Stoichiometry (Mole Relationships)

Chemical reactions are like recipies - two of these, one of those make 4 servings - and so on. If you want the recipie to come out right you need start with the right ratio of ingredients. You can make a bigger or smaller recipie, 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 recipie in mind.

Balance the following reaction:

$$\underline{1}\ N_{2\,(g)} + \underline{3}\ H_{2\,(g)} \dashrightarrow \underline{2}\ NH_{3\,(g)}$$

Using conversions, fill in the following table:

Situation	N_2	H_2	NH_3	Ratio of all three
For a single "recipie" how many molecules would you need or make?	1	3	2	1:3:2
If you made the "recipie" one hundred times, how many molecules would you need or make?	100	300	200	1:3:2
If you made the "recipie" 538 times, how many molecules would you need or make?	538	1614	1076	1:3:2
If you made the "recipie" 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

X100 X538 X 6.02×10^{23} molec. X22.4 XMass

1 (N_2) → ×28 ×2 ×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).

Name: _____

STOICHIOMETRY WORKSHEET #1
MOLE-MOLE CALCULATIONS

Sample Problems:

$2Al + 6HCl \rightarrow 2\,AlCl_3 + 3H_2$

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

a. How many moles of H_2 are produced?

$$.5\text{mol Al} \left| \frac{3\text{mol } H_2}{2\text{mol Al}} \right. = .75 \text{ mole } H_2$$

b. How many moles of HCl are needed?

$$.5\text{mol Al} \left| \frac{6\text{ mol HCl}}{2\text{mol Al}} \right. = 1.5\text{mol HCl}$$

$4Fe + 3\,O2 \rightarrow 2Fe_2O_3$

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

a. How many moles of O_2 are needed?

$$.75\text{mol Fe} \left| \frac{3\text{mol Fe}}{4\text{mol Fe}} \right. = 0.5625 \text{ mol Fe}$$

b. How many moles of Fe_2O_3 are produced?

$$.75\text{mol Fe} \left| \frac{2\text{ mol } Fe_2O_3}{4\text{mole Fe}} \right. = .375\text{mol } Fe_2O_3$$

c. How many grams of Fe_2O_3 is this?

Fe 2(55.8)=
O 3(16)=+
159.6

$$.75\text{mol Fe} \left| \frac{2\text{mol } Fe_2O_3}{4\text{mol Fe}} \right| \frac{159.6\text{ g } Fe_2O_3}{1\text{mol } Fe_2O_3} = 59.85\text{g } Fe_2O_3$$

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

$$10\text{g Fe} \left| \frac{1\text{mole Fe}}{55.8\text{g Fe}} \right| \frac{3\text{mol } O_2}{4\text{mole Fe}} = .134\text{mol } O_2$$

Homework Problems:

1 $C_2H_4 + 3\,O_2 \rightarrow 2\,CO_2 + 2\,H_2O$

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

a. How many moles of CO_2 are produced?

$$.75\text{mole } C_2H_4 \left| \frac{2\text{mol } CO_2}{1\text{mol } C_2H_4} \right. = 1.5\text{mol } CO_2$$

b. How many moles of O_2 are also needed?

$$.75\text{mol } C_2H_4 \left| \frac{3\text{ mol } O_2}{1\text{ mol } C_2H_4} \right. = 2.25\text{mol } O_2$$

P-2

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

$2H_3PO_4 + 3Mg(OH)_2 \rightarrow Mg_3(PO_4)_2 + 6H_2O$

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

a. How many moles of H_3PO_4 react?

$.42 \text{ mol } Mg(OH)_2 \left| \frac{2 \text{ mol } H_3PO_4}{3 \text{ mol } Mg(OH)_2} \right. = .28 \text{ mol } H_3PO_4$

b. How many moles of water are formed?

$.42 \text{ moles } Mg(OH)_2 \left| \frac{6 \text{ moles } H_2O}{3 \text{ moles } Mg(OH)_2} \right. = .84 \text{ mol } H_2O$

c. How many moles of $Mg_3(PO_4)_2$ are made?

$.42 \text{ mole } Mg(OH)_2 \left| \frac{1 \text{ mol } Mg_3(PO_4)_2}{3 \text{ mol } Mg(OH)_2} \right. = .14 \text{ mol } Mg_3(PO_4)_2$

d. How many grams of $Mg_3(PO_4)_2$ is this?

$.42 \text{ mol } Mg(OH)_2 \left| \frac{1 \text{ mol } Mg_3(PO_4)_2}{3 \text{ mol } Mg(OH)_2} \right| \frac{262.9 \text{ g } Mg_3(PO_4)_2}{1 \text{ mol } Mg_3(PO_4)_2} = 36.80 \text{ g } Mg_3(PO_4)_2$

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

$4Al + 3O_2 \rightarrow 2Al_2O_3$

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

a. How many moles of O_2 are needed?

$2.3 \text{ mole } Al_2O_3 \left| \frac{3 \text{ mol } O_2}{2 \text{ mol } Al_2O_3} \right. = 3.45 \text{ mol } O_2$

b. How many moles of Al are needed?

$2.3 \text{ mol } Al_2O_3 \left| \frac{4 \text{ mol Al}}{2 \text{ mol } Al_2O_3} \right. = 4.6 \text{ mol Al}$

c. How many grams of Al is this?

$2.3 \text{ mol } Al_2O_3 \left| \frac{4 \text{ mol Al}}{2 \text{ mol } Al_2O_3} \right| \frac{27 \text{ g Al}}{1 \text{ mol Al}} = 124.2 \text{ g Al}$

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

$5 \text{ g Al} \left| \frac{1 \text{ mol Al}}{27 \text{ g Al}} \right| \frac{3 \text{ mol } O_2}{4 \text{ mol Al}} = .138 \text{ mol } O_2$

$Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2\ Ag$

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

a. How mnay moles of copper will react?

$.15 \text{ mol } AgNO_3 \left| \frac{1 \text{ mol Cu}}{2 \text{ mol } AgNO_3} \right. = .075 \text{ mol Cu}$

b. How many moles of silver will there be?

$.15 \text{ mol } AgNO_3 \left| \frac{2 \text{ mol Ag}}{2 \text{ mol } AgNO_3} \right. = .15 \text{ mol Ag}$

c. How many grams of silver is this?

$.15 \text{ mol } AgNO_3 \left| \frac{2 \text{ mol Ag}}{2 \text{ mol } AgNO_3} \right| \frac{107.9 \text{ g Ag}}{1 \text{ mol Ag}} = 16.185 \text{ g Ag}$

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

$15 \text{ g Cu} \left| \frac{1 \text{ mol Cu}}{63.5 \text{ g Cu}} \right| \frac{2 \text{ mol Ag}}{1 \text{ mol Cu}} = .472 \text{ mol Ag}$

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

Stoichiometry: Moles to Grams

$2\ Na + Cl_2 \rightarrow 2\ NaCl$

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

$Cl_2 (35.5)=71$

$$\frac{36\text{g } Cl_2}{71\text{g } Cl_2} \left| \frac{1\text{mol } Cl_2}{1\text{mol } Cl_2} \right| \frac{2\text{mol NaCl}}{1\text{mol } Cl_2} = 1.01\text{ mol NaCl}$$

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

$$\frac{2.6\text{mol NaCl}}{2\text{mol NaCl}} \left| \frac{2\text{ mol Na}}{1\text{mol Na}} \right| \frac{23.0\text{g Na}}{1\text{mol Na}} = 59.8\text{g Na}$$

$Fe_2O_3 + 3\ CO \rightarrow 2Fe + 3\ CO_2$

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

$$\frac{1.5\text{mol } Fe_2O_3}{1\text{mol } Fe_2O_3} \left| \frac{2\text{mol Fe}}{1\text{mol Fe}} \right| \frac{55.8\text{g Fe}}{1\text{mol Fe}} = 167.4\text{g Fe}$$

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

$$\frac{4.5\text{g } CO_2}{44\text{g } CO_2} \left| \frac{1\text{mol } CO_2}{3\text{mol } CO_2} \right| \frac{3\text{mol CO}}{3\text{mol } CO_2} = .102\text{mol CO}$$

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

STOICHIOMETRY PRACTICE- Balance Equations First!

H 2(1) = 2
O 1(16) = 16
18

$$2\,H_2 + 1\,O_2 \rightarrow 2\,H_2O$$

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

$$2.5\text{moles } O_2 \left| \frac{2\text{mol } H_2O}{1\text{mol } O_2} \right| \frac{18\text{ g } H_2O}{1\text{mol } H_2O} = 90\text{g } H_2O$$

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

$$3\text{moles } H_2O \left| \frac{1\text{mol } O_2}{2\text{mol } H_2O} \right| \frac{32\text{g } O_2}{1\text{mol } O_2} = 48\text{g } O_2$$

$$2\,KClO_3 \rightarrow 2\,KCl + 3\,O_2$$

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

$$12\text{moles } KClO_3 \left| \frac{3\text{mol } O_2}{2\text{mol } KClO_3} \right. = 18\text{mole } O_2$$

$$2\,K + 1\,Cl_2 \rightarrow 2\,KCl$$

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

$$2.5\text{g K} \left| \frac{1\text{mol K}}{39.1\text{g K}} \right| \frac{2\text{mol KCl}}{2\text{mol K}} = .0639\text{mol KCl}$$

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

$$1.0\text{mol } Cl_2 \left| \frac{2\text{mol KCl}}{1\text{mol } Cl_2} \right| \frac{74.4\text{g KCl}}{1\text{mol KCl}} = 148.8\text{g KCl}$$

39.9
35.5
74.4

$$1\,Na_2O + 1\,H_2O \rightarrow 2\,NaOH$$

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

Na 2(23) = 46
O 1(16) = 16
62

$$469\text{g } Na_2O \left| \frac{1\text{mol } Na_2O}{62\text{g } Na_2O} \right| \frac{2\text{ mol NaOH}}{1\text{mol } Na_2O} = 15.1\text{mol NaOH}$$

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

$$15.3\text{moles NaOH} \left| \frac{1\text{mol } Na_2O}{2\text{mol NaOH}} \right| \frac{62\text{ g } Na_2O}{1\text{mol } Na_2O} = 474.3\text{g } Na_2O$$

P-5
See pg. N-2 and N-3 for help

G → G

Name: _____

STOICHIOMETRY WORKSHEET #2
MASS-MASS CALCULATIONS

Sample Problems:

$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

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

a. The mass of Fe that reacts

$$\frac{26\text{g } O_2}{} \left| \frac{1\text{mol } O_2}{32\text{g } O_2} \right| \frac{4\text{mol Fe}}{3\text{mol } O_2} \left| \frac{55.8\text{g Fe}}{1\text{mole Fe}} \right. = 60.45\text{ Fe}$$

Fe 2(55.8)
O 3(16)
159.6

b. The mass of Fe_2O_3 produced

$$\frac{26\text{g } O_2}{} \left| \frac{1\text{mol } O_2}{32\text{g } O_2} \right| \frac{2\text{mol } Fe_2O_3}{3\text{mol } O_2} \left| \frac{159.6\text{g } Fe_2O_3}{1\text{mol } Fe_2O_3} \right. = 86.45\text{g } Fe_2O_3$$

2. In the reaction **$2KClO_3 \rightarrow 2KCl + 3O_2$**

If 2.74 grams of KCl are produced, calculate:

a. The mass of O_2 produced

K 39.1
Cl 35.5
74.6

$$\frac{2.74\text{g KCl}}{} \left| \frac{1\text{mol KCl}}{74.6\text{ g KCl}} \right| \frac{3\text{mol } O_2}{2\text{mol KCl}} \left| \frac{32\text{g } O_2}{1\text{mol } O_2} \right. = 1.76\text{g } O_2$$

b. the mass of $KClO_3$ that reacts

$KClO_3$
K 74.6 | 74.6
Cl 35.5 | 48
O 3(16) | 122.6

$$\frac{2.74\text{g KCl}}{} \left| \frac{1\text{mol KCl}}{74.6\text{ g KCl}} \right| \frac{2\text{mol } KClO_3}{2\text{mol KCl}} \left| \frac{122.6\text{g } KClO_3}{1\text{mol } KClO_3} \right. = 4.50\text{g } KClO_3$$

Homework Problems:

Al 2(27) =
S 3(32) =
O 12(16) =
342

$1Al_2(SO_4)_3 + 6NaOH \rightarrow 2Al(OH)_3 + 3\,Na_2SO_4$

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

a. The mass of $Al_2(SO_4)_3$ that reacts

Na 23
O 16
H 1
40

$$\frac{22.7\text{g NaOH}}{} \left| \frac{1\text{mol NaOH}}{40\text{g NaOH}} \right| \frac{1\text{mol } Al_2(SO_4)_3}{6\text{mol NaOH}} \left| \frac{342\text{g } Al_2(SO_4)_3}{1\text{mol } Al_2(SO_4)_3} \right. = 32.35\text{g } Al_2(SO_4)_3$$

b. The mass of aluminum hydroxide produced

$Al(OH)_3$
27
+16(3)
3
78

$$\frac{22.7\text{g NaOH}}{} \left| \frac{1\text{mol NaOH}}{40\text{g NaOH}} \right| \frac{2\text{mol } Al(OH)_3}{6\text{mol NaOH}} \left| \frac{78\text{ g } Al(OH)_3}{1\text{ Mol } Al(OH)_3} \right. = 4.22\text{g } Al(OH)_3$$

c. The mass of sodium sulfate produced

Na_2SO_4
2(23) = 46
1(32) = 32
4(16) = 64
142

$$\frac{22.7\text{g NaOH}}{} \left| \frac{1\text{mol NaOH}}{40\text{g NaOH}} \right| \frac{3\text{ mol } Na_2SO_4}{6\text{mol NaOH}} \left| \frac{142\text{ g } Na_2SO_4}{1\text{mol } Na_2SO_4} \right. = 40.29\text{g } Na_2SO_4$$

See pg. N-4 for help

1 $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$

C_5H_{12}

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

C_5H_{12}
$5(12) = 60$
$1(12) = 12$
72

a. The mass of O2 that reacts

$$109\text{g } C_5H_{12} \left| \frac{1\text{mol } C_5H_{12}}{72\text{g } C_5H_{12}} \right| \frac{8\text{mol } O_2}{1\text{mol } C_5H_{12}} \left| \frac{32\text{g } O_2}{1\text{mol } O_2} \right| = 387.55\text{g } O_2$$

b. The mass of carbon dioxide produced

$$109\text{g } C_5H_{12} \left| \frac{1\text{mol } C_5H_{12}}{72\text{g } C_5H_{12}} \right| \frac{5\text{mol } CO_2}{1\text{mol } C_5H_{12}} \left| \frac{44\text{g } CO_2}{1\text{mol } CO_2} \right| = 333.0\text{g } CO_2$$

CO_2
12
32
44

c. The mass of water produced

$$109\text{g } C_5H_{12} \left| \frac{1\text{mol } C_5H_{12}}{72\text{g } C_5H_{12}} \right| \frac{6\text{mol } H_2O}{1\text{mol } C_5H_{12}} \left| \frac{18\text{g } H_2O}{1\text{mol } H_2O} \right| = 163.5\text{g } H_2O$$

1 $P_4 + 5O_2 \rightarrow 1P_4O_{10}$

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

g P_4O_{10}

a. the mass of tetraphosphorus decoxide that is produced

$$7.75\text{g } P_4 \left| \frac{1\text{mol } P_4}{124\text{ g } P_4} \right| \frac{1\text{ mol } P_4O_{10}}{1\text{mol } P_4} \left| \frac{284\text{ g } P_4O_{10}}{1\text{mol } P_4O_{10}} \right| = 17.75\text{g } P_4O_{10}$$

P_4
31
$\times 4$
124

b. The mass of O_2 that reacts

$$7.75\text{g } P_4 \left| \frac{1\text{mol } P_4}{124\text{g } P_4} \right| \frac{5\text{mol } O_2}{1\text{mol } P_4} \left| \frac{32\text{g } O_2}{1\text{mol } O_2} \right| = 10\text{g } O_2$$

124
$+10(16)$

$Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

If 11.3 g grams of NO_2 react, calculate:

HNO_3

a. The mass of nitric acid that reacts

$$11.3\text{g } NO_2 \left| \frac{1\text{mol } NO_2}{46\text{g } NO_2} \right| \frac{4\text{mol } HNO_3}{2\text{mol } NO_2} \left| \frac{63\text{g } HNO_3}{1\text{mol } HNO_3} \right| = 30.95\text{g } HNO_3$$

NO_2
14
$+32$
46

HNO_3
1
15
$+48$
63

b. The mass of copper that reacts

$$11.3\text{g } NO_2 \left| \frac{1\text{mol } NO_2}{46\text{g } NO_2} \right| \frac{1\text{mol } Cu}{2\text{mol } NO_2} \left| \frac{63.5\text{g } Cu}{1\text{mol } Cu} \right| = 7.79\text{g } Cu$$

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

$$11.3\text{g } NO_2 \left| \frac{1\text{mol } NO_2}{46\text{g } NO_2} \right| \frac{1\text{mol } Cu(NO_3)_2}{2\text{mol } NO_2} \left| \frac{187.5\text{g } Cu(NO_3)_2}{1\text{mol } Cu(NO_3)_2} \right| = 23.02\text{g } Cu(NO_3)_2$$

$Cu(NO_3)_2$
63.5
28
$6(16)$

d. The mass of water that is produced

$$11.3\text{g } NO_2 \left| \frac{1\text{mol } NO_2}{46\text{g } NO_2} \right| \frac{2\text{mol } H_2O}{2\text{mol } NO_2} \left| \frac{18\text{g } H_2O}{1\text{mol } H_2O} \right| = 4.42\text{g } H_2O$$

See pg. N-4 for help