2} \times \frac{2 \text{ mol H}_2\text{O}}{1 \text{ mol H}_2\text{O}} \times 18 \text{ g H}_2\text{O} = 90 \text{ g H}_2\text{O}$$

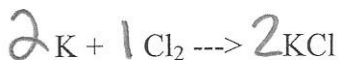
If 3.00 moles of H_2O are produced, how many grams of oxygen must be consumed?

$$\frac{3 \text{ moles H}_2\text{O}}{2 \text{ mol H}_2\text{O}} \times \frac{1 \text{ mol O}_2}{1 \text{ mol O}_2} \times 32 \text{ g O}_2 = 48 \text{ g O}_2$$



How many moles of O_2 can be produced by letting 12.00 moles of KClO_3 react?

$$\frac{12 \text{ moles KClO}_3}{2 \text{ mol KClO}_3} \times \frac{3 \text{ mol O}_2}{1 \text{ mol O}_2} = 18 \text{ mole O}_2$$



How many moles of KCl are produced from 2.50 g of K and excess Cl_2 .

$$\frac{2.5 \text{ g K}}{39.1 \text{ g K}} \times \frac{1 \text{ mol K}}{2 \text{ mol K}} \times \frac{2 \text{ mol KCl}}{1 \text{ mol K}} = 0.0639 \text{ mol KCl}$$

How many grams of KCl are produced from 1.00 mol of Cl_2 and excess K ?

$$\frac{1.0 \text{ mol Cl}_2}{1 \text{ mol Cl}_2} \times \frac{2 \text{ mol KCl}}{1 \text{ mol KCl}} \times 74.4 \text{ g KCl} = 148.8 \text{ g KCl}$$



How many moles of NaOH are produced from 469 grams of Na_2O ?

$$\frac{469 \text{ g Na}_2\text{O}}{62 \text{ g Na}_2\text{O}} \times \frac{1 \text{ mol Na}_2\text{O}}{1 \text{ mol Na}_2\text{O}} \times \frac{2 \text{ mol NaOH}}{1 \text{ mol Na}_2\text{O}} = 15.1 \text{ mol NaOH}$$

How many grams of Na_2O are required to produce 15.3 moles of NaOH ?

$$\frac{15.3 \text{ moles NaOH}}{2 \text{ mol NaOH}} \times \frac{1 \text{ mol Na}_2\text{O}}{1 \text{ mol Na}_2\text{O}} \times 62 \text{ g Na}_2\text{O} = 474.3 \text{ g Na}_2\text{O}$$

P-5

SEE pg. N-2 and N-3 for help

$$\begin{array}{r} 39.1 \\ 35.5 \\ \hline 74.4 \end{array}$$

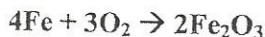
$$\begin{array}{r} \text{Na } 2(23) = 46 \\ \text{O } 1(16) = 16 \\ \hline 62 \end{array}$$

STOICHIOMETRY WORKSHEET #2

MASS-MASS CALCULATIONS

Name: _____

Sample Problems:



1. In the reaction above, if 26.0 grams of O_2 reacts, calculate

a. The mass of Fe that reacts

$$\frac{26\text{g O}_2}{32\text{g O}_2} \times \frac{1\text{mol O}_2}{3\text{mol O}_2} \times \frac{4\text{mol Fe}}{1\text{mol Fe}} \times \frac{55.8\text{g Fe}}{1\text{mole Fe}} = 60.45\text{g Fe}$$

b. The mass of Fe_2O_3 produced

$$\frac{26\text{g O}_2}{32\text{g O}_2} \times \frac{1\text{mol O}_2}{3\text{mol O}_2} \times \frac{2\text{mol Fe}_2\text{O}_3}{1\text{mol Fe}_2\text{O}_3} \times \frac{159.6\text{g Fe}_2\text{O}_3}{1\text{mol Fe}_2\text{O}_3} = 86.45\text{g Fe}_2\text{O}_3$$

2. In the reaction $2\text{KClO}_3 \rightarrow 2\text{KCl} + 3\text{O}_2$

If 2.74 grams of KCl are produced, calculate:

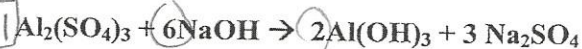
a. The mass of O_2 produced

$$\frac{2.74\text{g KCl}}{74.6\text{g KCl}} \times \frac{1\text{mol KCl}}{2\text{mol KCl}} \times \frac{3\text{mol O}_2}{1\text{mol O}_2} \times \frac{32\text{g O}_2}{1\text{mol O}_2} = 1.76\text{g O}_2$$

b. the mass of KClO_3 that reacts

$$\frac{2.74\text{g KCl}}{74.6\text{g KCl}} \times \frac{1\text{mol KCl}}{2\text{mol KCl}} \times \frac{2\text{mol KClO}_3}{1\text{mol KClO}_3} \times \frac{122.6\text{g KClO}_3}{1\text{mol KClO}_3} = 4.50\text{g KClO}_3$$

Homework Problems:



3. In the above reaction, if 22.7 grams of NaOH reacts, calculate

a. The mass of $\text{Al}_2(\text{SO}_4)_3$ that reacts

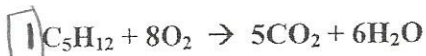
$$\frac{22.7\text{g NaOH}}{40\text{g NaOH}} \times \frac{1\text{mol NaOH}}{6\text{mol NaOH}} \times \frac{1\text{mol Al}_2(\text{SO}_4)_3}{1\text{mol Al}_2(\text{SO}_4)_3} \times \frac{342\text{g Al}_2(\text{SO}_4)_3}{1\text{mol Al}_2(\text{SO}_4)_3} = 32.35\text{g Al}_2(\text{SO}_4)_3$$

b. The mass of aluminum hydroxide produced

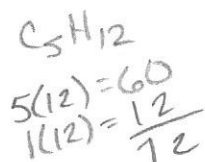
$$\frac{22.7\text{g NaOH}}{40\text{g NaOH}} \times \frac{1\text{mol NaOH}}{6\text{mol NaOH}} \times \frac{2\text{mol Al}(\text{OH})_3}{1\text{mol Al}(\text{OH})_3} \times \frac{78\text{g Al}(\text{OH})_3}{1\text{mol Al}(\text{OH})_3} = 4.22\text{g Al}(\text{OH})_3$$

c. The mass of sodium sulfate produced

$$\frac{22.7\text{g NaOH}}{40\text{g NaOH}} \times \frac{1\text{mol NaOH}}{6\text{mol NaOH}} \times \frac{3\text{mol Na}_2\text{SO}_4}{1\text{mol Na}_2\text{SO}_4} \times \frac{142\text{g Na}_2\text{SO}_4}{1\text{mol Na}_2\text{SO}_4} = 40.29\text{g Na}_2\text{SO}_4$$



4. In the above reaction, if 109.0 grams of pentane reacts, calculate:



a. The mass of O_2 that reacts

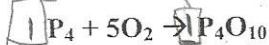
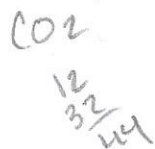
$$\frac{109 \text{g C}_5\text{H}_{12}}{72 \text{g C}_5\text{H}_{12}} \times \frac{1 \text{mol C}_5\text{H}_{12}}{1 \text{mol C}_5\text{H}_{12}} \times \frac{8 \text{mol O}_2}{1 \text{mol C}_5\text{H}_{12}} \times \frac{32 \text{g O}_2}{1 \text{mol O}_2} = 387.55 \text{g O}_2$$

b. The mass of carbon dioxide produced

$$\frac{109 \text{g C}_5\text{H}_{12}}{72 \text{g C}_5\text{H}_{12}} \times \frac{1 \text{mol C}_5\text{H}_{12}}{1 \text{mol C}_5\text{H}_{12}} \times \frac{5 \text{mol CO}_2}{1 \text{mol C}_5\text{H}_{12}} \times \frac{44 \text{g CO}_2}{1 \text{mol CO}_2} = 333.0 \text{g CO}_2$$

c. The mass of water produced

$$\frac{109 \text{g C}_5\text{H}_{12}}{72 \text{g C}_5\text{H}_{12}} \times \frac{1 \text{mol C}_5\text{H}_{12}}{1 \text{mol C}_5\text{H}_{12}} \times \frac{6 \text{mol H}_2\text{O}}{1 \text{mol C}_5\text{H}_{12}} \times \frac{18 \text{g H}_2\text{O}}{1 \text{mol H}_2\text{O}} = 163.5 \text{g H}_2\text{O}$$



5. In the above reaction, if 7.75 grams of P_4 reacts, calculate:

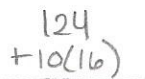


a. the mass of tetraphosphorus decoxide that is produced

$$\frac{7.75 \text{g P}_4}{124 \text{g P}_4} \times \frac{1 \text{mol P}_4}{1 \text{mol P}_4} \times \frac{1 \text{mol P}_4\text{O}_{10}}{1 \text{mol P}_4} \times \frac{284 \text{g P}_4\text{O}_{10}}{1 \text{mol P}_4\text{O}_{10}} = 17.75 \text{g P}_4\text{O}_{10}$$

b. The mass of O_2 that reacts

$$\frac{7.75 \text{g P}_4}{124 \text{g P}_4} \times \frac{1 \text{mol P}_4}{1 \text{mol P}_4} \times \frac{5 \text{mol O}_2}{1 \text{mol P}_4} \times \frac{32 \text{g O}_2}{1 \text{mol O}_2} = 10 \text{g O}_2$$



If 11.3 g grams of NO_2 react, calculate:

a. The mass of nitric acid that reacts

$$\frac{11.3 \text{g NO}_2}{46 \text{g NO}_2} \times \frac{1 \text{mol NO}_2}{1 \text{mol NO}_2} \times \frac{4 \text{mol HNO}_3}{2 \text{mol NO}_2} \times \frac{63 \text{g HNO}_3}{1 \text{mol HNO}_3} = 30.95 \text{g HNO}_3$$

b. The mass of copper that reacts

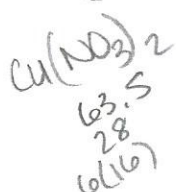
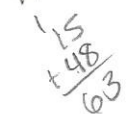
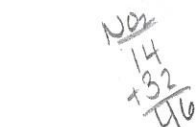
$$\frac{11.3 \text{g NO}_2}{46 \text{g NO}_2} \times \frac{1 \text{mol NO}_2}{1 \text{mol NO}_2} \times \frac{1 \text{mol Cu}}{2 \text{mol NO}_2} \times \frac{63.5 \text{g Cu}}{1 \text{mol Cu}} = 7.79 \text{g Cu}$$

c. The mass of copper (II) nitrate that is produced

$$\frac{11.3 \text{g NO}_2}{46 \text{g NO}_2} \times \frac{1 \text{mol NO}_2}{1 \text{mol NO}_2} \times \frac{1 \text{mol Cu}(\text{NO}_3)_2}{2 \text{mol NO}_2} \times \frac{187.5 \text{g Cu}(\text{NO}_3)_2}{1 \text{mol Cu}(\text{NO}_3)_2} = 23.02 \text{g Cu}(\text{NO}_3)_2$$

d. The mass of water that is produced

$$\frac{11.3 \text{g NO}_2}{46 \text{g NO}_2} \times \frac{1 \text{mol NO}_2}{1 \text{mol NO}_2} \times \frac{2 \text{mol H}_2\text{O}}{2 \text{mol NO}_2} \times \frac{18 \text{g H}_2\text{O}}{1 \text{mol H}_2\text{O}} = 4.42 \text{g H}_2\text{O}$$



P-7

See pg. N-4 for help